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Proceedings of the MISBE2011 - International Conference

Management and Innovation for a Sustainable Built Environment



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Editors:
Hans Wamelink, Rob Geraedts and Leentje Volker

The CIB conference MISBE2011 - Management and Innovation for a Sustainable Built Environment - was organised in Amsterdam, The Netherlands, in June 2011 by the Department of Real Estate & Housing, Faculty of Architecture, Delft University of Technology, in association with AESOP (Association of European Schools of Planning) and ENHR (European Network for Housing Research). This was also a joint meeting for CIB W055 Building Economics, W065 Organization & Management in Construction, W089 Building Research & Education, W112 Culture in Construction, TG76 Recognising Innovation, TG78 Informality & Emergence in construction, TG81 Global Construction Data.
During the conference an international group of 180 scientists and building professionals from 20 countries on all continents met each other and discussed from a broad perspective recent developments in management, innovation and planning of the built environment. The conference provided a challenging forum and vibrant opportunity for researchers and practitioners to share their research perspectives, research results and experiences on specific new challenges and emerging issues in practice, during the paper sessions and the specific workshops as well.

The Proceedings of MISBE2011 contain the collected papers presented on the International Conference MISBE2011 and cover the following topics:

- Management for sustainable design and construction
- Economics of the built environment
- Collaboration and integration in design and construction
- Innovation in construction
- Construction bidding and contracting
- Value driven design and delivery
- Planning for sustainable urban areas
- New technologies in planning
- Sustainable transformation
- Innovations in (strategic) urban planning
- Supply chain integration & collaboration
- Selecting partners and organizing collaboration
- Global construction data
- Social innovation & participation
- Deconstructing organisational paradoxes

Availability

The proceedings are published by TU Delft, Faculty of Architecture Real Estate and Housing and are available at: http://misbe2011.fyper.com/proceedings.htm

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PREFACE

These proceedings contain the collected papers presented on the International Conference "Management and Innovation for a Sustainable Built Enviroment". This conference is organised under the auspices of Working Commissions W55, W65, W89 and W112 of the International Council for Research and Innovation in Building and Construction (CIB), together with the European Network for Housing Research (ENHR) and the Association of European Schools of Planning (AESP).

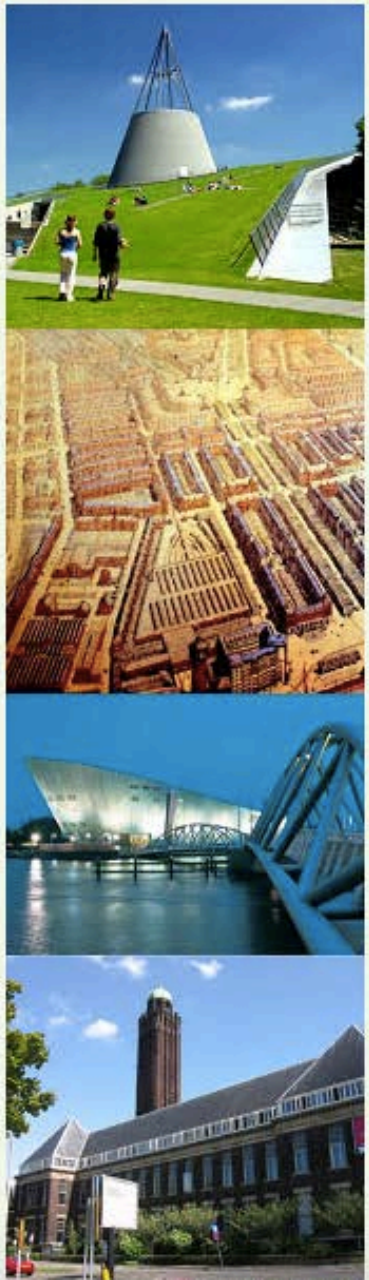
During the conference an international group of 180 scientists and building professionals from 20 countries on all continents met eachother and discussed from a broad perspective recent developments in management, innovation and planning of the built environment.

The organisers wish to express their gratitude to all those individuals who played an important role in the organisation of MISBE2011. We special thank the members of the local Organisation Committee and all members of the Scientific Committee.

Finally, the conference organisers wish to thank all speakers, participants, session chairs and workshop leaders for their involvement and contributions, making the conference a success.

Hans Wamelink
Rob Geraedts
Leentje Volker

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PASSIVE HOUSE NETWORKS: A SOCIAL INNOVATION TARGETING INNOVATION IN SME'S IN THE CONSTRUCTION SECTOR

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Abstract
This study examines opportunities for the emergence of SME networks regarding highly energy-efficient housing, as well as the barriers they face.
A theoretical innovation diffusion model is developed from the point-of-view of social and environmental entrepreneurship and sustainable consumption.
The qualitative analysis reflects key elements from the theoretical model and is based on a representative case study of a successful passive house network located in the Belgian Flemish Region. Data were gathered during the emergence of the network, by means of participant observation and action-based (thematic innovation) research. Interviews provided further supplementary information.
The study concludes that the successful emergence of an SME network regarding highly energy-efficient housing requires a holistic approach, in which both enterprises and clients are guided in each step of the innovation-decision process. In their role as intermediaries between clients and firms, change agents should be supported by policy that facilitates networks for innovation diffusion.

Keywords: Buildings; Energy efficiency; Passive house; Innovation diffusion; Enterprise networks.

INTRODUCTION

The importance of high energy efficiency in the construction sector is widely acknowledged. A wide range of innovative energy-efficient solutions are already available within enterprises, and thus at issue is why these innovations are not widespread. The outcomes of research into the barriers to and drivers of technological innovation are expected to speed up the necessary transformation of the housing sector towards energy efficiency (EeB 2009).
Of particular interest are enterprise network structures, since these are known to create an environment of formal relationships and contracts between enterprises, providers and clients and cooperation between enterprises, as well as being supportive for regional economic and social development (Brenner and Fornahl 2003; DeBresson and Amesse 1991; Ornetzeder et al. 2005; Porter 1998). In particular, networks are also known to form a 'locus' for the introduction and diffusion of new technological solutions (Ornetzeder et al. 2005).
Although there are some experiences with case studies of successful emergence of enterprise networks in different fields (see for example: Brenner and Fornahl 2003, Ornetzeder et al. 2005, Porter 1998, Scott 1993), how to implement an SME network for the diffusion of highly energy-efficient housing (and related technology) is not well known: the emergence of network structures to implement certain goals of sustainable development or innovation is a relatively new research field.

Nevertheless there are some parallel research fields, most exemplary on innovation diffusion (e.g. Brenner and Fornahl 2003, Rogers 2003), which can contribute to this research field. Indeed, to examine barriers and drivers for the emergence of SME networks, it is important to understand what drives innovation-decision processes in SMEs and how this relates to SME networks. It can be useful to investigate a case study in order to provide a better understanding how individual change in SMEs can result in collective social innovation. This work therefore studies the emergence of an SME network dedicated to innovation diffusion, using theory of innovation-decision processes.

RESEARCH QUESTIONS

The main research question in this paper is:

How can SME networks aiming at highly energy-efficient housing successfully emerge?
In order to investigate this question the work defines several subquestions, taking the emergence of an existing SME network as a representative case study for empirical research. The following subquestions are addressed in the next sections:

How can the emergence of a network dedicated to high energy-efficiency housing be studied in relation to innovation-decision processes?
To answer subquestion 1, a research model is developed in the next section, and a representative successful case study covering the field of highly energy-efficient housing is selected.

How did SMEs decide to adopt such a network?
In the analysis section, the research model is used to describe the case study.

What were the first steps of the network?
The research model is further used to describe and discuss the first actions of the network.

What can be learnt from the case study?
In the conclusion, the most important findings are summarized.

RESEARCH METHODOLOGY

Theoretical background

In general, there are several bodies of literature that can be relevant for answering subquestion 1, like findings in the fields of (emergence of) enterprise networks and networks for innovation development and social or environmental entrepreneurship (see introduction). A full theoretical overview is beyond the scope of this paper, but further reading can also be suggested considering product-service systems (Mont and Tukker 2006) and the concepts of bounded socio-technical experiments, technological innovation systems and in particular strategic niche management (Ornetzeder and Rohracher 2009). Since the focus of the study was on innovation diffusion, for the examination of decision-processes for the emergence of the case study network, as a general framework Rogers' theory of innovation diffusion was selected (Rogers 2003).
Researchers have been working on a scientific framework for diffusion of innovation since the 1950's. An early milestone is the work of Rogers, describing since 1962 methodologies

for diffusion research that even now are still being used, although in modified forms. The newest edition of this work (Rogers 2003) defines diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. The innovation-decision process was defined by Rogers (2003) as the process through which an individual (or other decision making unit) passes from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. According to Rogers' model, communication channels, and prior knowledge and conditions, can influence adoption. In the persuasion phase, the decision making unit can be influenced by the perceived characteristics of the innovation.
Rogers' scientific framework of innovation diffusion has also been used by Dutch researchers as a guiding model for market introduction of energy efficiency and sustainable development in the construction industry (Silvester 1996, van Hal 2000; Bos-Brouwers 2010). Damian Miller (2009) recently developed an integrated model for emerging markets, including Rogers' theory and based on four broad perspectives in innovation diffusion research defined by Lawrence Brown (1981): communication, economic history, market development, market infrastructure (see further in Figure 2).

Model development

Networks are known to develop, grow and decline similar to enterprises in innovation diffusion theory (see for example: Brenner and Fornahl 2003). Regarding innovation diffusion it thus makes sense to analyze (emerging) clusters or networks as (innovating) enterprises. However, social networks are also identified by a common goal, by a specific way of communication and action, as well as by a minimal internal institutional (organizational) structure (Fürst 2002). Regarding energy-efficient housing, Ornetzeder et al. (2005) suggested a strong focus on creation of trust and social capital, and learning processes and the need for a center of know-how as most important factors in the emergence of networks of enterprises. Also, social networks tend to focus on steering a paradigm shift, which means they try to influence ways of thinking and representing in order to influence action (Fürst 2002, Ornetzeder et al. 2005).
In the development of the present research model, it is noted that key to the social learning process regarding the implementation of highly energy-efficient housing as an innovation is how to break the so-called 'circle-of-blame' (see Figure 1), and transform it into a learning 'circle-of-innovation' (or circle of trust, see Figure 2).

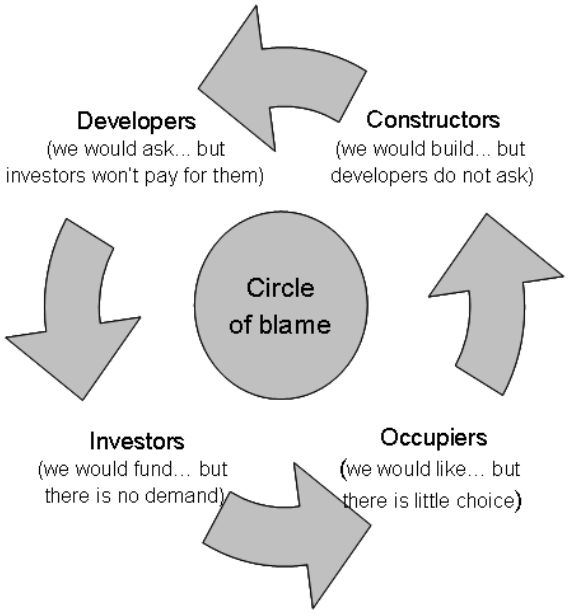


Figure 1: *Circle of blame. Source: SCFG (2000).*

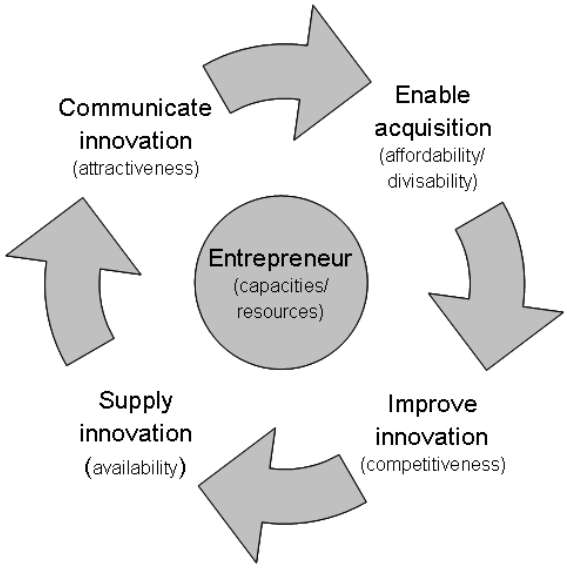


Figure 2: *Integrated analytical framework for innovation diffusion (interpretation based on: Miller 2009).*

A real challenge lies in combining structural technological and system changes (like social and innovation-oriented entrepreneurship as illustrated in Figure 2) with cultural and behavioral changes (like sustainable consumption), possibly by means of intermediary functions or new networks.

Based on a theoretical framework of sustainable consumption Peter Tom Jones and Vicky De Meyere (2009) proposed the 4E-model (see Figure 3, the model has its roots in Stevenson and Keehn 2006; Defra 2008) to explore effective strategies to change behavior towards sustainable consumption. This model can be useful when the research explores actions of the network regarding sustainable consumption.

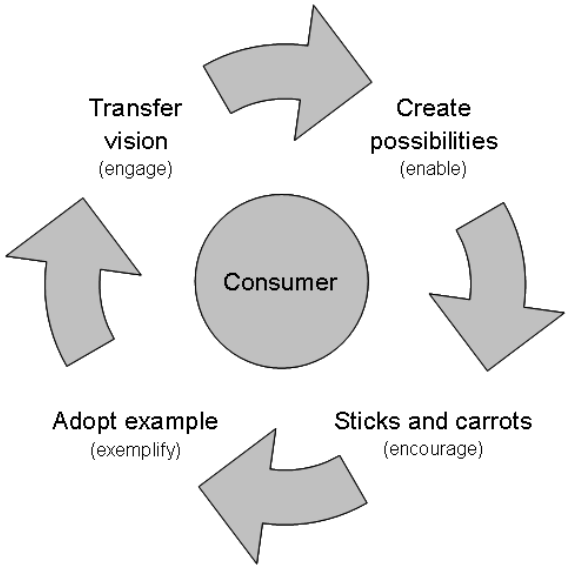


Figure 3: *The British 4E model provides an overview of a mix of complimentary instruments that can change consumption behavior: 'enable', 'encourage', 'exemplify' and 'engage' (interpretation based on the study by Jones and De Meyere 2009).*

In order to analyze the case study the research combines both models from Figure 2 (viewed from the supply side) and Figure 3 (viewed from the demand side).

Selection of a case study

In practice, the promotion of energy efficiency has long been the mandate of national governments and energy utilities. Nowadays, also in the framework of larger 'climate' or 'sustainability' agenda's, a lot of intermediary organizations already work on energy efficiency (Heiskanen et al. 2009), including a variety of governmental and nongovernmental organizations, public-private partnerships and regional or sectorial networks.

In the field of construction of highly energy-efficient housing different authors (Ornetzeder and Rohracher 2009; Mlecnik 2003) noted that nowadays new interest organizations focusing on passive houses shape the socio-technical system by mediating between producers and the policy level and by building systems to transfer these new technologies and practices into the mainstream building sectors. In the case of Austria, the evolving niche of highly energy-efficient passive houses seems to have the potential to profoundly transform existing construction practices (Ornetzeder and Rohracher 2009). Therefore a passive house related SME network was selected for further study.

As a case study, the research qualitatively investigates how an SME network, focused on passive house development, emerged in the Belgian Flemish Region. In 2002 a governmental agency decided to support a thematic innovation platform for SMEs in the construction industry during four years (IWT 2007, Mlecnik 2003) to stimulate thematic innovation in the regional construction industry. The main goal of the network was the diffusion of the passive house concept and technologies in the Flemish Region. Today, the network has shown strong growth and its influence reached even into policy development. While the word 'passive house' was regionally unknown in 2002, today it is an official word in Belgian federal income tax reduction law, hundreds of passive houses are being built every year in the Flemish Region and dozens of companies offer specific products, systems and services for a newly developed regional market of highly energy-efficient housing. Meanwhile the Flemish 'Passive House Platform' (PHP) has evolved from 18 founding members in 2002 to more than 300 members at the end of 2008, of which 158 can be characterized as enterprises, organizations and institutes.

To answer to the research question it can be important to have a rather complete view of the introduction and development of the case study (network PHP), including qualitative details that might be of importance in decision-making and replication of the network initiative. The paper is based on action-based innovation research by the author in the framework of a thematic innovation stimulation project (IWT 2007). Participatory observation in the set-up of the network led to permanent follow-up of the emergence and change of composition of the network. To provide empirical data, introductory interviews were performed amongst the founding and emerging members of PHP (2002-2006), focusing on: What are the characteristics of the member? What is expected from the collaboration with the network? What kind of information and initiatives are needed? What are the observed needs for the future?
The following section analyses the innovation-decision process for the set-up of the SME innovation network.

Limitations of the research
In social sciences the qualitative analysis of case studies has a long tradition, usually because more quantitative approaches are not sufficient or can even lead to wrong descriptions of the encountered phenomena (Ornetzeder et al. 2005). Unlike quantitative approaches of network research, which are usually more focused on interpreting the importance of relationships between members in a network or analysis of clusters, qualitative network research is more focused on interpreting the importance, actions and consequences of the network as a whole.
Organizational innovations tend to have a very specific emergence history which is highly related to local context and side conditions in a social context, which can limit the way a model can be transferred to another region or social context. The action-based research was conducted during the emergence period 2002-2006 of PHP, so starting conditions might be different today. Notably, the European context of energy performance of buildings legislation has changed. Also, interviewees were chosen in function of their relative importance to the introduction and development of the network, which can induce a high focus on the 'innovator' view. It is noted that, meanwhile for addressing the growth market, activities and business model of the examined case study have changed. The growth of the network from innovation to volume market is discussed in another paper (Mlecnik 2011).
The research does not to attempt to conclusively answer what a passive house SME cluster is, or is not, but to review and integrate experiences which may help in understanding the importance of mediators and SME networks as a liaison between sustainable consumers and innovating enterprises. Note that local success of a transfer process of a business model is highly dependent on motivation and competences of the lead actors, resources and social capital generation. However, the business model of the network 'Passiefhuis-Platform' (PHP) is known to have been transferred to other regions, for example to the Walloon Region (with the emergence of the 'Plate-forme Maison Passive') and to the Czech Republic (with the emergence of the 'Centrum Pasivniho Domu'), which makes it worth while to study more deeply.

ANALYSIS OF THE CASE STUDY

Emergence
Exemplify
The discussions between enterprises during the foundation phase of PHP clearly indicated a wish to achieve more sustainable construction on the regional level, based on examples from (and comparison with) other countries. Previous studies (SENVIVV 1998, CIR 2000, Eurima

2003) indicated that for example thermal insulation quality of buildings in the Flemish Region was amongst the worst in Europe. In 2002, there was also no concern from policy to set higher energy performance requirements: the Flemish Region was just confronted with the implementation of the European Performance of Buildings Directive (EPBD 2002) and just started re-inventing energy calculation procedures in collaboration with industry. At first, the EPBD policy approach led to distrust in the fashion of the typical 'circle of blame' (see Figure 1).

Engage

For some companies, this knowledge-action gap was a driver to discuss more effective strategies and business opportunities for sustainable housing, like for example in the IEA SHC Task 28 (2006). Several enterprises defended that to bridge this gap not only a 'circle of trust' – alternatively a 'green circle of naming' (Buck, 2008) – is needed, but also a broader conceptualization of actions for win-win situations and a more appropriate interpretation of knowledge, for example from neighboring countries. A Flemish engineering office, familiar with sustainability issues and studies, was keen on setting a higher energy performance standard in order to promote their services. Instead of trying to steer people's behavior by the (still non-existing) EPBD, they argued that it is necessary to enhance people's knowledge about the existence of solutions. They argued that in order to translate energy consciousness into consumer action, people not only need to know about the state (and energy coefficient) of the houses, but also about the root causes of the problem like insufficient thermal insulation, leaky construction details, improper use of solar gains and (health problems due to) lack of ventilation. It was observed that some non-profit organizations in the Flemish Region promoted for example renewable energy systems (ODE-Vlaanderen vzw) or sustainable construction materials (VIBE vzw), but that the root causes were insufficiently addressed by these promoters.

Enable

Keeping the root causes of the problem in mind, visions and socio-environmental possibilities and strategies towards change were developed. The engineering office played a key role in providing competences and resources for this development, using a small but subversive unit within the larger organization - what Rogers calls a 'skunkworks': an especially enriched environment that is intended to help a small group of individuals design a new idea by escaping routine organizational procedures (Rogers 2003: 149). An existing but dormant non-profit organization (Energie Duurzaam vzw) was used to pioneer the development of the social innovation, and an R&D worker was selected and given special resources, working on a crash basis to create the innovation and to find support for it.

Encourage

From innovation diffusion literature it is known that the availability of positive information is important in innovation adoption decisions (O'Neal et al. 1973). Energie Duurzaam collected answers from individual SMEs interested in profiling themselves in best energy-efficiency. The R&D worker could rely on the connection network of the engineering office to find motivated individuals within companies. In-depth interviews with possible key stakeholders led to initial knowledge diffusion, and further persuasion and decision of some companies to adopt an SME network. The adoption process was further formalized in regular meetings between interested companies, in order to gain confidence and to develop a common vision. This common vision – diffusion of knowledge to stimulate high energy-efficiency in buildings - was formalized as a goal for a non-profit organization, to be erected. Instead of

protesting against slow policy development, the psychology of change was defined as a framework including positive community building, and positive feedback loops as strategies.
Once a proposal for a common vision was developed and set into statutes of a non-profit organization, it was presented to a larger group of possible stakeholders, including companies from the sustainable building sector, as well as traditional building companies and prominent building research institutes. As expected, traditional companies and even the building research institutes were at first reluctant, but the decision was left to them if they wanted to join the movement. However, to join the movement, they were asked to formalize their intent and write consent to stimulate innovation for high energy-efficiency by means of a letter signed by their director.

Competences/ resources
A first barrier to tackle was the exact meaning of 'energy efficiency' in order to attract competences. It was obvious from the different discussions that the enterprises wanted to distinguish themselves from companies that care less regarding energy efficiency. So most companies agreed to set a higher standard, even compared to 'low energy', such as a factor four energy reduction, or even including other sustainability criteria. The engineering office proposed to examine the example of the passive house concept as a high energy-efficiency target, since they recently discovered that in Germany hundreds of passive houses had already been built, which consumed less than a factor four compared to the proposed new energy performance legislation in implementation of the European Performance of Buildings Directive (EPBD). In further meetings it became clear that the passive house standard was best documented (be it in German) with directly available performance criteria, available technologies for import and diffusion, and available tools for energy calculation (which were still missing for normal EPBD calculation). In this framework the decision fell to adopt the passive house standard as a first concept for promotion during the first years of the non-profit organization.
A second barrier was the funding of the non-profit organization. At the organizational level an energy efficiency network can be conceptualized as commercializing a non-profit organization. Many non-profits remain fearful of commercial operations undercutting their social mission (Dees 1998; Fowler 2000), and this was also apparent in the discussion with possible stakeholders. Many enterprises were reluctant to join formally with possibly large member contributions without a clear view how the organization would be able to support itself. It was formalized that a viable business would be the best option to generate a dependable income to pay for network actions: the benefits energy efficiency networks create are public, but they are nonetheless incurring private costs.
Also, since mostly small and micro-enterprises were interested to develop such a competitive niche market, the organization could not rely on substantial member contributions. Funding opportunities were searched and a resource channel of the Institute for the Promotion of Science through Technology (IWT, Flemish Community) was considered as a viable option. To obtain resources the companies had to engage in stimulating thematic innovation and a substantial number of SMEs (more than 10 according to the grant programme) had to co-contribute. Since this would allow 80% funding for more than 2 full-time employees during four years, the SMEs decided to cover the remaining 20% with membership fees. Further, a distinction was made in membership fees according to the size of the company (small, medium or large enterprise, and later also micro-enterprises as a separate category), to allow the micro- and small enterprises, showing wild ideas and clear motivation for innovation, to participate.
After one year of preparatory work, this action led to the foundation of PHP in October 2002 with 18 members, just before the official IWT funding application was submitted. The

number of founding members, the inclusion of a large enterprise as opinion leader, and the transparency and multi-disciplinarity of the organization, created a highly visible signal towards the construction industry with diverse media attention. PHP was erected to be the first multidisciplinary organization in the construction industry involving members such as architect's offices, engineering offices, distributors, materials producers, system providers, installers, contractors, and so on. It was decided that the management can change as rapid as the expected evolution: every two years a number of members of the management board would be chosen amongst the members. A first management board was selected to represent and guard the holistic approach, including a contractor, a climate system provider, an installer, an architect, an engineering office and an individual representing possible owners.

First steps

Concerning the motivation of the innovators to join the network, the interviewees mentioned to be vision driven expecting to get a jump on the competition, not by lower product cost, but by faster time to market, more customer service, or some other business advantage. As a result of the emergence trajectory, they were prepared to champion the passive house concept against resistance and to bear bugs and setbacks that accompany innovation. The innovator group included mostly micro- or small enterprises, e.g. the passive house design offices, engineering offices, contractors, installers and suppliers involved in the first demonstration projects.

In contrast to the single-issue focus of other existing organization in the Flemish Region - for example ODE-Vlaanderen and VIBE - PHP started from a holistic perspective on what has to be done. Instead of fear, guilt and shock as motives for action, hope, optimism and pro-activity were stimulated by developing an attractive vision for future innovation, focusing on the many examples of SME innovation developments in for example Germany and Austria. Thus, like in Austria (Ornetzeder and Rohracher 2009), passive houses in the Flemish Region have been very much developed in a bottom-up fashion without central steering but requiring a high degree of coordination and intermediation processes, with similar initiatives for the development of technical guidance, dissemination of information, development of certificates and quality assurance, and so on.

Table 1 illustrates that the general elements of the social marketing activities of the employees of the network during the first years included innovation specific information provision, the approach to include more enterprises (especially SMEs), the reinforcing of innovation as well as building up a regional and communal identity towards possible clients.

Compared to Austria (Ornetzeder and Rohracher 2009), a stronger focus was put from the beginning on providing innovation directly to SMEs. In the first two years the collective action was stressed, promoting the integrated holistic approach of the passive house concept. It was made clear to the individual companies that they could benefit by using the passive house concept as a 'coat-hanger' for their own products, systems and services.

Considering both the entrepreneur and the consumer perspective, in the first years 'engage' and 'exemplify' were clearly the main focus since the market had to be introduced. For most companies, 'exemplify' meant that the passive house technologies and solutions had to be demonstrated. This was tackled by the employees of the network by organizing a small conference and technology fair soon after the erection of the platform. This enabled companies to network and brainstorm about possible demonstration projects. Two holistic demonstration projects were kick-started by individuals from the leading engineering office, who decided to build their own house in the passive house standard. As consulting engineers they could rely on their opinion leadership in order to convince architects and contractors to participate in their project. Once the demonstration projects were available, construction site

and building visits convinced other actors. In the mean time, bus tours were organized by the network to visit key demonstration projects and companies in nearby Germany.

Target group	*SME network actions*	*Number of actions 2003-2004*	*Number of actions 2005-2006*
Companies and clients	Company and demonstration project visits	70	67
	Technical publications	7	37
	Lectures/ seminars	22	45
	Newsletters	8	12
	Promotional publications	5	43
	Web site actions	1	6
Mainly companies	Networking actions for companies	18	16
	Actions for membership	1	4
	Larger innovation networking initiatives	4	7
	Technology watch (innovation support)	2	8
	Innovation studies	4	7
	Stimulating international cooperation + partner search	5 + 2	10 + 2
	Grant application support	2	9
	Guidance of innovation projects	4	4
Mainly clients	Answering technology questions	300	450
	Guided question transfer	100	60

Table 1: *Activities of the SME network PHP according to year of activity. Based on: (IWT, 2007).*

Media attention of the 'first houses without heating' spurred enthusiasm and requests for providing more information to interested companies and clients. Innovator-clients appeared to be highly receptive to the proposed solution due to their environmental concern. The clients who adopted first were usually from the upper middle class and could reserve an extra budget for realizing the concept. In comparison, later clients wanted to be well informed and followed workshops and visited demonstration projects in order to form an opinion. They usually also rationalized the passive house concept compared to the perspective of another low energy option. However, their final decision appeared also to be highly influenced by other parameters like the experienced comfort during visits of the demonstration project.
After the first four years, the declining media attention for passive houses (gap from innovation to growth market), led to new business development. Figure 4 exemplifies the business model development of PHP, summarizing Figures 2 and 3. Amongst other, a stronger focus was set on quality assurance of passive houses.

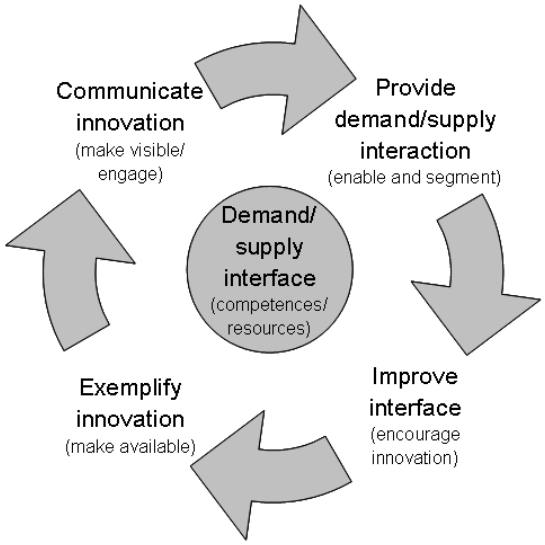


Figure 4: *Business model development of a change agency/ SME network in order to encourage innovation through demand/supply interaction.*

CONCLUSION

The model developed for innovation diffusion studies of SME networks focused on highly energy-efficient housing, and the application of the model on a case study, provide interesting new insights. Member-companies can be engaged by exemplifying opportunities and by positive communication focusing on their shared common meanings, beliefs and mutual understanding. A holistic approach promoting an integrated concept and involving actors from different disciplines on a regional level has the advantage that the SME network can also excel in, for building projects necessary, heterophilous and neutral communication. Innovative passive house technologies and services appear to be suitable as a focus for the emergence of an SME network focusing on highly energy-efficient housing. The role of such an SME network as a 'change agent' and formal gate-keeper between innovation-push and demand-pull, can be envisaged.

For emerging networks it is important to define 'interventions' as coherent objective in the innovation phase to bring about behavior change in order to produce identifiable outcomes and transitions. An SME network for the diffusion of highly energy-efficient housing can emerge on several activities. It can stimulate persuasion and a favorable attitude towards innovation by providing detailed information to both clients and innovating companies. It can help the individual with engaging in activities that lead to a choice to adopt the innovation, for example by providing or directing to further personal training. It can help the individual (or other decision making unit) with the implementation, for example, directing to established or certified professionals. Finally, it can help in providing confirmation when the individual (or other decision making unit) seeks reinforcement of the decision already made. The case study shows that guiding the client or the innovating company through the whole decision-taking process with suitable responses in each step of the decision process can contribute to success.

The study exemplifies that the role of motivated agents from an SME network is imperative for steering innovation-decision processes towards the implementation of passive houses, both for enterprises and for clients. This role could have never been achieved without support by innovation policy that facilitated the set-up of a specific thematic network for innovation diffusion.

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ADVANCEMENT OF SUSTAINABLE DEVELOPMENT, CONTRACTING, DESIGN, AND SUPPLY BUSINESSES VIS-A-VIS CONSTRUCTION MARKETS

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Abstract
The background involves the multiplication of Porter's (1980) five forces framework and the prior design of the 8-arena framework for capturing complexity of managing businesses within each of hundreds of (inter)national construction markets. In turn, the aim of this theoretical paper is to advance environmental sustainability as part of managing the four primary businesses. The sustainability of construction-related business management is enabled by implanting drivers into each of the eight competitive arenas. In life-cycle contracting and development businesses, the novel drivers include the coupling of object development ideas with sustainability advantages. In design-build contracting businesses, such drivers include the re-engineering of value chains with all tiers of designers, subcontractors, and suppliers. In design businesses, such drivers include the transformations of design firms into long viewers, path dependency breakers, stock-specific programmers, object-specific planners, impact blockers, and impact cause tracers. In supply businesses, such drivers include the adoptions of cradle-to-cradle certifications, product formula renewals, and full responsibility takings over the life-cycles of supplied units. In the future, practitioners and researchers alike could adopt this high-sustainability 8-arena framework.

Keywords: building products, business management, construction, design, sustainability

INTRODUCTION

Built environments and their sustainable advancement are herein approached from **a business management viewpoint** as follows. One of the generic definitions on sustainability is adopted and quoted, followed by a brief review of the recent perceptions and concepts for managing businesses in sustainable ways in various contexts outside and inside built environments. This review justifies the aim-setting for the paper as a whole and its focus on the advancement of sustainable development, contracting, design, and supply businesses.

In general, **sustainable** is defined to be capable of, relating to, or designating forms of human economic activity and culture that do not lead to environmental degradation, especially avoiding the long-term depletion of natural resources (OED 2011). On the one hand, an indicative, cross-industrial survey resulted in the finding that only 54% of the 335 managers assessed that their firms are extremely or very concerned about sustainable performance as part of supply chain management. Overall, these firms still focus mainly on **cost and financial concerns**. Moreover, the respondents are not yet convinced by academics, consultants, and others who argue that sustainability improvements may in fact help the bottom line, instead of cutting profits (Prokesh 2010).

On the other hand, the top management in many leading firms are perceiving that environmentally friendly businesses truly determine how successful they will be in the long run and, thus, **long-term goals** are being set along the dimensions of sustainability (Orange 2010). For example, Unilever has declared that they will run their supply chains fully sustainably by the year 2020. In practice, such advancements will require technical,

management, process, and cultural innovations as well as the engagement of all units and people within globally scattered organizations (Senge in Prokesh 2010). Typically, Nidumolu et al. (2009) advocate that pioneering business managers adopt **a generic, 5-stage process** for becoming sustainable, i.e. (i) viewing compliance as opportunity, (ii) making value chains sustainable, (iii) designing sustainable products and services, (iv) developing new business models, and (v) creating next-practice platforms.

Herein, **the focal contexts** involve the four coinciding spheres of (inter)national built environments, capital investment markets, real estate markets, and construction markets. These spheres deal with the design, implementation, services, and life-cycle aspects of both existing object stocks and new, object-specific investments in various sectors, i.e. natural resources utilization, energy supply, telecommunications, transportation, other infrastructure, manufacturing, and general building. Later, only the term **"construction markets"** is used to encompass all these spheres.

Some years ago, Fergusson and Langford (2006) postulated that as **environmental strategies** are developed, competencies in managing environmental issues will grow and lead to improved business performance. Based on the thin evidence in the UK context, they initially verified **the three propositions**, i.e. (a) UK firms are considering environmental issues within their strategic management at least informally in compliance with legislation and contractual obligations, (b) improved environmental performance is increasingly, with a varying rate, included within strategic management plans, and (c) at least more proactive firms are managing environmental responsibility at a strategic level to gain competitive advantages. Recently, Jones et al.'s (2010) survey resulted in the similar, low-sustainability findings in the US engineering and construction industry. It is herein assessed that such low-sustainability states in managing firms and their businesses are prevailing today across the construction globe.

Thus, **the aim of this theoretical paper** is to advance environmental sustainability inside firms and as part of managing their development businesses, contracting businesses, design businesses, and supply businesses in construction markets, respectively. **The three sub-aims** are as follows: (i) to re-introduce the 8-arena framework that Huovinen and Kiiras (2005a-c, 2006, 2007, 2009) have designed for capturing complexity of managing a business across the eight competitive arenas that are embedded inside each of targeted (inter)national construction contexts, (ii) to implant the high-sustainability drivers into the six of these competitive arenas and as part of the managing of each of the four primary businesses, and (iii) to conclude with some remarks on the future advancement of high-sustainability business management, including the validation of the 8-arena framework and the implanted high-sustainability drivers.

The management of the four primary businesses in highly sustainable ways is herein defined to encompass the utilization and development of natural resources in ways which are compatible with the maintenance of these resources, and with the conservation of the natural and built environments, for current and future generations (applying OED 2010). Sustainability calls for incorporating environmental and green concerns into business-level management, but sustainability is causally related to bottom lines and social issues, too. Similarly, project-level management is - along managing contract, quality, schedule, budget issues - considering how every project (or capital investment object) will impact communities, environments, and businesses (applying Fister Gale 2009).

PRIOR MULTIPLICATION OF PORTER'S FIVE FORCES FRAMEWORK VIS-A-VIS CAPTURING COMPLEX COMPETITION IN CONSTRUCTION MARKETS

Within the strategic management literature, **Porter's (1980/1998) five forces framework** offers a generic frame of reference for any firm who aims at attaining its business goals in its industry. This framework applies to high-tech, low-tech, and service industries, including global and local construction industries or markets. There are five basic forces that are attached to one focal competitive arena, at a time.

In turn, Huovinen and Kiiras (2005a-c, 2006, 2007, 2009) have redefined and multiplied Porter's five forces in order **to understand and explain competition** between various stakeholders within several causally interrelated, upstream and downstream arenas and across them in any construction market. In this paper, this multiplication of Porter's five forces into the 8-arena framework is re-introduced as follows.

It is argued that each construction market consists of **the eight competitive arenas with incumbents** who are interacting as procurers and sellers as follows: (1) rivalry among focal sellers in their base arena, (2) the bargaining power of clients in the next downstream arena, (3) the bargaining power of subcontractors, sub-designers, and suppliers in chained upstream arenas, (4) the threats of substitute offerings, and (5) the threats of entrants (Figure 1).

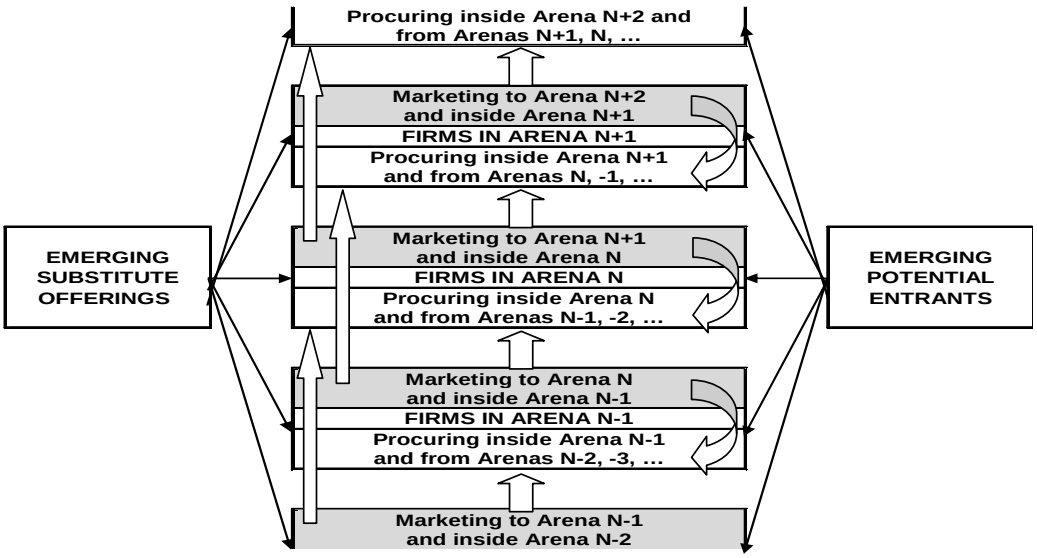


Figure 1: *Incumbents as procurers and sellers across targeted arenas in a focal construction market (Huovinen and Kiiras 2005a; applying Porter 1980/1998).*

It is axiomatic that each procurement route, which each procurer (client) chooses, determines the rules of competition and the nature of marketing in a coupled upstream arena. In turn, a set of marketing routes couple the related duos or trios of downstream arenas into value adding chains even project by project. Each incumbent occupies **the two principal roles** of a procurer and a seller in its base arena. As a seller it interacts via marketing routes with targeted clients in downstream arena(s). As a procurer it acquires inputs via procurement routes from upstream arena(s) and from inside the same arena(s).

The most downstream arena, i.e. **Arena 1 of Uses** involves stakeholders who use **capital object stocks**, including building stocks and infrastructure stocks, as part of built environments. Users occupy and operate individual capital objects, e.g. buildings and pieces of infrastructure over their life cycles. In turn, these various spaces, utilities, and structures enable users to fulfill their purposes and compete for the best effectiveness of their primary operations in a country, an economy, or a society. Many stakeholders are assuming a dual role, i.e. such users act also as the owners (in Arena 2) of the objects that they occupy or exploit.

Arena 2 of Ownership includes stakeholders who own capital objects and stocks. The two primary owner groups are as follows. Owner users compete in terms of (a) enabling the most effective use of and operations related to their objects and (b) earning the best value for their invested capital under long-term ownerships. Professional owners compete for achieving the same goals through speculative or long-term ownerships and renting stocks to desired users as tenants (in Arena 1).

Arena 3 of Life-Cycle Services includes firms who compete for providing various services to owners (in Arena 2) and users (in Arena 1) over (the contract periods of) the life cycles of capital object stocks. The two primary service groups include real estate management services as well as operation and maintenance (O&M) services.

Arena 4 of Capital Investing includes stakeholders who invest in, initiate, and manage their new, modernization, and renovation investments in various sectors. In the short or middle term, these capital investors compete for the highest possible returns through selling their objects to versatile owners (in Arena 2). The four primary investor groups are developers, owner investors, venture capitalists, and financiers. Investors' procurement strategies and routes determine the existence of two other arenas, by each object. On the one hand, many investors are realizing their capital investments by handing out single ("turnkey") contracts to the most competent contractors around (in Arena 5). On the other hand, several investors can themselves manage capital object-specific processes and, thus, hand out multiple subcontracts to firms (in Arena 6) for carrying out all designs, procurements, construction works, and installation works.

Arena 5 of Wholes includes principal contractors and CM consultants who compete for taking full responsibilities via single contracts for the design and implementation of investors' (in Arena 4) object-specific investment plans. Primary competitor groups consist of system, general, turnkey, and design-to-build contractors as well as construction management (CM) firms. Typically, these contractors of wholes (a) arrange competitive biddings and hand out a set of engineering and design contracts to the best designers and a related set of subcontracts for trade-specific works to the best subcontractors, or (b) package first design, procurement, and works into sub-systems, arrange systemic biddings, and hand out contracts to the most advanced sub-system contractors (in Arena 6).

Arena 6 of Parts includes designers and subcontractors who compete for the realization of the parts of investment objects via multiple contracting. The two primary client groups include capital investors (in Arena 4) and contractors of wholes (in Arena 5). Competitor groups involve engineers and designers of various disciplines as well as sub-system, plant, machinery, equipment, main, HEVAC, specialty, and trade contractors.

Arena 7 of Prefabricated Products includes suppliers and traders who compete for delivering versatile prefabricated building products and components to principal contractors

and CM consultants of wholes (in Arena 5), contractors of parts (in Arena 6), and assemblers of components (inside the same Arena 7). By definition, suppliers and traders of these inputs do not take responsibility for works at sites. The three broad supplier groups are building product suppliers, component suppliers, and construction equipment suppliers.

The most upstream arena, i.e. **Arena 8 of Construction Materials** includes suppliers and traders who compete for delivering all kinds of materials such as copper, steel, wood, glass, stone, sand, and ceramics to product or component suppliers (in Arena 7) or directly to contractors at sites (in Arena 6; or even Arena 5).

New substitute offerings may emerge related to one or several primary arenas even in the short term. Annually, **potential entrants** decide to target new construction markets. In each market, entrants may try to enter only one arena or two or more arenas concurrently based on their arena strategies, respectively. In addition, there are **other (in)directly competing stakeholders** such as financiers and traders as well as **supporting stakeholders** such accountants, administrators, lawyers, promoters, trainers, and transporters.

In principle, all procurers have **important latitude** to rethink and influence the internal structure and boundaries of focal arenas and to position themselves relative to other actors. Even leading procurers can never stop learning about their markets and upstream arenas, rivals in base arenas, procurement routes, and building environments in order to improve their performance (applying Porter 1980/1998: xi-xii, xiv).

Indeed, each of these 8-arena sectors and markets are facing **sustainable or green standards battles** in global, international, continental, and national contexts. Such battles are over what constitutes sustainable or green construction and built environments in the first place. It is herein posited that major developers, contractors, designers, and suppliers should become actively involved in debates and shaping rules and standards. Otherwise, managers and their businesses will be assessed sooner or later against sustainability standards that they cannot meet such as the certification of Leadership in Energy and Environmental Design (LEED) also outside the USA (aligning with Unruh and Ettenson 2010).

Within the demand side (in Arenas 1-2), pioneering owners and users will set the required levels of sustainable, societal developments and built environments. In the EU-wide context, one of the exemplary initiatives is the Energy-efficient Buildings (EeB) PPP with a roadmap towards the realization of the challenging vision, i.e. by the year 2050, most buildings and districts could become energy neutral and have a zero CO2 emission. A significant number of buildings would then be energy positive, thus becoming real power plants, integrating renewable energy sources, clean distributed generation technologies, and smart grids at district levels. The rate of change of the built environments will be realized through the six planned intervention or natural mutation moments, i.e. (i) the renovation of energy infrastructures, (ii) new building additions, (iii) refurbishment, (iv) large maintenance, (v) HVAC system replacements, and (6) demolition (EC 2010).

In the next three sections of this theoretical paper, this author is sharing his foresights on the sustainable developments **in the supply side (in Arenas 3-8),** i.e. leading and pioneering firms will implant high-sustainability drivers into and across focal competitive arenas as part of managing their four businesses, respectively, within targeted (inter)national construction markets and contexts (Fig. 2).

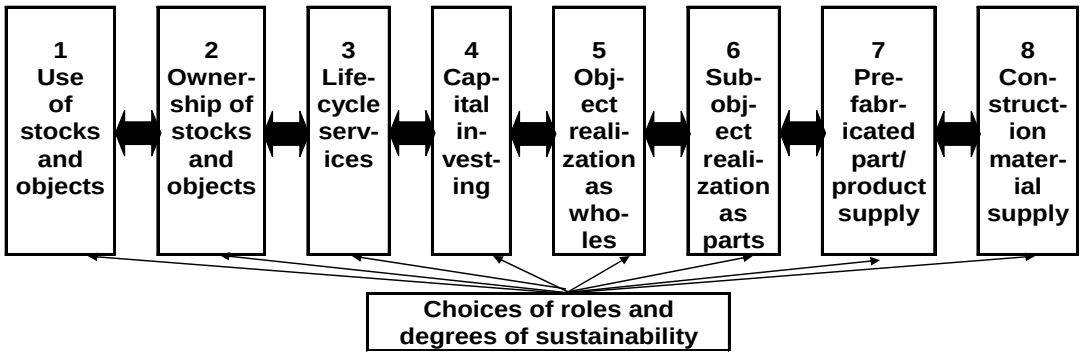


Figure 2: *Choices of stakeholders occupying Arenas 1-8 within each construction market.*

IMPLANTING ENVIRONMENTAL SUSTAINABILITY INTO ARENAS 4-6 AND 3 AS PART OF MANAGING DEVELOPMENT AND CONTRACTING BUSINESSES

Construction contractors are choosing their businesses, respectively, from among many alternatives such as life-cycle, PPP, and other financing-based contracting, object development as well as design-build, main, specialty, and trade contracting, complemented with life-cycle services, in building and infrastructure sectors within (inter)national contexts. New objects are being constructed and the existing ones are being renovated.

The future implanting of high-sustainability drivers into each of (inter)national construction markets will take place **when firms are managing their development businesses and contracting businesses** in targeted arenas as follows (in part applying Fister Gale 2008, 2009) (Fig. 3):

- In life-cycle, PPP, and other financing-based contracting businesses (Arena 4b), firms are orchestrating the planning and realization of object-specific sustainability programs through all internal organizational layers and the 2-5 tiers of external contractors and suppliers. Life-cycle management involves a capital investment ideation, the early crafting of alternative object scopes with sustainability advantages, the sub-setting of high-sustainability goals, and the continuous measurement of impacts on sustainability against these goals as part of a total progress via delivery, use, and maintenance processes (and stages).
- In object, property, and infrastructure development businesses (Arena 4c), developers are launching similar organizational penetrations. In addition, developers are using filters for pre-screening each potential object-specific party in terms of trustworthiness, loyalty, performance, and necessary competencies. Developers are relying on value adding parties to innovate on their behalf. Object-related parties need to trust each other for any sustainable initiative to work.
- In CM contracting and CM consulting businesses (Arena 5a), CM firms are securing buy-ins from all contracted parties according to sustainability plans. CM firms make sure that each designer, sub-contractor, and supplier is actually doing what they say they are doing in conformance with high-sustainability. For this monitoring, CM teams tailor and use a reliable metrics. Open relationship networks are built in order to communicate on a real-time basis and to find viable solutions when something goes wrong.

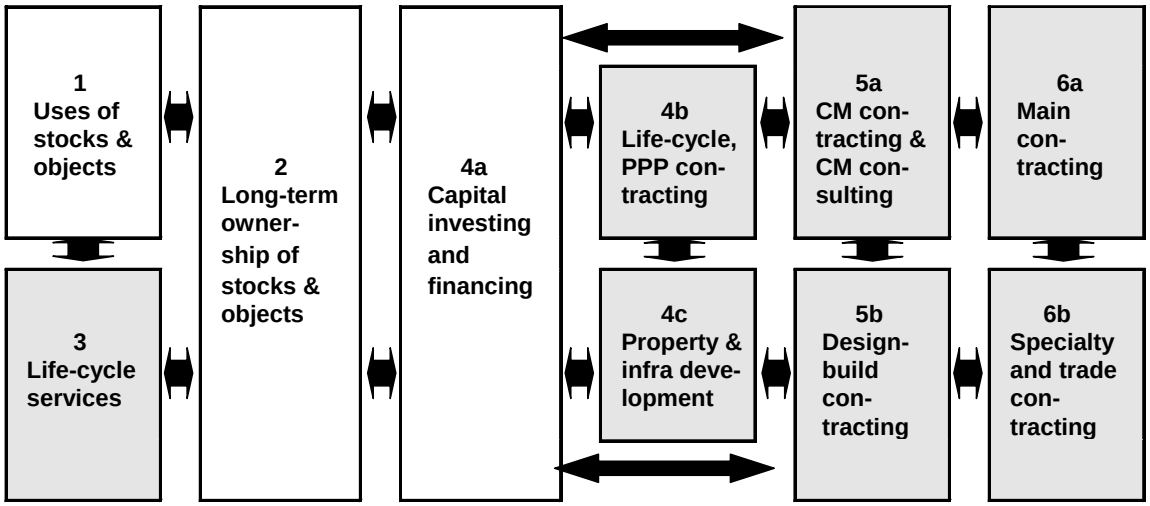


Figure 3: *Implanting of high-sustainability as part of managing of development businesses (in Arenas 4b-c), contracting businesses (in Arenas 5a-b and 6a-b), and life-cycle service businesses (in Arena 3).*

- In design-build contracting businesses (Arena 5b), DB contractors are collaborating with leading designers in order to offer high-quality, high-sustainability, and cost-effective object solutions. Sustainability is one of key drivers for the re-engineering of DB value delivery chains that encompass all tiers of designers, subcontractors, and suppliers. Self-assurance procedures are endorsed.
- In main contracting businesses (Arena 6a) and specialty & trade contracting businesses (Arena 6b), such contractors are planning their dual sustainability management systems that are compatible with their clients' systems (in Arenas 4-5) and their suppliers' systems (in Arenas 7-8). Specialty contractors are improving sustainability that is embedded in their sub-supply chains and the tiers of suppliers.
- In life-cycle services businesses (Arena 3), leading providers are having the in-depth understanding of the types and degrees of the negative and positive impacts of alternative existing and novel solutions on stock-specific and object-specific sustainability, where and when impacts actually occur during each stage. They cultivate intelligence upon how alternative changes made in the particular upstream and downstream stages of life-cycles decrease and even block negative impacts.

In the future, developers ensure their competitive edges by integrating **eco-investing principles** into capital objects and development processes. Likewise, contractors ensure their competitive edges by implanting **eco-contracting principles** into objects as wholes and parts as well as contracting processes (applying Orange 2010).

Typically, **Skanska AB** of Sweden is enhancing green offers for advanced clients. The foundational focus of Skanska Green Business is exclusively on the refurbishment of existing office buildings and it includes green solutions for more energy efficiency. Skanska can cut energy consumption in half in existing buildings. Energy-efficient designs include such features as low-speed, high-efficiency ventilation systems, efficient waste heat recovery systems, the use of district heating and cooling, super-insulated windows, the use of parking facilities as heat sinks in winter, energy-efficient elevators, and low-energy lighting with daylight and occupancy sensors (Fasth 2010).

IMPLANTING ENVIRONMENTAL SUSTAINABILITY INTO ARENAS 6, 5, AND 3 AS PART OF MANAGING DESIGN BUSINESSES

Design firms are choosing their businesses, respectively, from among many alternatives such as societal and urban planning, architectural, feasibility study, engineering, design, consultation, assessment, and inspection services, complemented with programming expertise and software selling, in building and infrastructure sectors within (inter)national contexts. New and under-renovation capital objects are being investigated, designed, and enabled.

The future implanting of high-sustainability into each of (inter)national construction markets will take place **when firms are managing their design businesses in targeted arenas via eight sustainability (S) drivers** as follows (in part applying Fister Gale 2008, 2009) (Fig. 4).

Foresights, visions, and other long views (S1) on sustainable developments up to the years 2030, 2040, and 2050 (and even beyond) are being prepared by specialized teams and experts inside design firms for public and private stakeholders (in Arenas 1-4). Reports contain cross-sectional and longitudinal views on the focal, more or less sustainable states of affairs. Long views are based on the modeling of alternative, causally interrelated developments in societies, built environments and natural environments, resources, and technologies. Thus, design firms deepen their systemic understanding on sustainability in part by collaborating with top universities and research institutes.

Scenarios and forecasts (S2) on more and less sustainable futures are being crafted by teams and experts inside design firms for public and private stakeholders (in Arenas 1-4). Development path dependencies are embedded within each of alternative scenarios on sustainability and paths with milestones leading towards such alternatives. Scenarios are over-viewing the best and worst futures that, in turn, are being guessed by involved stakeholders along the dimensions of sustainability. Forecasts are highlighting likely long- and short-term net changes in sustainability and they are justified by the most recent and historical evidence. In turn, a set of assumptions are underlying each scenario and forecast. Thus, design firms ensure their expertise in part by recruiting both seasoned experts with their deep, tacit knowledge and young talents with their minds open for novel approaches.

Life-cycle knowledge on individual capital objects and object stocks (S3) is being itemized and accumulated inside design firms and then offered as programs and tools for long-term owners, investors, and developers (in Arenas 1-5) in order to enable effective, stock-level sustainability management. Stock-specific programs include criteria for assessing the degrees of sustainability of alternative existing and new objects to be included in focal stocks. Programs include metrics for comparing the life-cycles and stages of each object inside focal stocks. All this is being synthesized into the rating of stock-specific sustainability indexes. Thus, design firms advance their expertise in part by continuous learning about portfolio management, technology platforms, and alike.

Life-cycle knowledge on individual objects (S4) is being systemized inside design firms and then offered as plans and tools for owners and other key stakeholders (in Arenas 2-5) in order to enable effective object-specific sustainability management. Object planning is coupled with tools for taking sustainability into account as part of feasibility analyses, goal-setting, investment management, design management, PM, process management, FM, and other maintenance management. Moreover, pre-structured plans include also the design and rating of pre-planned roles that parties assume from investment ideas to the end of life-cycles

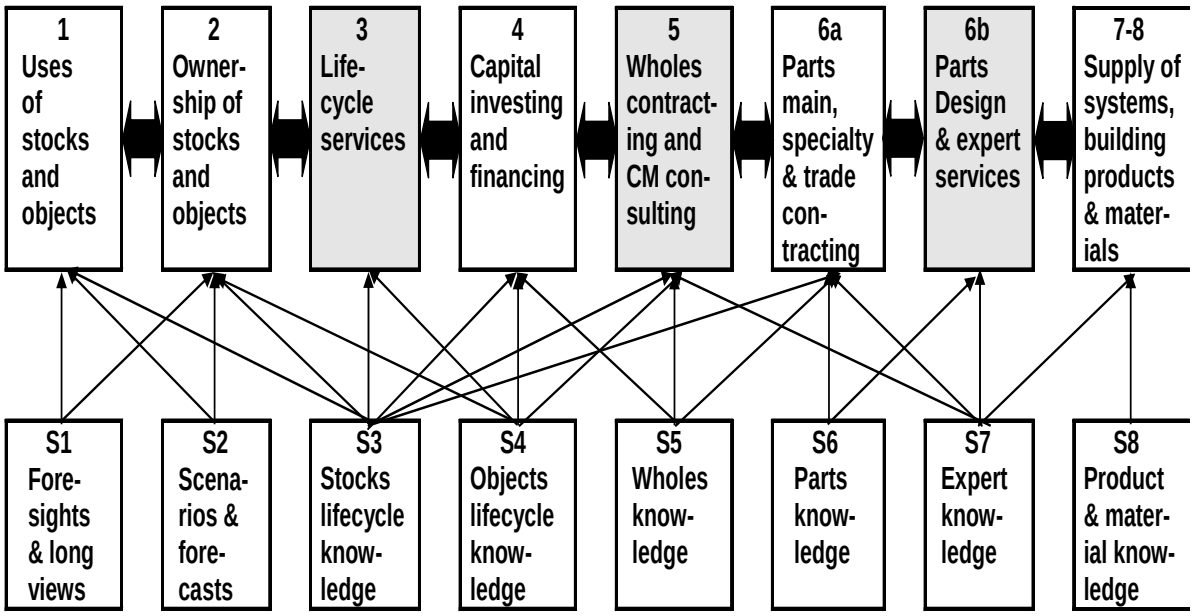


Figure 4: *Implanting of high-sustainability via the eight drivers (S1-S8) as part of managing of design businesses (in Arena 6b), CM consulting businesses (in Arena 5), and life-cycle service businesses (in Arena 3).*

(including reuses). Knowledge covers impacts on environment, biodiversity, fair trade, stakeholder health, and human rights. Thus, design firms also collaborate with and sub-contract external experts in order to master and offer complete knowledge.

Knowledge on wholes (S5) is being cultivated inside design firms and then offered (i) to investors and developers (in Arena 4) who are realizing their objects through single contracts (e.g. PPP, turnkey, design-build, and CM) as well as (ii) to related contractors and CM consultants (in Arena 5) in order to enable effective whole-specific sustainability management. Knowledge on a complex project as a whole and its impacts on communities and environments is a valuable part of avoiding negative impacts, mitigating risks, increasing revenues, and better managing costs. Thus, core design firms extend their expertise bases towards sustainability in CM consulting businesses and managing contracts of wholes.

Knowledge on parts (S6) is being deepened inside design firms and then offered (i) to investors and developers (in Arena 4) who are realizing their objects through multiple part-specific contracts (e.g. trade-based contracts) as well as (ii) to chained contractors and designers (in Arenas 5-6) in order to enable effective part-specific sustainability management. The depth of knowledge on part-specific sustainability is often decisive when parts at hand are being designed and specified. Thus, specialized design firms invest in their own expertise on sustainability. These specialists are also attractive partners in the eyes of other design firms and contractors.

Expert knowledge on sustainability measurement (S7) is being accumulated inside design firms and then offered to contractors, designers, and suppliers (in Arenas 5-8) for the auditing, testing, and verifying the degrees of sustainability as part of the assurance and proving of the conformance or the detection of non-conformance between sustainability

requirements and delivered products and materials. Thus, many design firms specialize towards measurement (and testing) and nourish such hands-on knowledge as part of their total knowledge reservoirs.

Knowledge on systems, structures, products, components, and materials (S8) is being accumulated inside design firms and then offered to suppliers and traders (in Arenas 7-8) and contractors (in Arenas 5-6) in order to enable effective part-specific sustainability management. Technical systems (e.g. elevators, HEVAC systems) consist of structures, products, components, and materials. Part-specific knowledge on sustainability is composed of the three aspects of the making of a particular part, its content, and its use or performance over a life-cycle. Thus, design firms extend and deepen their expertise in order to cover all targeted parts (e.g. components) or they specialize and focus on one or some of them. Specialization is also taking place along the dimension of materials, e.g. sand, concrete, wood, metals, fibers, plastics, glass, and their composites.

In the future, being green and sustainable will mean taking into consideration the entire life-cycles of objects in built environments when designing them. **Eco-intelligence** is a core competency underlying all high-sustainability drivers (S1-S8) in design businesses. When architects, urban planners, and engineers start to utilize the intelligence of natural systems, they can create societal systems, infrastructures, built environments, and single objects that are essentially waste-free and allow nature and societies to successfully coexist (applying Orange 2010).

Typically, **Pöyry Group** of Finland perceives that a sustainable world will not happen by itself. It must be created and new engineering solutions must be developed. This is where Pöyry can contribute and make a real difference by designing realistic and innovative solutions that consider all aspects of sustainability. Pöyry's in-depth expertise extends to the fields of energy, industry (e.g. pulp & paper), urban & mobility and water & environment. The concept of Balanced Sustainability is about improving resource efficiency. This concept involves finding solutions to improve energy, water, material, and supply chain efficiencies while improving overall returns on investments (Pöyry Group 2011).

IMPLANTING ENVIRONMENTAL SUSTAINABILITY INTO ARENAS 7-8, 6, AND 3 AS PART OF MANAGING SUPPLY BUSINESSES

Suppliers and traders are choosing their businesses, respectively, from among many alternatives such as the supply and trading of prefabricated building and infrastructure systems, building products and components as well as construction materials, complemented with life-cycle services, in building and infrastructure sectors within (inter)national contexts. Systems, products, and materials are being delivered for new and under-renovation objects.

The future implanting of high-sustainability drivers into each of (inter)national 8-arena markets in each of respective contexts will take place **when firms are managing their supply businesses in targeted arenas** as follows (in part applying Fister Gale 2008) (Fig. 5):

- In system supply businesses (Arena 7a), the keen understanding of sustainability is prevailing across suppliers' organizations and supply chains. Cradle-to-cradle (C2C) and similar certifications indicate truly that all human and environmental health

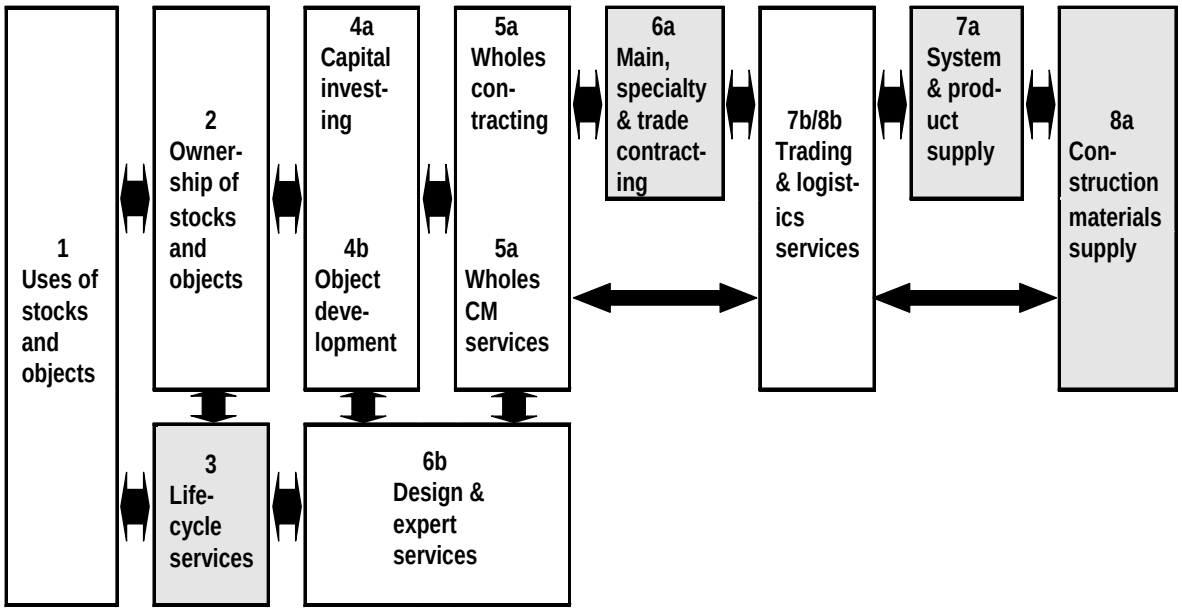


Figure 5: *Implanting of high-sustainability as part of managing of supply businesses (in Arenas 7a and 8a) complemented with contracting businesses (in Arena 6a), and life-cycle service businesses (in Arena 3).*

criteria are being constantly monitored to ensure that materials-based systems are not harmful and that elements can be recycled, remanufactured, or composted. Often this means getting all members in supply chains to agree on changes in their ways of making products and giving system managers access to their product formulas.

- In building product supply businesses (Arena 7a), C2C certifications are forming foundations that, in turn, have to be realized by choosing viable materials together with secondary and tertiary suppliers and by engaging such suppliers with product assemblers' own sustainability vetting processes. In addition, pioneering product suppliers are creating advantages in terms of using sustainable processes and raw materials, offering sustainable packaging, providing more energy-efficient and less polluting products, minimizing energy consumption, advertising environmental impacts, and engaging in product stewardship by taking back products after the ends of their lives.
- In construction material supply businesses (Arena 8a), C2C certifications are likewise prevailing. In particular, material suppliers are training their organizations to participate clients' sustainability programs, e.g. by analyzing, compiling, and handing over lists that cover each ingredient, chemical, etc. Non-disclosure agreements are being signed in the case of proprietary ingredients.
- In main, specialty, and trade contracting businesses (Arena 6a), suppliers are diversifying their core businesses into contracting businesses along their respective parts of supply. New kinds of part-centered (e.g. system-centered and product-centered) contractors become fully responsible for the conformance of their parts' contents and quality, their local assembly or erection operations at sites, and the performance and use of their parts over life-cycles, respectively. Pioneering suppliers are overcoming hurdles for such entries by competency acquisitions, training, piloting, etc.

- In life-cycle service businesses (Arena 3), suppliers complement their core businesses with in-depth services that are based on the understanding of life-cycles of focal parts consisting of systems, products, components, and materials, respectively. Such suppliers are selling their knowledge on sustainability and providing their services for extending the life-cycles of their own or similar offerings in highly sustainable ways. For some parts and sub-parts (and their suppliers), the highest sustainability-increasing or -decreasing impacts occur in the extraction of raw materials. For others, major impacts occur during use and disposal.

In the future, it seems that suppliers and their value and sustainability adding supply chains will involve materials that are perpetually circulated and, once used, can be disposed of in any natural environment and decompose into the soil. Instead of ending up in a landfill, systems, products, components, and materials can be circulated in endless cycles. For suppliers and traders, thinking in terms of cradle-to-cradle design, versus cradle-to-grave design, can be revolutionary. Typically, pioneering **wholesalers and retailers** as gatekeepers will launch market-wide ratings and labeling systems that survey suppliers about their ecological footprints and score building products and construction materials based on how environmentally and socially sustainable they are (applying Orange 2010).

In turn, **internationally leading suppliers** will adopt the toughest external and internal common norms because this actually allows them both to gain leaderships and to save money. Internally, the enforcement of a single norm at a supplier's all manufacturing units allows to exploit economies of scale and to optimize supply chain operations (applying Nidumolu et al. 2009).

Typically, **KONE Elevators** of Finland is seriously responding to a fact that elevators and escalators can account for 2-10% of a building's energy consumption. KONE wants to be the innovation leader in eco-efficient solutions for its industry. Great potential is seen in further reducing the impacts of buildings on natural environments by offering innovative and energy efficient solutions. In the year 2009, KONE released a range of elevators which reduced energy consumption by 30% compared to its previous volume models. KONE is annually re-setting more demanding targets in terms of improving the energy-efficiency and the eco-efficiency over the life-cycles of its products and minimizing its operational carbon footprint (KONE 2010).

CONCLUSIONS

It is herein suggested that **pioneering firms and other key stakeholders** adopt the theoretical, 8-arena framework in order to foresee, envision, set realistic aims, and also attain these aims vis-a-vis the realization of high environmental sustainability across (inter)national businesses, built environments, capital investment sectors, and construction markets at desired future points in time.

In turn, this author is planning to conduct **a series of empirical investigations in order to validate the 8-arena framework and the novel to-be-implanted high-sustainability drivers** concerning leading firms in each of the four primary businesses with targeted (inter)national contexts. Besides, other interested researchers and parties may use the 8-arena framework as **a diagnostic tool** for assessing the current and future degrees of environmental sustainability in focal contexts and preparing their recommendations to key private and public

stakeholders for the enhancement of respective businesses and competitive arenas in highly sustainable and effective ways in the future.

In practice, **the market-wide implanting** of one or several high-sustainability drivers into the eight competitive arenas needs to be planned so that each implanting event corresponds to a focal (inter)national context in terms of current higher and lower degrees in sustainability versus the targeted higher degrees, local environments, owners and investors with their life-cycle preferences, investment programs, and procurement strategies, firms with their sustainable, competitive rationales as well as other private and public stakeholders with their development agendas, legislations, and supporting roles.

So far, most difficulties in **actual sustainability advancements** can be traced down to the fundamental errors of focusing on parts - like energy saving technologies in the case of transiting from fossil-fuel economies to clean-tech economies - rather than on built environments, sectors, markets, and causally routed arenas as a whole. Besides sustainable technologies, many innovative business models, market adoption strategies, and government policies will be needed. A case in point, **the Masdar Initiative** was launched in Abu Dhabi in the year 2006 in order to develop a clean-tech sector and to realize **the world's first carbon-neutral city**. It is too early to say whether Masdar will be successful (Johnson and Suskewicz 2009). Indeed, it is herein perceived that the concept of City of Masdar corresponds well to the adoption of the 8-arena framework for any market-wide or sector-wide renewal and implanting process. Their 5-dimensional business model includes (i) sectoral and area development, (ii) high-sustainability investing in new technologies and solutions, (iii) the design and supply of new systems and products, (iv) carbon strategy development and realization, and (v) sustainability focused university-level research and education.

Finally, it seems that pioneering business management teams keep expanding their expertise by **cross-partnering** between developers, contractors, design firms, and suppliers not to talk about other stakeholders that have in-depth or extensive knowledge on sustainable built environments. Aligning with Senge (Prokesh 2010), it would perhaps be more effective to focus on managing in hands-on, environmentally non-harmful ways - and at the same time to use the word "sustainability" as little as possible because it is too generic.

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MANAGING OF CONSTRUCTION-RELATED BUSINESSES IN ENVIRONMENTALLY SUSTAINABLE WAYS - A FOCUSED REVIEW OF 62 CONCEPTS

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Abstract
The on-going literature review has revealed a platform of the 62 construction-related business management (BM) concepts, published mainly via the journals between the years 1990-2009. The aim of this paper is to enhance the managing of construction-related businesses in highly environmentally sustainable ways. A focused review resulted in the expected findings, i.e. environmental sustainability is so far being taken into account only by the 8 (13%) BM concepts within the 62-concept population. Academic and practicing concept designers can incorporate sustainability into BM concepts as a dimension, an element, an attribute of managing, and/or a criterion in business decision making. In turn, sustainability is herein enhanced by designing a 5-element, high-sustainability BM concept. The five pioneering firms are used to highlight sustainable elements such as offerings with no negative impacts, business processes with minimal carbon footprints, core competitiveness nurturing based on sustainability foresights, business framing with high-sustainability rules, and dealings with sustainable collaborators. CIB related researchers can both individually and jointly incorporate sustainability in their existing and new BM concepts. It is envisioned that this reviewer be able to report on higher sustainability in managing by the year 2015.

Keywords: business management, construction, design, literature review, sustainability

INTRODUCTION

The background involves **the on-going literature review** that has revealed the 62 construction-related business management (BM) concepts, published mainly via the journals between the years 1990-2009 (e.g. Huovinen 2010). The reviewer argues that **BM is the most challenging, evolving, and critical area (or level) within strategic management** both in general and across various private and public contexts (Huovinen 2003). Herein, **built environments** are seen to be coupled with capital investment, real estate, and construction markets that deal with design, implementation, services, and life-cycle aspects of both existing object stocks and investments in new objects across the utilization of natural resources, energy supply, telecommunications, transportation, other infrastructure, manufacturing, and general building concerns. Later, the term **"construction markets"** is used to encompass all these built environments and concerns.

The main aim is to enhance the managing of construction-related businesses in highly environmentally sustainable ways in the future. The three sub-aims are as follows. (i) The unique review of a population of 62 construction-related BM concepts, published mainly via journals between the years 1990-2009, is briefly introduced. This reviewer explores especially **the degrees of environmental sustainability** that the authors have incorporated inside each of their respective BM concepts. Next, the key finding is being told for the sake of the setting of a meaningful, second sub-aim. Namely, this focused review reveals that only 1 (2%) BM concept deals with sustainability to a medium degree and 7 (11%) BM concepts take sustainability into account to a low degree.

In other words, it seems that the existing construction-related BM concepts are not advancing sustainability. Thus, (ii) **an exemplary, 5-element, high-sustainability BM concept** is being designed in this paper. Each element is illustrated with the pioneering action of a globally leading firm in its targeted construction markets. Finally, (iii) some future actions are put forth in order to enhance high-sustainability BM in the contexts of built environments.

62-CONCEPT PLATFORM AND EIGHT SCHOOLS OF THOUGHT ON BM

The review consists of **the three review rounds** that have been carried out in the years 2003, 2006, and 2010. The same limitations have been re-adopted to maintain the validity and to expose any major developments. Hart's (1998) literature review **guidelines** have been relied upon. The method for the reviewing of conceptual literature, i.e. the replicable ways of searching, browsing, in-/excluding, retrieving, inferring, moderate coding, describing, and analyzing the construction-related conceptual data is introduced in Huovinen (2003, 2006).

The volumes of **the 20 construction-related journals** (1990-2009) and those of **the 42 management journals** (1990-2008) have been browsed comprehensively. This is so because peer reviewers apply the most rigorous criteria when they are pre-reviewing manuscripts for publishing in scientific journals. Otherwise, the degrees of the comprehensiveness of the search has varied markedly via the other formal channels, i.e. (i) generic and construction-related management books and reports, (ii) chapters in edited, generic and construction-related management books, (iii) generic and construction-related management journals, (iv) generic and construction-related management conference proceedings, and (v) generic and construction-related management databases. This author will submit the itemized lists of all the publication channels on request.

In this short paper, the 62-concept population can only be overviewed in terms of the following three questions. **Question 1. What is the relatedness of the 62 concepts to one or several of eight schools of thought on BM?** Generic BM research involves the eight schools of thought: (1) Porterian school, (2) resource-based school, (3) competence-based school, (4) knowledge-based school, (5) organization-based school, (6) process-based school, (7) dynamism-based school, and (8) evolutionary school (Huovinen 2008). During the three review rounds, each of the BM concepts could be assigned to one of the eight schools based on the authors' rationales and replies to the question "What is the primary way (element) of managing that will enable managers to set challenging business goals and also to attain them?", within their root references. The combined share of 15 Porterian concepts, 14 organization-based concepts, 10 knowledge-based concepts, and 10 dynamism-based concepts is 79%. Overall, none of the schools (and their key generic concepts) has triggered a coherent, published flow of construction-related BM concepts or applications. The temporal pattern is emerging and fragmented. Only the 10 (16%) new concepts have been published via the journals between the years 2006-2009 (Table 1). **Question 2. What is the relatedness of the 62 construction-related BM concepts to one or several applied scientific fields?** 32 (52%) concepts are primarily related to construction management, 11 (18%) concepts are related to project management, 11 (18%) concepts are related to corporate real estate services, and 8 (13%) concepts are related to industrial management and international marketing. Overall, no established research traditions or groups exist in the area of construction-related BM. Only 7 (11%) concepts have been designed by the authors who are affiliated with the business schools. Clearly, construction is outside the interests of generic management researchers vis-à-vis alternative contexts and application areas.

Table 1: *Relatedness of the 62 construction-related BM concepts (published between the years 1990-2009) to the eight schools of thought (Huovinen 2010).*

School of thought on BM	Concepts published btw 1990-2002 (1st review)		Concepts published btw 2003-2005 (2nd review)		Concepts published btw 2006-2009 (3rd review)		All concepts	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1 Porterian school	11	(29%)	0	(0%)	4	(40%)	15	(24%)
2 Resource-based school	1	(3%)	0	(0%)	0	(0%)	1	(2%)
3 Competence-based school	3	(8%)	0	(0%)	2	(20%)	5	(8%)
4 Knowledge-based school	7	(18%)	3	(21%)	0	(0%)	10	(16%)
5 Organization-based school	9	(24%)	4	(29%)	1	(10%)	14	(23%)
6 Process-based school	0	(0%)	4	(29%)	3	(30%)	7	(11%)
7 Dynamism-based school	7	(18%)	3	(21%)	0	(0%)	10	(16%)
8 Evolutionary school	0	(0%)	0	(0%)	0	(0%)	0	(0%)
Sum	38	(100%)	14	(100%)	10	(100%)	62	(100%)

Question 3. For what primary contexts, i.e. industries, businesses, or sectors have the authors designed their 62 concepts, respectively? 21 (34%) concepts address construction or building, 21 (34%) project-based business, contracting, complex product systems, or combined engineering, purchasing, and construction (EPC) projects, 10 (16%) real estate development and services, and 5 (8%) capital investments-based businesses, 4 (6%) design and consulting services, and 1 (2%) building products supply.

ASSESSED DEGREES OF SUSTAINABILITY INSIDE THE 62 BM CONCEPTS

In general, OED (2011) defines **sustainable** "to be capable of, relating to, or designating forms of human economic activity and culture that do not lead to environmental degradation, especially avoiding the long-term depletion of natural resources". Herein, **sustainability in construction-related BM** is defined to encompass the utilization and development of natural resources in ways which are compatible with the maintenance of these resources, and with the conservation of the natural and built environments, for current and future generations (applying OED 2011). Sustainability calls for incorporating environmental and green concerns into business level management, but sustainability is causally also related to bottom lines and social issues. Similarly, project level management is - along managing contract, quality, schedule, and budget issues - considering how every project (or capital investment object) will impact communities, environments, and businesses (applying Fister Gale 2009).

In this paper, sustainability is approached according to the above mentioned definitions. For the focused review, **the four degrees of environmental sustainability** were pre-defined as follows. A particular BM concept may take environmental sustainability into account to:

- a high degree, i.e. sustainability is one of the primary elements along one, several, or all dimensions of BM such as a business goal, a key attribute of offerings, competitive

advantages, and strategies as well as an edge of competitiveness and a key performance indicator of business processes, organizations, project portfolios, etc.

- a medium degree, i.e. sustainability is one of the supportive elements along one, several, or all dimensions of BM
- a low degree, i.e. sustainability is only an implicit part of a firm's offerings and underlying expertise in built environments and/or it is taken into account only as one requirement or tendency in clients' buying behavior, one criterion in stakeholders' decision making, one factor in environmental analyses, etc.
- no degree, i.e. the authorship is silent vis-a-vis environmental sustainability, no single 'thing' is explicitly written along this dimension in the reference.

Overall, this sub-review revealed that only 1 (2%) BM concept deals with sustainability to a medium degree and 7 (11%) BM concepts take sustainability into account to a low degree. No high-sustainability BM concepts belong to the 62-concept population. **The concept-specific results** are compiled in Tables 2-8, by each of the 7 schools of thought on BM (there are no construction-related, evolutionary BM concepts). Within these tables, the identified, original terms are quoted. When such a quotation is coupled with a statement "no degree", this implies that the authors are using, respectively, the terms sustainable, sustainability, environment(al) only in the spheres of strategic, business, and project management or real estate development. Therein, sustainability refers to the continuity of a focal firm, unit, or other entity and environments refer to business environments and work environments. The references in the text refer only to the authorship and its BM concept presented in the respective, resultant tables. This reviewer will submit a complete list of the 58 references containing a population of the 62 construction-related BM concepts on request.

Only one dynamism-based, construction-related BM concept is taking sustainability into account, but to a medium degree as follows (Table 5). **Chinowsky with Meredith (2000)** have defined the seven areas of a firm’s strategic management within a feedback framework (wheel) including (1) vision, mission, and goals, (2) core competencies, (3) knowledge resources, (4) education, (5) finance, (6) markets, and (7) competition. Within a civil engineering organization, these strategic management activities are a process to ensure that a constant focus is retained on the core purpose of existence. The framework allows leaders to formulate strategic concepts. In particular, they emphasize that re-examining a firm’s strengths requires a move beyond the thoughts of current, short-term profit centers, to a focus on the objectives the organization can potentially achieve over a sustained period of time and effort. Leveraging human resources into core strengths along a competency spectrum provides an organization with confidence, knowledge, and abilities to pursue objectives with the greatest possibility to succeed. **A medium degree** of sustainability is incorporated as (i) a firm's environmentally sensitive core designs that are based on many support strengths and, in turn, (ii) core designs enable the design of project-specific solutions. (iii) Environmental engineering is one of the surface characteristics of core competencies. (iv) An environmental area is designed as one of a firm's knowledge areas. (v) Environmental testing is listed as a competency (Chinowsky with Meredith 2000: 130, 142, 146).

Among the 15 Porterian BM concepts, there are two low-degree concepts (Table 2). **Veshosky (1995)** has used Porter’s (1980/1998) generic competitive strategies as a basis for developing an analytical framework and applying this to the design segment of the A/E/C industry in the USA. The content and use of the cost leadership, the differentiation, and the focus on a niche have been elaborated. He has concluded that the formulation and implementation of explicit business strategies appear likely to be superior to strategies that

occur by default. **A low degree** of sustainability is indicated as environmental systems and facilities among a firm's project types as well as core competencies for managing hazardous waste (Veshosky 1994: 43-45). In turn, **Huovinen (2001)** has designed a competitive strategy framework for technology-intensive contractors. It is based on the idea of creating the best fit between the primary decision maker, i.e. the focal investor with its need and investment process and the most competent contractor with its solution and delivery process. The framework consists of four areas: (a) business scope and objectives, (b) marketing and sales, (c) investment solution, and (d) contract fulfilment. **A low degree** of sustainability is designed as one of clients' decision making criteria, i.e. environmental impacts are taken into account when choosing winning solutions or bids (Huovinen 2001: 73).

Among the 14 organization-based BM concepts, there are two low-degree concepts as well (Table 3). **Flanagan (1994)** envisioned that, by the year 2000, a successful construction company will have many desired features of a service provider, i.e. flat, lean, quick to respond to change, IT intensive, expert resources (lockers), shared design skills (by chambers), marketing intensive, more global in outlook, i.e. acting locally but thinking globally, alert to financing issues, involved in project creation, complex as well as technologically sensitive and driven. **A low degree** of sustainability is designed as follows: (i) Environmental consciousness and sustainability are among the 11 forces that drive strategies, (ii) in design, external impacts on surroundings, e.g. energy, traffic, waste, and ecology are becoming more important, and (iii) successful companies are concerned about the environment and the community (Flanagan 1994: 312, 316, 318). In turn, **Huovinen and Hawk (2003)** have designed a collaborative client-supplier relationship model for globally operating building product suppliers. **A low degree** of sustainability is implanted as a product's environmental impacts among the 11 decision making criteria that clients use for choosing winning bids (Huovinen and Hawk 2003: 158).

Among the 10 knowledge-based BM conceps, there is only one low-degree concept (Table 4). **Love et al. (2002)** have introduced a model for long-term learning alliances, total quality management (TQM), and integrated supply chains in construction. One of the sub-models consists of systems thinking, learning culture, knowledge and communication, changing mental models, joint learning structure/processes, and the development of learning relationships. A long-term learning alliance improves the ability of staff, i.e. to become more productive and less likely to make mistakes. One of the goals is to attain a successful project that can enhance the reputations of all parties. **A low degree** of sustainability is designed as taking into account the ethical consideration of the social and environmental responsibility in such cooperative alliances (Love et al. 2002: 12).

Among the 7 process-based BM concepts, there is only one low-degree concept (Table 6). **Anderson and Merna** (2005) have designed a framework for managing new business development processes in the case of firms offering project management services. **A low degree** of sustainability is implanted as environmental management among the 11 domains of development (Anderson and Merna 2005: 175). Among the 5 competence-based BM concepts, the assessment resulted in identifying no degrees of sustainability (Table 7). Instead, sustainability is being taken into account to a low degree within the only resource-based BM concept (Table 8). **Lowendahl (1997/2000)** has designed the three generic strategies, the four resource types, the four dimensions for resource-based differentiation, and the three phases in the evolution in the case of professional service firms. **A low degree** of sustainability is indicated as environmental protection among alternative targeted markets (Lowendahl 1997/2000: 106).

Table 2: *Assessed degrees of sustainability inside the 15 Porterian, construction-related BM frameworks, published between the years 1990-2009 (the 1st school).*

Author (year)	Applied concept and its focal context	Assessed degree of sustainability based on the key quotations (page number)
Betts, Ofori (1992)	Applying Porterian concepts in construction firms in the UK	No degree, "sustainable strategies" and "business environments" are mentioned.
Winch, Schneider (1993)	2x2 matrix: strong delivery, experience, ideas, ambition in UK architectural practices	No degree, "competitive environments" is mentioned.
Veshosky (1994)	Analytical, applied framework for the design segment of the A/E/C industry in the USA	**Low:** Environmental systems (43) and facilities (44) as project types, hazardous waste related to core competencies (45).
Jennings, Betts (1996)	New generic strategy model to UK quantity surveying practices with IT support	No degree, "external environments surrounding business arenas" and "sustain-able competitive advantages" are mentioned.
Roulac (1999)	Real estate value chain as part of development in the USA	No degree, "environment is essence of experience and creativity" is mentioned.
Roulac (2001)	8 strategies, 7 contributions to advantages in the US real estate	No degree, "work environments enhance productivity" is mentioned.
Pinto et al. (2000)	Project supplier's value chain	No degree
Huovinen (2001)	Competitive strategy in technology-intensive contracting	**Low:** Solutions' environmental impacts as one of clients' decision making criteria (73)
Langford, Male (2001)	Adapted 5 forces shape the UK industry structure	No degree, "relationships between firms and environments" is mentioned.
Rapp (2001)	Adapted 5 forces (incl. speedy response) and a client value chain in the US construction	No degree, "environmental opport-unities and threats as part of a SWOT or 5 forces analysis" is mentioned.
Kale, Arditi (2002)	Mode (cost, quality, time, inno-vation) and scope (geography, delivery systems, clients) in the US construction industry	No degree, "environmental determinism vis-a-vis explaining firm performance " is mentioned.
Milosevic, Srivannaboon (2006)	Framework for aligning PM and a firm's business strategy in US engineering, industrial firms	No degree
Singer et al. (2007)	Model for combining real estate and competitive strategies in Dutch multinational companies	No degree, "work environments that stimulate productivity" is mentioned.
Chiang et al. (2008)	Volume building strategy of contractors in Hong Kong	No degree, "sustainable sources of competitive advantages" is mentioned.
Heywood, Kenley (2008)	Sustainable competitive advantage model for corporate real estate in Australia	No degree, "sustainable competitive advantages and competitiveness" and "environmental changes" are mentioned.

Table 3. *Assessed degrees of sustainability inside the 14 organization-based, construction-related BM concepts, published between the years 1990-2009 (the 5th school).*

Author (year)	Applied concept and its focal context	Assessed degree of sustainability based on the key quotations (page number)
Leinberger (1993)	Managerial systems change strategy in the US real estate	No degree
Flanagan (1994)	Successful construction company in the year 2000 (based in the UK)	**Low:** Environmental consciousness and sustainability are among 11 forces that drive strategies (312). In design, external impacts on surroundings, e.g. energy, traffic, waste, ecology) are becoming more important (316). Successful companies are concerned about the environment and the community (318).
Artto (1999)	Organizational model for PM in a project-oriented company	No degree, "multi-project environments" is mentioned.
Bennett (2000)	7 partnering pillars balance competition and cooperation in the UK construction industry	No degree, "companies that survive long-term" and "networks interact with their environments" are mentioned.
Davies, Brady (2000)	Dynamic framework for capability building and interactions btw. levels within a firm offering complex product systems	No degree, "firm capabilities, adapting to, and a changing environment" is mentioned.
Hobday (2000)	Project-based organization offering complex product systems	No degree
Turner, Keegan (2000)	Management of operations in a project-based organization	No degree
Sauer et al. (2001)	PM-centered organization with its projects in the Australian construction industry	No degree
Cheng, Li (2002)	Customized model of partnering in the construction industry in Hong Kong	No degree
Huovinen, Hawk (2003)	Model for building product suppliers to manage their client relationships and collaboration	**Low**: "A building product's environmental impacts" is one of 11 criteria that clients use for choosing a winning bid (158).
Kendall (2003)	Support to PM office management in project-driven firms	No degree
Huovinen (2004)	Managing 5–element, capital investments-based business in organization-based ways	No degree, "governance takes place along ... environmental dimensions" is mentioned.
Kiiras, Huovinen (2004)	Virtual CM company model	No degree
Thiry, Deguire (2007)	Vertical and horizontal integration in project-based organizations (PBOs)	No degree, "turbulent environments" is mentioned.

Table 4: *Assessed degrees of sustainability inside the 10 knowledge-based, construction-related BM concepts, published between the years 1990-2009 (the 4th school).*

Author (year)	Applied concept	Assessed degrees of sustainability based on the key quotations (page number)
Hawk (1992)	Continual learning system based on a learning capability in international building	No degree, "in a relative stable environment", "environmental forces" and "environmental technologies" are mentioned.
Anell (2000)	Analysis matrix for a Nordic firm's project portfolio management	No degree
Davies, Brady (2000)	Organizational learning-cycle model for UK firms offering complex product systems	No degree, "external, changing technological and market environments" is mentioned.
Love et al. (2000)	Conceptual model for a learning organization in construction	No degree, "... adapt to changing environmental conditions" and "a learning environment" are mentioned.
Langford, Male (2001)	Four ways of knowledge-based management in the UK construction industry	No degree, "knowledge ... is the only sustainable source of competitive advantage" is mentioned.
Love et al. (2002)	Model for construction alliances founded on TQM and integrated supply chains in the contexts of Hong Kong	**Low**: To take ethical consideration of the social and environmental responsibility in cooperative alliances (12).
Robinson et al. (2002)	KM framework including knowledge maps for continuous improvement in UK project organizations	No degree, "dynamic business environments" is mentioned.
Huovinen (2003)	Systemic concept for managing a 5-element, capital investments-based business in KM ways	No degree
Borner (2004)	Project and success-oriented KM for design-build contractors in Swiss markets	No degree, "environment/industry/ market" and "competitive environments" are mentioned.
Walker (2005)	Knowledge competitive advantage (K-Adv) concept for Australian construction firms	No degree, "sustainable business practices" and "external environments" are mentioned.

Table 5: *Assessed degrees of sustainability in the 10 dynamism-based, construction-related BM concepts, published between the years 1990-2009 (the 7th school).*

Author (year)	Applied concept and its focal context	Assessed degrees of sustainability based on the key quotations (page number)
Meklin et al. (1999)	Framework of a Finnish firm's project business management	No degree
Barrett (2000)	Model of FM and a process to link core businesses and FM in the UK	No degree, "the business environment" is mentioned.
Chinowsky with Meredith (2000)	7 areas of strategic management, feedback with a competency spectrum and maps in US civil engineering organizations	**Medium:** Environmentally sensitive core designs are based on support strengths. Core designs enable project solutions (130, 142). Environmental engineering is one of surface characteristics (146). Environmental area and testing is a competency (150).
Lampel (2001)	Modified, extended theory on core competencies that support core project processes in EPC projects	No degree, "the wider environment" is mentioned.
Langford, Male (2001)	Contingency model of strategic management in managing construction and supply chains in the UK	No degree, "sustainability versus strategic options and choices" and "environmental evolution" are mentioned.
de Haan et al. (2002)	Fit between market, a firm's strategy, its capabilities, and key external and internal conditions supporting capabilities in the Dutch building industry	No degree
Huovinen (2002)	Framework for managing a firm's competitiveness in a global, capital investments-based business	No degree, "sustainability of firms" is mentioned.
Mitchell-Ketzes (2003)	Linking workplaces to businesses in the USA	No degree, "healthy, sustainable environments" and "sustainable practices and design" are mentioned.
Osgood Jr. (2004)	Strategy alignment model and map for real estate and businesses in the USA	No degree
Huovinen (2005)	Recursive global, capital investments-based business management as a system	No degree

Table 6: *Assessed degrees of sustainability in the 7 process-based, construction-related BM concepts, published between the years 1990-2009 (the 6th school).*

Author (year)	Applied concept and its focal context	Assessed degrees of sustainability based on the key quotations (page number)
Kaya et al. (2004)	World-class FM framework for UK-based firms	No degree, "sustainability of business processes" is mentioned.
Rogers (2004)	High performance unit in FM services businesses in NZ	No degree
Anderson, Merna (2005)	Business development process in PM services in the UK	**Low:** Environment management is one of 11 domains of development (175).
Morris, Jamieson (2005)	Linking corporate strategies and project strategies in firms	No degree, "project environments" is mentioned.
Lindholm et al. (2006)	Model for value adding real estate in firms	No degree, "... provide an environment that enhances productivity" is mentioned.
Salonen et al. (2006)	Framework for ship power suppliers and systems sales	No degree
Whitla et al. (2006)	Global strategies for contractors based in Hong Kong	No degree

Table 7: *Assessed degrees of sustainability in the 5 competence-based, construction-related BM concepts, published between the years 1990-2009 (the 3rd school).*

Author (year)	Applied concept and its focal context	Assessed degrees of sustainability based on the key quotations (page number)
Huovinen (1999)	Recursive, competence-based approach for managing a firm in capital investment markets	No degree, "firms, management, and environments" and "environmental stochastic factors" are mentioned.
Langford, Male (2001)	Strategies for international construction and the internationalization of UK firms	No degree, "traditional and overseas environments" and "sustainable competitive advantages" are mentioned.
Trejo et al. (2002)	Capability assessment for core competency development in US construction & engineering	No degree
Davies et al. (2007)	Model for selling, integrating capital goods into systems	No degree
Helander, Möller (2007)	Framework for managing supplier-client relations in complex system businesses	No degree, only "changes in business environments" is mentioned.

Table 8. *Assessed degree of sustainability in Lowendahl's resource-based framework for managing a professional service business, published in the year 1997 (the 2nd school).*

Author (year)	Applied concept	Assessed degrees of sustainability based on the key quotations (page number)
Lowendahl (1997/ 2000)	3 strategies, 4 resources, 4 dimensions for differentiation, and 3 phases for (US) professional service firms	**Low**: Environmental protection as a market (106).

DESIGN OF A HIGH-SUSTAINABILITY CONCEPT FOR MANAGING BUSINESSES IN CONSTRUCTION-RELATED CONTEXTS

In general, Nidumolu et al. (2009) advocate that pioneering business managers in their various contexts adopt **a generic, 5-stage process** for becoming sustainable, i.e. (i) viewing compliance as opportunity, (ii) making value chains sustainable, (iii) designing sustainable products and services, (iv) developing new business models, and (v) creating next-practice platforms.

For the management of businesses in construction-related contexts, environmental sustainability is herein incorporated as the primary sub-elements into a BM concept (applying Huovinen 2002). It is proposed that the successful management of a business in a construction-related context be based on the adoption of **a 5-element, high-sustainability business system**. The two elements through which a viable firm interacts with its competitive offering markets are redefined first, then the three more internal elements follow (Figure 1).

Offerings and competitive strategies with no/low negative impacts on environments
A firm advances its competitive strategies and offerings (the front-line element 1) in order to offer the best solutions to targeted clients and managing all the contracts to be won for high client satisfaction, the highest degrees of sustainability, and high firm profitability. By definition, **offerings with no/low negative impacts** enable a firm to pre-empt or over-satisfy client needs, excel among competitors, and meet its business-specific, high-sustainability goals in the short term. In practice, the valuable knowledge on sustainability needs to be recreated on a continuous basis and then differentiated into strategies and customized into offerings. Typically, the top management of **KONE Elevators** of Finland is aware of a fact that elevators and escalators can account for 2-10% of a building's energy consumption. KONE wants to be the innovation leader in eco-efficient solutions for its global industry. A great potential is seen in further reducing the impacts of buildings on the environment by offering innovative and energy efficient solutions. In the year 2009, KONE released a range of elevators which reduce the energy consumption by 30% compared to the previous volume models (KONE 2010).

Business processes with minimal carbon footprints
A firm integrates its business processes (the process element 2) to ensure the targeted level of operative effectiveness. In practice, a firm’s business processes and contract tasks are managed as a dynamic, IT-supported matrix where teams play integrative, flexible roles. By definition, **business processes with minimal carbon footprints** allow a firm both to ensure and to increase the targeted effectiveness across contracts to be won. In practice, generic and contract-specific, high-sustainability knowledge needs to be integrated and virtualized before leveraging it into a firm's processes. Typically, **the top management of HOCHTIEF** of Germany has itemized a set of the goals for cutting carbon emissions together with their clients in the area of active climate protection such as (i) cutting company carbon emissions in Germany and the UK by 5.0% by the year 2011 by lowering office power consumption (2008 base year), (ii) cutting Turner's (the subsidiary's) carbon emissions in the USA by 5.0% in the next five years (2006 base year), (iii) switching the major office locations in Germany fully over to green power, (iv) offering green power to construction sites, and (v) cutting business trips by 2.5% by the year 2011 through the greater use of communication technologies (HOCHTIEF 2010). In turn, **KONE** is annually re-setting more demanding targets in terms of improving the energy-efficiency and the eco-efficiency over the life-cycles of its products and minimizing also its operative carbon footprint (KONE 2010).

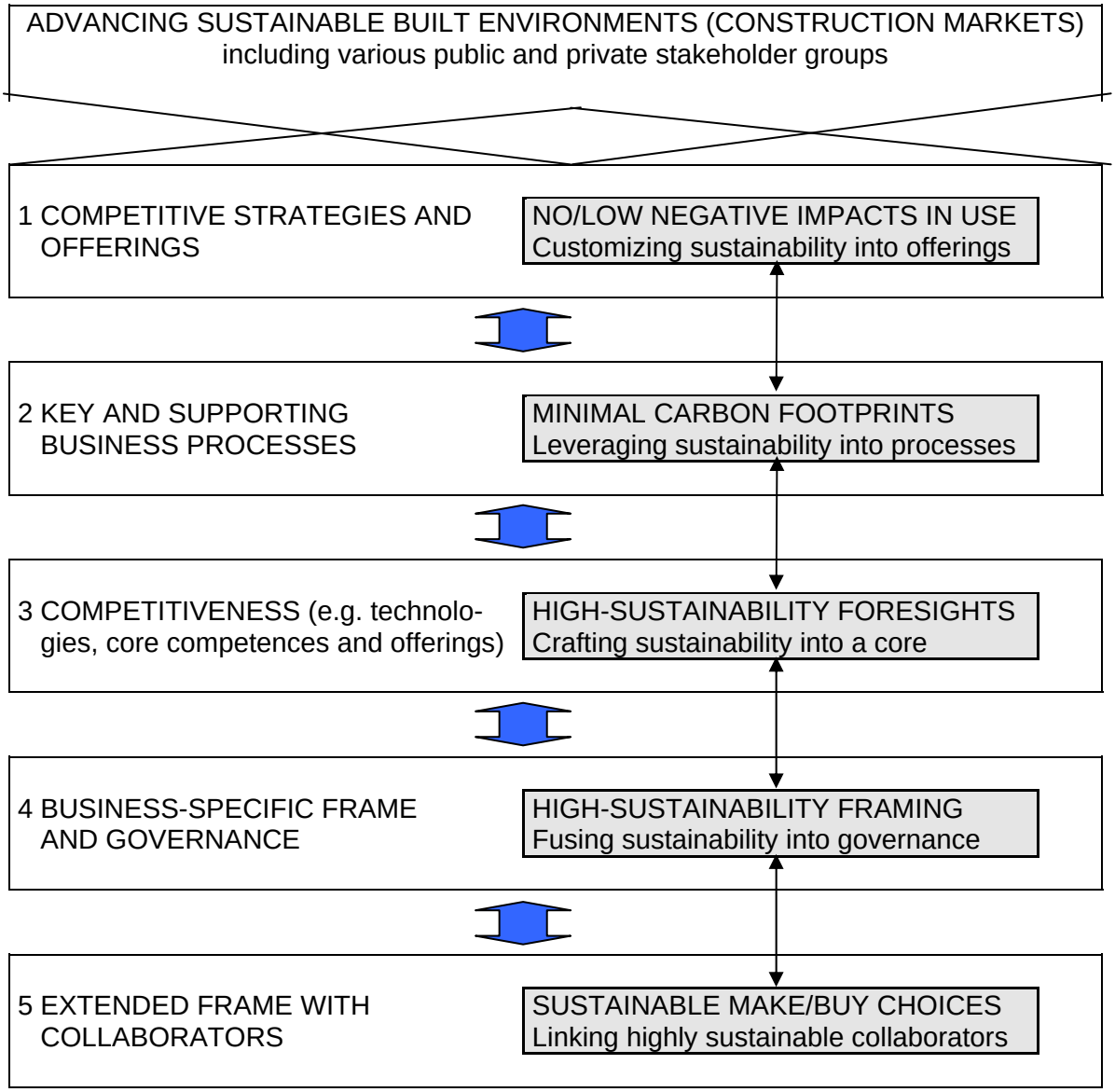


Figure 1: *Management of a 5-element business in high-sustainability ways vis-a-vis the advancement of built environments across the globe (applying Huovinen 2002: 336).*

Core competitiveness based on high-sustainability foresights

A firm nurtures its core technologies, competences, and offerings (the back-end element 3) in order to create competitive advantages and to prolong the current edge as long as possible. By definition, **a firm's competitiveness** is being nurtured based on its high-sustainability foresights that involve business opportunity perceptions, technology foresights, a technology platform, a core competence architecture, a core offering portfolio, and innovation paths. In practice, such foresightful knowledge on sustainability needs to be acquired or invented, rechecked continuously, and then comprehended before crafting it into technologies, core competences, and offerings. Typically, **Pöyry Group** of Finland perceives that a sustainable world will not happen by itself. It must be created and new engineering solutions must be developed. This is where Pöyry can contribute and make a real difference by designing realistic and innovative solutions that consider all aspects of sustainability. Pöyry's in-depth

expertise extends to the fields of energy, industry (e.g. pulp & paper), urban & mobility and water & environment. The concept of Balanced Sustainability is about improving resource efficiency. It involves finding solutions to improve energy, water, material, and supply chain efficiencies while improving the overall return on investments (Pöyry Group 2011).

High-sustainability framing and governance of a firm's businesses

A firm frames each of its businesses both externally and internally (the frame element 4) in order to optimize each business system's (unit's) existence and outcomes that add value to business performance and firm shareholding. The framing takes place along an inter-dependent set of legal, financial, venturous, organizational, institutional, social, and sustainable dimensions. By definition, **a high-sustainability framing** covers firm ownership, top management, business venturing, financing, and the preferred ways of firm-market interactions. In practice, knowledge on sustainability needs to be self-produced or bought, and then updated many times before it is fused into owners' and top management's decisions on business scopes. Typically, the top management of **Skanska AB** of Sweden is leading their corporation in order to be best-in-class regarding margins, the safest firm in the industry, and the leading "Green construction and development company" in the year 2015. The new business plan for 2011-2015 outlines the green future for Skanska (Karlström 2010).

Extended, business-specific frames with sustainable collaborators

A firm's extends its business-specific frames by engaging itself in collaboration (the extended frame element 5) with various domestic, foreign, global, and local stakeholders. The extent and depth of each collaborative relationship vary according to business-affecting goals agreed upon between parties. Forms include partnerships, networking, and similar new forms of physical and virtual collaboration in the long term. By definition, **sustainable collaboration** includes the synergistic ways of make/buy choices, opportunity exploitation, benefit balance, and risk avoidance. In practice, this (originally tacit) internal knowledge on sustainable collaboration is first explicated and documented before it can be exchanged between one, more, or all elements within collaborators' business systems. Typically, **Nokia Siemens Networks (NSN)** is positing that environmental leadership can be a differentiator for their customers, i.e. farsighted operators who are prepared to reduce energy usage, to improve network and system designs, and to create environmental sustainability for the entire business. In turn, NSN takes a holistic approach to environmental performance over product lifecycles. NSN foresees that the adoption of environmentally sustainable business strategies requires an overhaul of each "old way" of doing things. NSN integrates environmental issues into procurement processes. NSN is encouraging its networked suppliers to take a full environmental responsibility for their operations. NSN ensures that its suppliers embrace sustainable practices. Supplier and collaboration agreements include specific requirements such as using a documented environmental management system, meeting standards for raw materials content, and monitoring the environmental performance (NSN 2008).

CONCLUSIONS

Concerning interested researchers, it is suggested that **high-sustainability BM concepts be advanced** so that they meet the following criteria in terms of serving as (a) a foundation of a meaningful communication vis-a-vis environmental sustainability, (b) a perspective or a way of looking at the empirical BM world related to construction markets and built environments, (c) a means of classifying and generalizing sustainability-focused BM situations, e.g. stating the conditions when the management's (and other key stakeholders') efforts are likely to be

successful and those conditions under which their efforts are likely to be carried out in vain, and (d) a component of a theory or a model and thus of an explanation, prediction, and prescription for high-sustainability BM in construction-related contexts (applying Ghauri and Gronhaug 2002). In particular, CIB related researchers are herein encouraged to incorporate environmental sustainability in their existing and new BM concepts through joint and individual efforts in the future. In turn, this author will follow up the emergence of both generic and construction-related BM concepts on an annual basis. It is envisioned that higher sustainability vis-a-vis business managing can be reported upon already by the year 2015.

Concerning practicing business managers in construction-related firms, some recommendations are put forth so that managers take into account **high-sustainability throughout all business transactions** in terms of (i) envisioning the preferred states and ways of managing environmental sustainability issues, e.g. in the years 2015 and 2020, (ii) embedding high-sustainability into the setting of business goals, (iii) incorporating high-sustainability into BM thinking as a major decision making criterion, and (iv) adding the minimization of negative impacts on natural and built environments onto dual agendas for business performance enhancement and competitiveness development.

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SYSTEM INNOVATION FOR SUSTAINABLE BUILT ENVIRONMENTS: THE CASE OF LIGHT EMITTING DIODES

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Abstract
The United Kingdom (UK) government policy is increasingly directed at transforming the built environment to an environmentally sustainable one. The government, for example, has set a target for a reduction in carbon emissions by 80% by 2050 compared to 1990 levels. A large number of new policies and regulations are being introduced to minimise the impact of the built environment and the construction industry on the environment. These pressures are inducing a large amount of product and process innovation across distributed networks: manufacturers, suppliers, installers, clients, users, and so on. To address this challenge, this research suggests that the explicit adoption of a multi-level perspective of sustainable transition management as a way forward. The key point of the multi-level perspective is that transitions or long-term changes come about through interplay between processes at different levels in different phases. This model consists of three levels: socio-technical landscape, regime, and technical niches. This paper reports on an ongoing research project which is tracking, real time, the start-up and growth of a company which is developing and introducing a range of leading edge light emitting diode (LED) technologies. Interim results will be presented with the focus being on the distributed interaction between the principal actors: a LED module manufacture, a luminaire (light fitting) manufacture and a range of end users.

Keywords: High technology, light emitting diodes (LEDs), multi-level perspective, system innovation

INTRODUCTION

The United Kingdom (UK) government policy and regulation is increasingly directed at making buildings far more environmentally sustainable. A key source of environmental burden from buildings is lighting, which accounts for around 20% of the UK's energy consumption (Climate Change Act 2008; Carbon Trust, 2007a). The future consumption trend is upward, despite improvements in energy efficiency per lumens output. Projections indicate that the "global demand for artificial light will be 80% higher by 2030" (IEA, 2006: 26) and that particular "energy demand for domestic lighting … [will] … double between 2005 and 2030" (IEA, 2010: 14). The shift to more sustainable consumption patterns is not solely a technical matter; rather, it involves myriad changes in the institutional context, as well as the design, operation and use of lighting at building and urban levels. But appropriate technological innovation to develop more environmental sustainable lighting technologies is central to any credible, long-term effort to improve the situation. The current situation, for example, is one where "of the 628 million lamps installed in UK homes, around 60% use inefficient tungsten filament technology" (DEFRA, 2008: 7).

Light emitting diodes (LEDs) are poised to make a significant contribution to carbon reduction (BIS and DECC, 2009: 47) and "appear to have the greatest scope for improvement and may yet transform the global lighting market" (IEA, 2006: 42). This resonates with the Ad-hoc Advisory Group (2008: 12) which stated that, potentially, more than 50% of the electrical energy could be saved per year in the near future by switching to LED lighting.

LEDs are solid-state semi-conductor devices that produce light. LED technology has significant functional and environmental benefits over traditional lighting technologies such as incumbent incandescent and halogen technologies (TSB / DIUS, 2007). They have several major benefits [1]. First, LEDs have a practical operational life of '50,000 hours' (Carbon Trust, 2007b: 12) compared with 1000 or 2-4000 for incandescent and halogen lamps respectively. This can potentially reduce maintenance cost. Second, LEDs exceeds the energy efficiency of conventional lighting technologies. For example, white LEDs are over 400% more efficient than incandescent lamps and 300% more than halogen (TSB / DIUS, 2007).

The better functional performance of LEDs, compared to incumbent technologies, is clear. But superior technical performance of a particular technology is no guarantee that it will become the dominant technology. Systems innovation (which adopts a multiple level, multiple actor perspective) is an important new stream of theory which is providing new insights into the innovation diffusion process; particularly ushering in a better understanding of why (and under what conditions) niche or disruptive technologies become (or do not become) established technologies in a given sector or technology field (for example, see Geels and Schot, 2007; Rotmans et al., 2001).

This paper reports on an ongoing exploratory research project which is tracking, real time, the start-up and growth of a company which is developing and introducing a range of leading edge LED technologies. A systems innovation approach is adopted to reflect on the interim results. The results reveal the pivotal institutional barrier of LEDs not being supported by national and international standards, as well as the obstacle of high capital cost in the procurement decisions at a local level. The interim results give tentative support of the value of using a systems innovation approach to understand uptake and diffusion a new technology. There is a need for significantly more theorising and empirical work in a built environment context to develop the descriptive and explanatory utility of systems innovation. This paper is structured as follows. Section 2 briefly discusses the multi-level perspective of sustainable transition management. Section 3 sets out the research questions and an overview of the research methodology. Section 4 presents the interim results with the focus being on the distributed interaction between the principal actors. Finally, discussion and conclusion are drawn.

MULTI-LEVEL MODEL OF INNOVATION AND SYSTEM TRANSFORMATION

Innovation theory and empirical evidence has long stressed that new technologies are the emergent outcome of a range of interconnected institutional and organisational activities. The linear view of innovation, for example, where new technologies are pushed into the market has been all but discredited. Further, there is recognition that the shift from the current, unsustainable trajectory of societies to sustainable paths cannot be achieved in a fragmented, ad-hoc fashion. There is a need for co-ordinated policy and action across a range of diverse domains and levels. In response to this agenda the multi-level view of system innovation is being developed. Geels and Schot's (2007) multi-level perspective of 'socio-

technical systems' on technological process innovation in the built environment distinguishes three conceptual levels: socio-technical landscape, socio-technical regimes, and technical niches (Geels and Schot, 2007; Geels, 2005) (see Figure 1). Each level is discussed below.

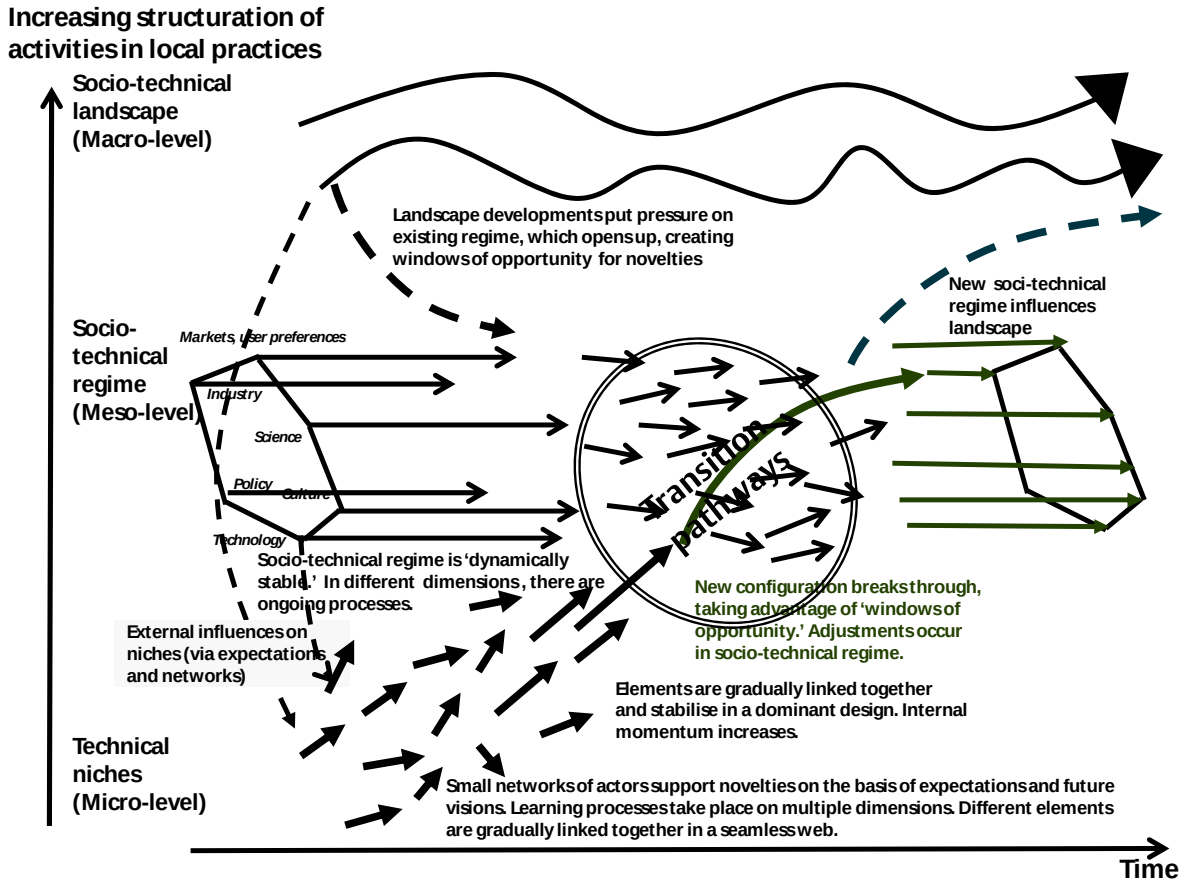


Figure 1: A dynamic multi-level perspective on system innovations (adapted from Geels and Schot, 2007: 401)

First, socio-technical landscape (macro) level represents the broader political, social and cultural values and institutions (such as standards, regulations) that form the deep structural relationships of a society and only change slowly (decades). The landscape guides actors' perceptions and activities. Within this landscape, there are socio-technical regimes and technical niches.

Second, socio-technical regime (meso) level represents "the prevailing set of routines or practices that 'actors' and institutions use and that create and reinforce a particular technological system" (Foxon et al., 2010: 1204). These practices include: "engineering practices; production process technologies; product characteristics, skills and procedures … all of them embedded in institutions and infrastructures" (Rip and Kemp, 1998 cited in Foxon et al., 2010). Regime accounts for "the stability of existing large-scale systems (in transport energy etc.)" (Schot and Geels, 2008: 545). Within the existing regime, incremental, often product, innovation is generated.

Finally, technical niches (micro) level is where "market niches provide early footholds for radical innovation" (Geels, 2008: 522). Micro-level niches are 'protected spaces' where new technologies, new novelties etc emerge. Geels (2005: 450) further comments that it is difficult to create radical innovations within socio-technical systems because of the stabilising mechanisms. Radical innovations tend to be encouraged through regulation and/or financial incentives (such as taxes and R&D subsidies). For instance, the UK government is currently guaranteeing high prices for electricity produced by microgeneration technologies [2] to encourage the R&D, uptake and diffusion of such technologies.

The key point of the multi-level perspective is that transitions (long-term changes) come about through the interplay between processes at different levels in different phases. As a consequence, transition pathways [3] (see Figure 1) need to be created and managed to encourage the adoption and diffusion of 'niche' new technologies so that, overtime, they become the dominant technology. Geels (2005) argue that radical innovations emerge (the transition is) through three phases. In the first phase, radical innovations emerge in niches, often outside of the existing regime. There are no stable rules (e.g. dominant design) and actors improvise, and engage in experiments to work out the best design and find out what users want. The networks that carry and support the innovation tend to be small. Innovations at this stage do not form a threat to the existing regime. In the second phase, the new innovation is used in small market niches, which provide resources for technical development and specialisation. The new technology develops a technical trajectory of its own and rules begin to stabilise (e.g. a dominant design). But the innovation still forms no major threat to the regime, because it is used in specialised market niches. New technologies may remain stuck in these niches for a long time (decades), when they face a mis-match with the existing regime and landscape. As long as the regime remains stable, niche innovations have little chance to diffuse more widely. The third phase is characterised by wider breakthrough of the new technology and competition with established regime, followed by a stabilisation and new types of structuring. The multi-level perspective of transition management emphasises that "both internal niche-dynamics and external developments at regime and landscape level are important for wider breakthrough and diffusion" (Geels, 2005: 452) and transition pathways arise through the dynamic interaction of technological and social factors at these different levels.

RESEARCH QUESTIONS AND METHODOLOGY

The ongoing research is guided by the following research questions:

1. How does the lighting supply chain (including LED module manufacturer, luminaire manufacturers, specifiers and end-users) engage with new LED technology?

2. What are the drivers and barriers underlying end-users decisions to adopt / reject such technology?

The project brought together representatives from the key parts of the supply chain: LED module manufacture, luminaire (light fitting) manufacturer and end-users. A brief description of each project partner is presented below.

The LED module manufacturer, a small LED lamp manufacturer based in California in the United State of America, funded in July 2007, is a start-up company. Its business model is to

design and manufacture LED light modules that allows light fitting manufacturers to add significant value in multiple applications and markets which leverage their existing channels.

The luminaire (light fitting) manufacturer and installer, established in 1982, is an established original equipment manufacturer (OEM). It works with module (lamp) manufacturers and end users to produce standard and bespoke products and systems for a range of indoor and outdoor applications.

End-users include three technical and four non-technical end-users. Technical end-users include three specifiers (hereafter specifiers 1, 2 and 3). The specifier 1 was formed in 1978 and is one of the UK's largest mechanical and electrical (M&E) building services engineering consultancy practices. It specialises in bespoke building services engineering solutions to a wide range of market sectors, including healthcare, education, research, local government, pharmaceutical and commercial clients. The specifier 2, based in Scotland, is privately owned firm. The firm provides M&E building services engineering consultancy services. Specifier 3, also based in Scotland, is an electrical contractor.

Non-technical end-users include an airport operator, a property group, a regional museum, art gallery and archives service and an in-house maintenance function of a marina. The airport operator is the country's largest UK-owned airport operator. The pilot site (an airport) was located in North West England. The property group, founded in 1958, is an international property group with broad skills across the property value chain. The property group operates three core businesses: project management and construction, property investment management and property development. The pilot site (a shopping centre), opened in 1999, is Europe's largest combined retail and leisure destination. The third one is a major regional museum, art gallery and archives service. The organisation is responsible for twelve museums, galleries and heritage sites. The pilot site (a museum) is located in North East England. Finally, an in-house maintenance function of a marina. The marina opened in 2010 and is situated in Scotland. Its facilities include deepwater, sheltered berthing and built facilities, including accommodation, restaurants and bars and shops.

Data collection techniques include interviews, meetings, workshops and company documentation.

INTERIM RESULTS

This section is structured into two sub-sections: barriers to the adoption of LEDs technologies and enablers for the adoption of LED technologies.

Barriers to the adoption of LED technologies

1. High initial capital cost / high purchase cost

It is clearly LEDs has far better functional performance than the existing lighting technologies (e.g. tungsten and compact fluorescent lights), but the high capital costs was a major barrier. The 'high initial capital cost' of LEDs is clearly demonstrated by the comments of the luminaire manufacturer and end users. One of managing directors of the luminaire manufacturer, for example, expressed his concerns towards this barrier:

"As an overview, taking it above this [LED] technology, when it was going through 'how do we get sustainable energy efficient technology in the marketplace, there is a tremendous

amount of negativity in the actual purchasing process of taking this technology on because of the initial capital cost, and that's the biggest barrier we face with this."

The 'high initial capital cost' strongly links to the second barrier discussed below.

2. Decoupled capital and maintenance budgets
When the capital and maintenance budget is disjoined within the client system, the adoption of LEDs appears to be impossible. This is evident in one of managing directors of the luminaire manufacturer, stating that:

"Where [a local authority] have the capital budget for expenditure is absolutely nothing to do with the maintenance budget, nor are they linked. Until the people who are in charge of the budgets for this link the two together to get an overall saving, their short termism is costing the country millions."

3. Lack of standards
Standards are playing an essential role in the growth of the LED lighting market and the rate of adoption of LED lighting in various applications. Without standards, performance comparison can be difficult or impossible, and specifications cannot be traced to a meaningful reference. This can make customers and specifiers uneasy about using LED lighting for their projects even niche actors' perceived that LEDs is fully developed. One of the end-users (specifier 2), for example, was skeptical of claims of LEDs' long life by saying:

"… the first criteria would have to be 'can I trust the life' … that would be the first one because you get quoted lots of things … a golden number of 50,000 hour life on a LED … it's easy to quote a number … it's hard to prove that number, I guess, isn't it?"

The importance to comply with regulations is further reinforced by one of end-users (specifer 1), stating that:

"… my experience here with people who have used LEDs has been quite open … our engineers here are very open, forward thinking solutions. We do work within the realms of British Standards."

Lack of standards, particularly play a key barrier for the deployment of LEDs products in the construction sector. One of managing directors of the luminaire manufacture, for instance argue that unless the LED products is specified, otherwise, it will not be introduced into the construction projects.

".. when we're dealing with the design and build marketplace, the whole criterion of that is to get the most competitive tender in that satisfies your remit with a twelve month period, and this technology [LED], unless it is written in under design and build specification that it must have certain points, then it will never go in because the contractor will not pay eighty / one hundred pounds for a luminaire when he can buy ten or twenty pounds for a luminaire, and he doesn't care after twelve months of the problem.

4. Lack of awareness or enthusiasm of electrical engineers (e.g. lighting designers)
Electrical engineers can be significant influencers on LED purchases both by the choices they make for lighting fixtures in new construction, so lack of awareness or enthusiasm on their part can be a barrier to LED technology adoption. The resistance to change in designers and

clients to use LEDs, in part, because it would mean disrupting and changing the existing 'regime' or 'way of doing things.' Another managing director of the luminaire manufacturer, for example, indicated the challenge to introduce a radical technology (rather than incremental technology) into the development of new products:

"Our approach to product, because the lighting market place and engineers are conservative people who get very comfortable with certain pieces of technology, to move them radically in different direction becomes a problem to them … so it's easier for them to embrace the idea of a low voltage or a diachronic replacement … let's try and replicate something that works, that is more in their comfort zone to get a higher market uptake."

Specifiers seek to offer leading-edge technology to their customer. LEDs are transforming their offer but at the same time introducing new challenges. Specifier 1, for instance, noted that:

"… there are always conflicting requirements, and the hardest one to reconcile is when it's a personal conflict. I don't mean personality, a personal conflict of somebody in a design team might prefer something else because they've used it in the past on another project and it was a really good result so they like that. You suggest something new, perhaps, and they may … I wouldn't say reluctance, but there may be a bit of 'Is it okay? Do I really want to move to that?"

5. Lack of awareness or knowledge of LEDs from clients

What was interesting is that, in most cases, the client itself does know what it wants prior to installation. It is only when the lighting installation is in place that the client knows whether it was the right or wrong solution. This situation is amplified in the case of LEDs as this is, in most cases, a totally novel technology for the client. The lack of awareness/knowledge of the client about the LED product is evident in the one of managing directors of the luminaire manufacturer and installer, stating that:

"I don't know a single end user who would have any awareness at all [of LEDs]. In the old days when we used to talk about metal halides, people had firsthand experience … now, with this, it's just not on their radar …"

6. No experience or having bad experience of clients of using LEDs

No experience or having bad experience of clients of using LED has negative impacted on the adoption process. This is demonstrated by one of the end users (specifier 1), stating:

"Sometimes a university … may have a small project that doesn't actually involve us, a small value project where they've bought a few LEDs, tried them, bad experience, and they're not experts in the LED or lighting field, so they may just go with that as a bad experience and think 'I'm not going to use them again.' So that's the kind of barrier that we might see."

<u>Enablers for the adoption of LED technologies</u>

1. Whole life cycle costing

The 'whole life cycle costing' was considered as an important factor in introducing LED products into the project. Specifier 1 stated how the end user was convinced by deploying the new LED technology:

"The good thing for us is the energy departments … specifically at University of … their energy department is quite keen on using new technologies that save energy. With those product if I can save at least thirty or forty percent for certain types of products then it make sense to do so."

That can be said that the concept of the 'whole life cycle costing' is addressing the both the 'high initial capital cost' and 'disjointed capital and maintenance budgets' barriers.

2. Reduction in maintenance works and low maintenance cost

The benefits of long life of LED products clearly demonstrate in the reduction of maintenance works and costs. This benefit to reduce the maintenance work was demonstrated by specifier 1, quoting how the new LED product was adopted by the end user:

"That was an architect. I showed it to the maintenance team after that meeting on site because I got to know them there, showed them the products, and the first thing they said was 'Great. That means I won't need to keep changing [lamps] that I keep changing every few months."

3. The important role of specifiers

The important role of specifiers in helping end users' acceptance towards new LED product is evident in specifier 1:

"Quite often when I employed as the specialist and are very seldom challenged on the design of the lighting, other then the way it appears with the design team, because the design team predominantly will include an architect. The architect on this one, I showed him the products because I was interested in it, of course, and I showed him the kind of output you get with LEDs and it was met with nothing but extremely open arms, such is the effect that the architect believed he would try to find as many jobs as he possibly could to use them on.

This is particularly when there is no LED standard in place. Specifier 1, for example, described the reason why he adopted the LED technology in his projects:

"It's very difficult that one, isn't it, because it's hard to give me any concrete evidence for anything. I have to rely on the experts who are supplying it and whatever warranty they might provide to me. So on this project it's a five year warranty, and that's all I can really go on, actually."

The interactions within social-technical regimes also present a challenge in the transition. One of managing directors of luminaire manufacturer and installer, for example,

"When you talk about end users, …you talk to people who are lighting professionals and that's what they do, they'll embrace it, but, again, how well they communicate it to their client because, at the end of the day, the client after a while glazes over and just thinks 'Oh yes, it looks nice. It's pretty.' He doesn't know why it's pretty."

DISCUSSION AND CONCLUSION

The findings, when viewed through the multi-level perspective, bring into the sharp focus two key, interrelated issues. First, at a technical niche level, the current generation of light emitting diodes (LEDs) demonstrate clear functional benefits, but are significantly hampered by their high initial cost compared to incumbent lighting technologies (Unger, 2011). The

specifiers may be engaging with client systems to win the argument concerning whole life cycle cost attributes. But this engagement is very limited and patchy. Clients are locked into existing technologies and installation / maintenance routines which often lock-out consideration of the LEDs option. Second, at a social-technical landscape level, the specifiers are being hampered in two respects. Specifiers themselves may be locked in to particular lighting solutions. Further, where specifiers do consider LEDs, the lack of standards and certification schemes for the technology introduces too much uncertainty and risk.

This exploratory paper advocates that a broadening of the debate beyond the flat, linear view of, say, the traditional new product development to a multi-level perspective provides policy makers potential levers to bring about more effective system innovation. In this case, the LEDs technology itself is not the bottleneck – it is the way clients and specifiers are locked into old technologies and practices. The lock-in is further aggravated by the absence of LEDs standards and certification schemes. This is, in many respects, a somewhat common-sense message: technological innovation is not without context, it is embedded within landscape institutions and regime networks. But in the clamour for new sustainable technologies, this message is too often lost in the noise and, as a consequence, the system innovation required is not being progressed. In summary, LED technology, to substitute the incumbent, less environmentally-friendly lighting technologies, requires more robust transition pathways which are created and supported by legitimising standards and new knowledge sets for specifiers.

Finally, to reiteate, this exploratory paper has mobilised the multi-level perspective to construct a better, albeit partial, understanding of why and how new technologies (in this case LEDs) are adopted and diffused. We advocate that significantly more theoretical and empirical research should be undertaken to investigate whether the multi-level perspective has real purchase and traction in a construction context to move the sector to an environmental trajectory.

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NOTES

[1] For more discussions on LEDs technologies, see Held (2009), Carbon Trust (2007b).

[2] The term 'microgeneration' is understood to be the "… onsite generation of low- and zero-carbon heat and electricity in domestic, public and commercial properties (Bergman and Jardine, 2009: 6).

[3] Transition pathways are defined by "the interactions between the internal regime dynamics and wider landscape factors and niche alternatives, which destabilize the incumbent regime and eventually give rise to a new regime" (Foxon et al., 2010: 1207).

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SUSTAINABLE PLANNING AND LAND VALUATION. NEW FORMS OF SUBURBAN GROWTH IN AREAS OF THE SPANISH MEDITERRANEAN COAST

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Abstract
The present study analyzes residential models in coastal areas with large influxes of tourism, the sustainability of their planning and its repercussion on urban values. The project seeks to establish a methodology for territorial valuation through the analysis of externalities that have influenced urban growth and its impact on the formation of residential real estate values.
This will make it possible to create a map for qualitative land valuation, resulting from a combination of environmental, landscape, social and productive valuations. This in turn will establish a reference value for each of the areas in question, as well as their spatial interrelations. These values become guidelines for the study of different territorial scenarios, which help improve the sustainable territorial planning process.
This is a rating scale for urban planning. The results allow us to establish how the specific characteristics of the coast are valued and how they can be incorporated into sustainable development policies.

Keywords: territorial valuation; sustainable planning; suburban growth

INTRODUCTION. CURRENT SITUATION

The urban territorial structure of developed countries has changed significantly over the past several decades, due to service sector expansion, transportation improvements (Leinfelder,2007) and population growth, prompting the regeneration and planning of suburbia, which goes beyond a territorial transformation as it also involves social, political and economic changes. These transformations have made the regeneration and planning of ample suburban fabrics necessary, and have provoked a profound territorial, social, political and economic transformation.

The discourse about the meaning of city and countryside is not unique for all the countries. The European RURBAN-project conclusions (Overbeek, 2006) indicate a dominant planning discourse. This sets that city and countryside are two separate entities that need a complementary and simultaneously opposite policy: new developments are concentrated in urban areas, while the open space is safeguarded against new developments.

On a territorial level, these changes have caused the classic appraisal models for urban value to lose validity. In this context, how are the countryside and the city valued?
North-West-European countries share a rural tradition in which agriculture and the environment are central elements within the urban planning. As a consequence, countryside is

highly valued as a space for production and consumption and the city and urbanisation are perceived in a more negative way. In contrast, the Mediterranean rural tradition approaches the countryside negatively and perceives city and urbanisation quite positively because it stimulates economic development.

However the traditional political dichotomy in simple categories ‘city’ and ‘countryside’ is being questioned increasingly. It ignores the complexity and stratification of society (Halfacree, 2004). The relations between places and activities have become very complex in network society and concern different spatial scales at the same time (Leinfelder, 2007).

Most of development possibilities are in open space where there are now areas of environmental interest. This stance has led to the devaluation of the environmental potential of many areas of the Spain’s Mediterranean coast due to the intense pressure of the tourism industry. In these locations, the significant increase in residential land has contributed to a gradual loss of the territory’s environmental values. The main problem is that the economy of these areas is based on tourism linked to environmental values. The primary purpose of encouraging the preservation of environmental values may not be financial, but financial justification for these actions is nearly always required (Crompton, 2007)Therefore there is a contradictory situation and it is remarkable how planning has not taken clear role for open space in ‘network urbanity’ (Leinfelder, 2007).

Currently, land value responds to more than just accessibility factors and urban hierarchical structuring. It is also defined by its capacity to support marketable real estate products and the market value of said goods. This market value is determined by a set of qualities or attributes that cannot be traded independently, but rather only as an integrated market unit. The group of variables that affects each choice has a direct impact on the property appraisal process (Kauko, 2008). Its analysis is fundamental to understanding the complex system of urban development and growth.

Given this scenario, it seems particularly relevant to develop innovative methodologies that specify tools and techniques capable of meeting developmental and land management requirements on a regional and local scale. The offer has a spatial location, which must be considered for the market analysis (Gutiérrez and Gould, 1994).

The main goal of this study is to rehearse new techniques for sustainable development planning using technological applications. The analysis of externalities that have had an influence on urban growth and the appraisal of residential real estate products will help establish a methodology for land valuation.

The work creates different outlines for urban valuation. The result is approximate to an economic valuation on a territorial scale. It analyzes the impact of the urban and natural attributes that make a city attractive. This analysis is supported by economic, social, environmental and urban planning concepts, and is used to explain the variability of urban land values.

In order to determine whether the planning previsions will adequately meet the requirements of the demand, we must explore to what extent the differential characteristics of these products adapt to the level of significance or valuation of their territorial location. This differentiation of municipalities allows us to study the integral characteristics of a location’s real estate market.

These formulas have been amply used in studies applied to the housing market. In Spain, however, there are few known experiments to this effect. Additionally, this project’s proposal

is of particular interest due to the dynamic development of this area over the past several years, its marked suburban character destined for second homes and the significant influence of tourism on its expansion.

OBJECTIVES

The purpose of classifying urban development models is to identify their fundamental characteristics by establishing the requirements for competitiveness and sustainability that must be met in order to guarantee territorial progress in the economic, social and spatial sphere.

To this effect, the investigation is linked to fields of study related to urban planning, management and valuation; and proposes a global study with different objectives.

- To identify and analyze the different factors used to formulate the obtained real estate values.
- To systematize a process for land valuation through the analysis of externalities that have had an influence on urban growth.
- To determine the interaction between urban value and land value, assessing the sustainability of real estate activities.

SCOPE OF ANALYSIS

Traditional settlements and New forms of suburban growth

The scope of the study is the Spanish Mediterranean coast, and more specifically the area known as Vega Baja del Segura, which is made up of 27 municipalities. This area boasts a large diversity of landscapes and ecological factors, and has historically maintained a clear distinction between urban and rural spaces. This dichotomy has drastically changed over the past decades. The tourism industry has created a large demographic and economic growth, which has provided the incentive for an extremely dynamic land market.

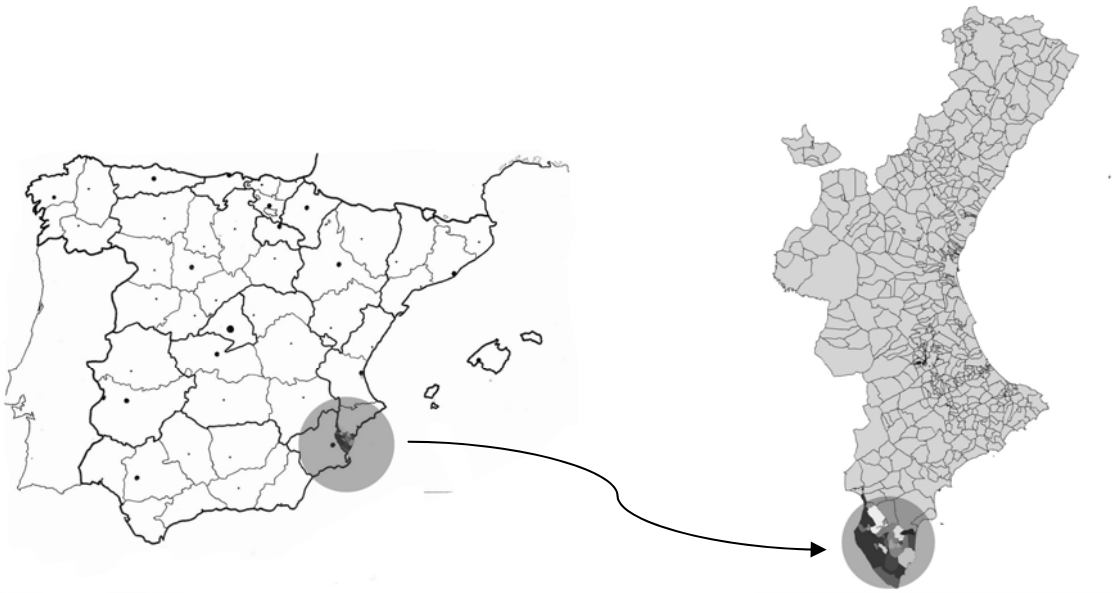


Figure 1: *Location of the scope of Vega Baja del Segura in Spain. Source: the authors*

This growth has caused a marked transformation in the traditional settlement criteria, implanting a new and more complex system that has caused the rural environment to gradually take on a quasi-urban morphology from urbanization processes and facilities. The clear distinction that has traditionally existed between the settlement patterns of the agrarian and urban populations has disappeared. People don't perceive rural areas as a mosaic of independent zones on an urban planning. These are perceived in a qualitative and integral way as an attractive setting for living and recreational activities (Leinfelder,2007). The implementation of new uses, activities and lifestyles that are typically urban in nature, has led to a growing homogenization of the suburban space and a progressive mixing of the urban meshwork with rural structures.

The residential model that responds to this phenomenon is one of low-density housing developments, which penetrate inland towards a town's interior from the coast. This new model results in a significant scattering of the population, giving the area the lowest population density in the province.

According to this approach, the old system of traditional settlements with their marked rural character and center in Orihuela can be distinguished from a new model that has developed from the coast towards the interior, organized hierarchically from the center of Torrevieja. The dialectic process between both systems has produced the current distribution model whose principal characteristic is homogenization. This has led to the development of typically urban lifestyles in very small nuclei in the interior, and typically rural values in urban structures.



Figure 2: *Network of settlements. Source: the authors.*

In conclusion, the settlement system in the Vega Baja del Segura should be analyzed from a territorial point of view, due to the complications that arise in trying to establish a border between rural and urban settlements. The rural sphere cannot be considered as independent of the urban sphere, given that it is a functional, hierarchical space that has intense interaction with the entire network of cities in the Vega Baja.

Population system and economic model

This process has occurred in conjunction with a clear modification of the population structure and the area's production sectors, creating an economic model in the Vega Baja that reflects the strong impact of the large-scale establishment of the tourist sector on an area with strong agricultural roots and a marginal industrial sector. Tourism has become a strategic industry for generating wealth, with extremely significant effects on the area's economy.

The economy of the Vega Baja del Segura is traditionally rooted in agriculture. This impeded the formation of a social structure during the nineteenth and beginning of the twentieth centuries, and has prevented a true industrialization of the area. The agrarian economy experienced a crisis in the sixties, due to the aging and lack of alternatives for a largely uneducated population. However, the Vega Baja has traditionally boasted natural conditions favorable to the strong development of the tourism industry. Factors such as climate, the coast and the landscape resulted in a massive influx of tourists since the 1960s, reaching a spectacular level in the mid 1980s. This was especially true in the town of Torrevieja. This development of the tourism industry provoked an extremely significant increase in population, both on and near the coast, turning the town into a well-known destination for sun and beach within the Community of Valencia and the rest of Spain.

The clear consequence of this development was an increase in local incomes, sparking a significant expansion in the construction sector and converting the service sector into the pillar of the local economy. One factor that intensifies the influence of tourism on other secondary sectors like industry and construction tied to real estate promotion, is that this type of tourism is not centered on hotels, but rather on a type of tourist who spends large portions of the year in the area and is therefore in the market for a second home. This circumstance has brought about a tourism model characterized by a minimal presence of hotels, a predominance of offers for a second residence and an undeclared, non-hotel based offer.

This model initiated a migration of agricultural laborers towards the main population centers and created strong ties between the active population and the construction sector. Additionally, the model attracted an older population, in large part from the rest of the European Union, who made this town their vacation destination or the site of their long-term second residence.

A population pyramid that demonstrates a clear tendency towards a narrowing of its base and a significant widening of cohorts of an advanced age indicates significant distortions with regards to the average age of the population. This results in an increment in the aging rate and a modification of production sectors. The services demanded by this population are limited; a phenomenon that makes it difficult to propel the industrial sector as it stagnates the dynamic of labor demands and thereby blocks the economic development of the zone.

In the area's interior, where elderly immigration is less intense, the classic aging process of rural economies is taking place, pushing young laborers to other areas and clearly throwing the population pyramid out of balance.

Over the past few years, construction has been seriously affected by the financial and real estate crisis triggered in mid 2007. One of the first victims of this phenomenon was employment in the Spanish construction industry. The dependence of this area's economy on the service and construction sectors has meant significant increases in the rate of unemployment, mainly affecting the migrant population.

METHOD OF ANALYSIS

In order to reach the goals of this project, a methodological study was carried out relating to a description and quantification of the different aspects that define the territory and effect the evaluation of the real estate product. As a base of analysis, we will use data from the real estate market itself, establishing links between territory and urban value. This implies a detailed and reliable study of values on the sale of finished products and a complete characterization of the territory using ecological, landscape, productivity and environmental criteria.

The evaluation is considered from a double perspective: territory and real estate. How do territorial characteristics determine urban value? Does the distribution of existing urban values respond to territorial characteristics? Does real estate development respond to sustainable territorial guidelines? And, using spatial market analysis, where can we, or should we, establish new supply points (Beaumont, 1991)?

The analysis was carried out using a tool similar to GIS (GeoMedia Professional). This provided agile information management and the creation of maps that represent the qualitative value of each part of the territory, defining areas of fragility and potential for urban developments. This process allows us to define whether or not the distribution of urban values is related to the land valuation and if it meets criteria for territorial sustainability.

The analysis is structured into the following phases:

- Sample selection
- Database design and sample description
- Database processing. Spatial distribution of variables
- Land valuation. Areas of fragility and potential

Sample selection

The first phase of the study is based on the selection and systematization of a set of data obtained through market research carried out in the area of the study. The analytical validity is based on the quality of the information used as a reference for obtaining the market value, and the reliability of the geographical data and spatial precision.

The sample has been stratified into two subsamples based on the typology (multi-family and single-family), due to the fact that they constitute different real estate offers, in which the potential buyers look for incomparable features and therefore present differentiated valuations.

The market study brings together a sufficiently representative sample of finished properties already for sale, both in the primary and secondary markets, with an age of less than 10 years. The research is transversal in character. The data is from a homogenous period of time where

variables such as sale prices and the preferences and needs of potential buyers do not vary significantly. The data was collected between January and August of 2009. The field work was carried out through the compiling of data specific to the present study (73%), market studies for mortgage valuations (21%), market studies for appraisals, expert valuation reports and viability studies (6 %), carried out over the same period.

The utilized data was sufficiently representative and appropriately corrected from unconditional offers. The information was verified and all data that differed unjustifiably from the average market value for the area or that was incomplete, was discarded (Roca, 1987).

The 3,845 pieces of data that made up the original sample were whittled down to a market study consisting of 3,300 units of information, from throughout the entire area. It is a representative sample of the different zones distributed in the following manner.

TOWN	**MULTI**-FAMILY	**SINGLE**-FAMILY
Albatera	73	18
Algorfa	20	8
Almoradí	82	11
Benejúzar	10	7
Benferri	6	23
Benijófar	1	6
Bigastro	34	15
Callosa del Segura	45	17
Catral	17	17
Cox	13	10
Dolores	10	21
Formentera del Segura	82	2
Granja de Rocamora	1	11
Guardamar del Segura	267	46
Jacarilla	6	8
Los Montesinos	30	12
Orihuela Costa	265	252
Orihuela	143	56
Pilar de la Horadada	77	132
Rafal	6	1
Redován	6	25
Rojales	14	26
San Fulgencio	6	6
San Isidro	25	2
San Miguel Salinas	6	14
Torrevieja	998	311
VEGA BAJA	2243	1057

Figure 3: *Spatial distribution of the sample. Source: the authors.*

Database design and characterization of the sample

The group of properties chosen for the basis of the analysis has been qualified using more than 200 variables. The characterization of the sample has a dual aspect that on one side will determine those physical characteristics that qualify the constructed element and on the other, those directed at the characterization of the territory.

In this phase, we attempted to define all of those pieces of data that permit the differentiation of the real estate product from a point of view that is both territorial and related to the demand criteria. This process helped to stratify the sample using criteria of homogeneity, making it possible for us to subsequently conduct explanatory analysis.

The variables or factors for analysis can be grouped together into four families; the first two directed at the characterization of the property and the remaining two at the characterization of the territory:

1 market variables and valuation
2 intrinsic or typological attributes linked to the constructed element and characteristic aspects of the area
3 extrinsic or location related attributes linked to the censual units
4 extrinsic or location related attributes linked to the property

In Family 1, "Market variables and valuation", different defined aspects include the surveyed sale price, unitary market price and repercussion value of the land. The information sources include real estate agents, specialized publications and real estate and individual's websites. The variables obtained from the surveyed market values were compiled by the authors for the purpose of the study.

In Family 2, "Typological variables", the defined aspects include housing programs, construction quality, characteristic typology and occupation levels for properties used as homes, among others. We obtained the characteristic typological variables referring to the territorial scope or censual unit from the data provided by the 2001 Census conducted by the National Institute of Statistics, or compiled by the authors using said data.

Family 3, "Extrinsic territorial variables", takes into account environmental, economic, social and urban structure factors, with reference to the land unit or censual unit where the sample is located. The characteristic typological variables were obtained from the 2001 Census data conducted by the National Institute of Statistics or compiled by the authors from said data.

In Family 4, "Extrinsic values of the variables", the analyzed factors mainly had to do with the environment, infrastructures and facilities with reference to each sample. The variables were obtained through the compilation of field data by the authors.

Database processing. Distribution of spatial variables.

The resulting data set is introduced in an appropriately coded Excel database, and transformed into factors that will determine the final classification of each part of the territory. To this end, the property register mapping for each town was used as the basis, creating a reliable starting point for geo-referencing each sample, for the subsequent production and quality control of the relevant themes.

The use of GIS as a tool for scientific research (Moldes, 1995) is derived from its capacity to respond to spatial questions (Gutierrez and Gould, 1994). The use of GIS technology makes it possible to create complex maps that represent a territory's total qualitative value. This in turn will orient and sensitize with respect to the distribution of values that can be geographically located on a territory, and effectively support the implantation of necessary protection regulations. The GIS data structures detect fragile or vulnerable areas within each scope, in addition to areas with greater potential for growth.

On the other hand, by using the sample obtained during the data collection process, we can find out the market value segmentation for residential housing products in the analyzed area,

both with regards to single-family and multi-family homes. We can determine if there is a link between territorial valuation and the spatial distribution of property values by using the link between the total quality valuation map and the land value map.

The following is a list of the available information that has been incorporated into a Geographic Information System. It is divided into five areas. The following variables were taken into consideration in order to define the territorial valuation:

AREA 1 ECONOMIC

- Weight of unemployment rate
- Socioeconomic condition by homes
- Active population rate / dependent population rate
- Sector / field of activity

AREA 2 ENVIRONMENTAL

- Type of landscape
- Conservation value of the territory
- Buffer of influence from the golf course
- Buffer of influence from the beach

AREA 3 POPULATION

- Average education level
- Average age
- Percentage of Spanish / foreign population

AREA 4 INFRASTRUCTURES AND FACILITIES

- Buffer of influence from transportation infrastructure
- Sanitation facilities

AREA 5 EDIFICATORY TYPOLOGY

- Characteristic residential typology
- Seasonal variation
- Vacant homes index
- Average home size

Territorial valuation. Areas of fragility and potentiality

Valuing the quality of a territory means stipulating a reference value for each of its comprised areas. The concept of “value” incorporates a broad spectrum of different valuations or factors that condition its determination. Once said value has been determined, it becomes possible to estimate the impact of the different actions planned on the territory and articulate mechanisms that will guarantee the preservation of its values.

In this sense, all planning tools should take into consideration an impact evaluation of the actions planned for the territory and how consumers value them. The evaluation of an action’s viability should be based on technical, economic, environmental and social criteria.

The variables included in the five highlighted areas (environmental, economic, population, facilities and typology) were subject to a range of analysis. Using this analysis, different maps were then established by theme, constituting the degree of vulnerability or fragility of

the territory in each of the areas. The superimposition of said maps allows us to make a qualitative valuation map for the territory.

This map established a value reference for each of the areas, as well as for their spatial interrelationships. In this way, the value becomes a guideline for the study of the different territorial zones offering an integral vision of the area with regards to territorial planning.

Once the social demands have been recognized, as well as environmental and economic potentials, we will be in the proper position to establish guidelines that will contribute to improving the sustainable planning process for the territory. In order to qualitatively estimate each of the dimensions of the total value, hierarchical scales with value ranges will be applied to the thematic maps (Moldes, 1995), using said measurement as a reference for determining the critical areas and the areas with a potential for development.

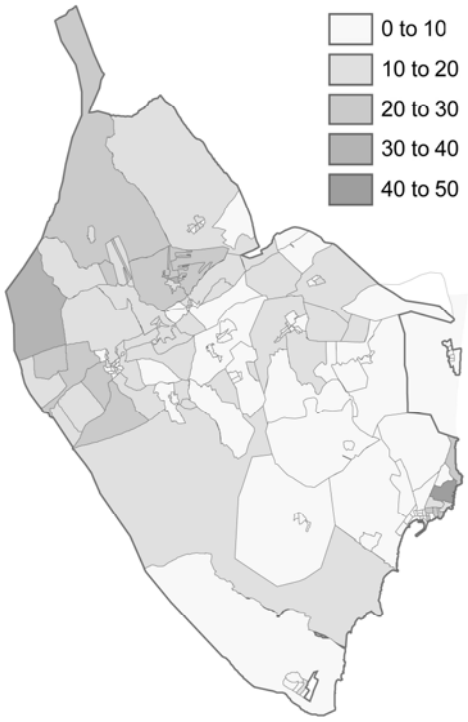
One example of these types of applications (Laurini and Thompson, 1991), was used in the selection of suitable areas for new residences in a part of Maryland where the selection criteria were based on the proximity of fire stations, secondary schools, distances from main highways and flood lands. Also of note are the territorial guidelines established to determine the most suitable area for housing developments in Randstand, Holland (Geertman and Toppen, 1990).

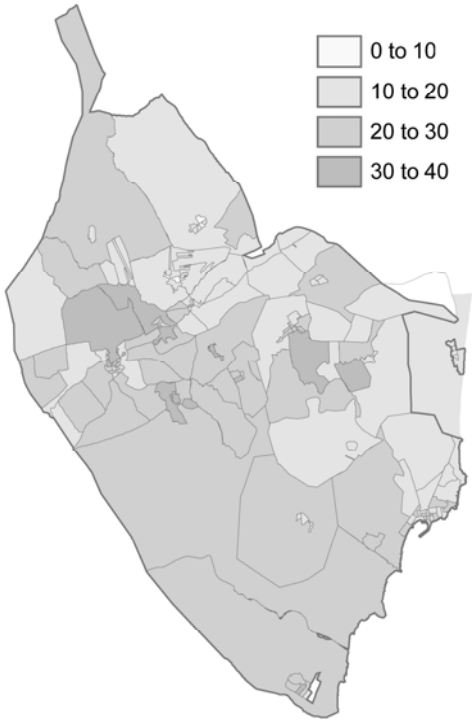
RESULTS. MAP OF TERRITORIAL VALUATION

The final goal of the executed analysis is to determine which areas are fragile, and which have the potential for development. The objective is to create a tool that makes planning decisions easier and favors the selection of the most ideal location with regards to the necessities of each demand profile. The results will therefore be displayed keeping this objective in mind.

Economic fragility

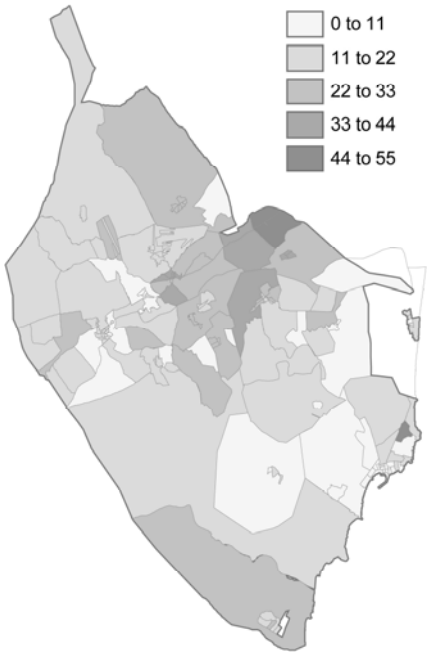
The analysis of the characteristic production sectors for each censual unit makes it possible to detect a clear a renunciation of the historic economic motor of the province: agriculture. The economic model is headed down a new road, that of the tourism and real estate sectors. This makes looking back impossible, given that much of the cultivation areas have been transformed into land susceptible to urbanization. An increasing withdrawal of the agricultural sector can be observed towards the area’s northeast, as well as a significant advance of the construction sector as it colonizes the vacated fields (Fig. 7).

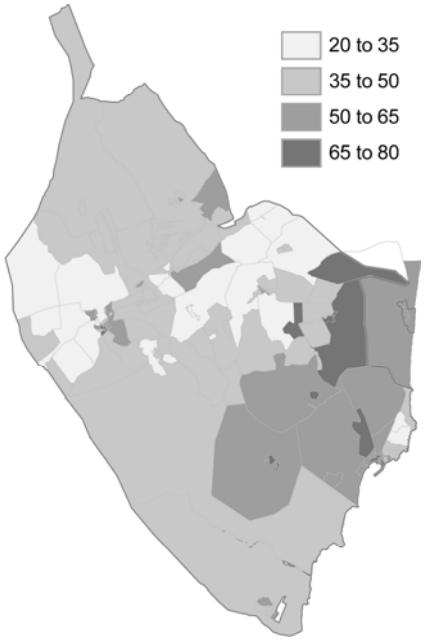




Figures 6 and 7: *Impact on the agrarian sector and construction sector within the area's economic structure. Source: the authors.*

An incipient interest in industry can also be observed (Fig. 8) next to the nucleus of Almoradí. This is sparked by the potential of the network of infrastructures and the strong implantation of the service sector (Fig. 9) in the pre-littoral strip that runs alongside Torrevieja.





Figures 8 and 9: *Impact on the industrial sector and service sector within the area's economic structure. Source: the authors.*

The new structuring of the production sectors demonstrates a clear reflection of the average socioeconomic levels of the homes and the unemployment and active population rates, while provoking a highly significant fragility from an economic point of view. The coastal and pre-coastal strips are transformed into areas with a strong economic dependence on residential tourism and its related real estate activity. The current economic situation has truly compromised the sustainability of this structure.

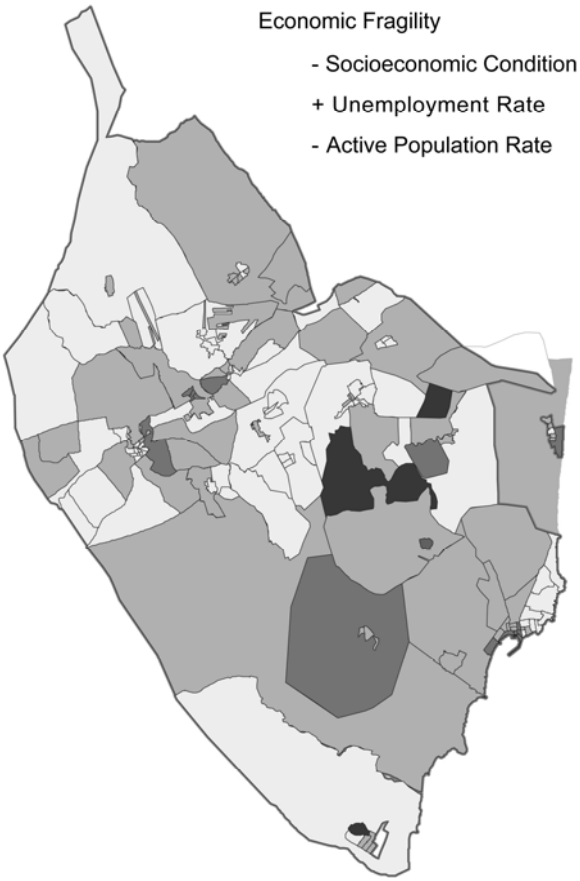
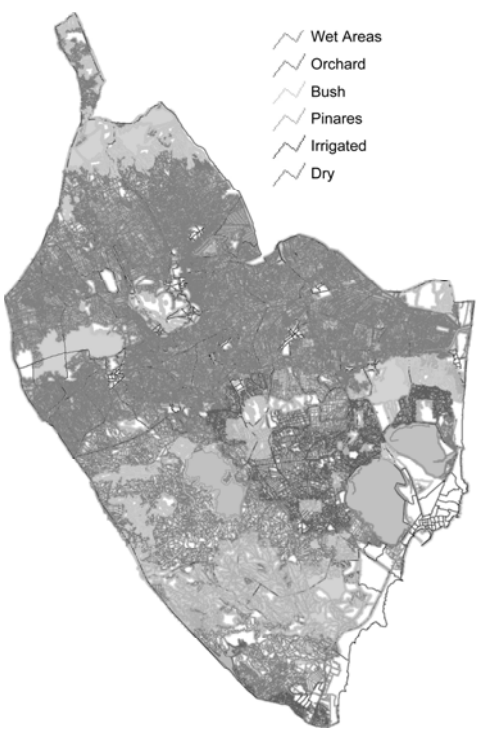
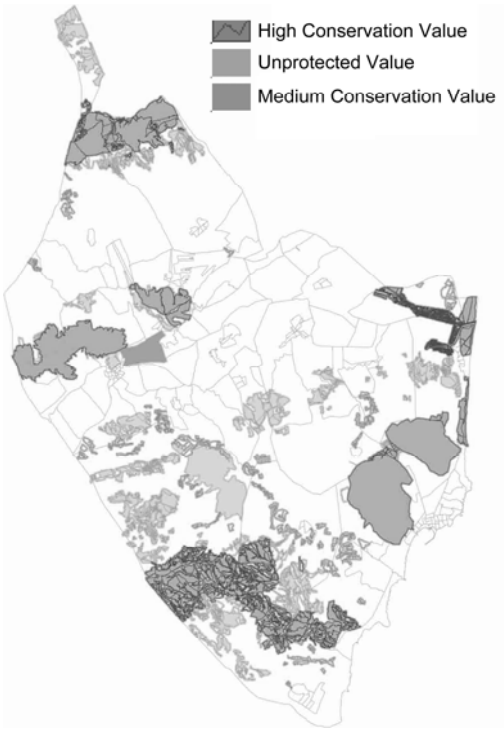


Figure 10: *Thematic map of economic fragility. Source: the authors.*

Environmental fragility

The coastal strip has been losing many of its original and potential environmental values as a result of the massive urbanization process that has reached the very edge of the coast. The most environmentally fragile areas are located on the pre-littoral strip. Here, there are highly valued areas for conservation, without any protection statues, that have been covered with golf courses in an effort to maintain a rural framework while opening the door to intense residential development (Fig. 11 and 12).





Figures 11 and 12: *Landscapes and value for land preservation. Source: the authors.*

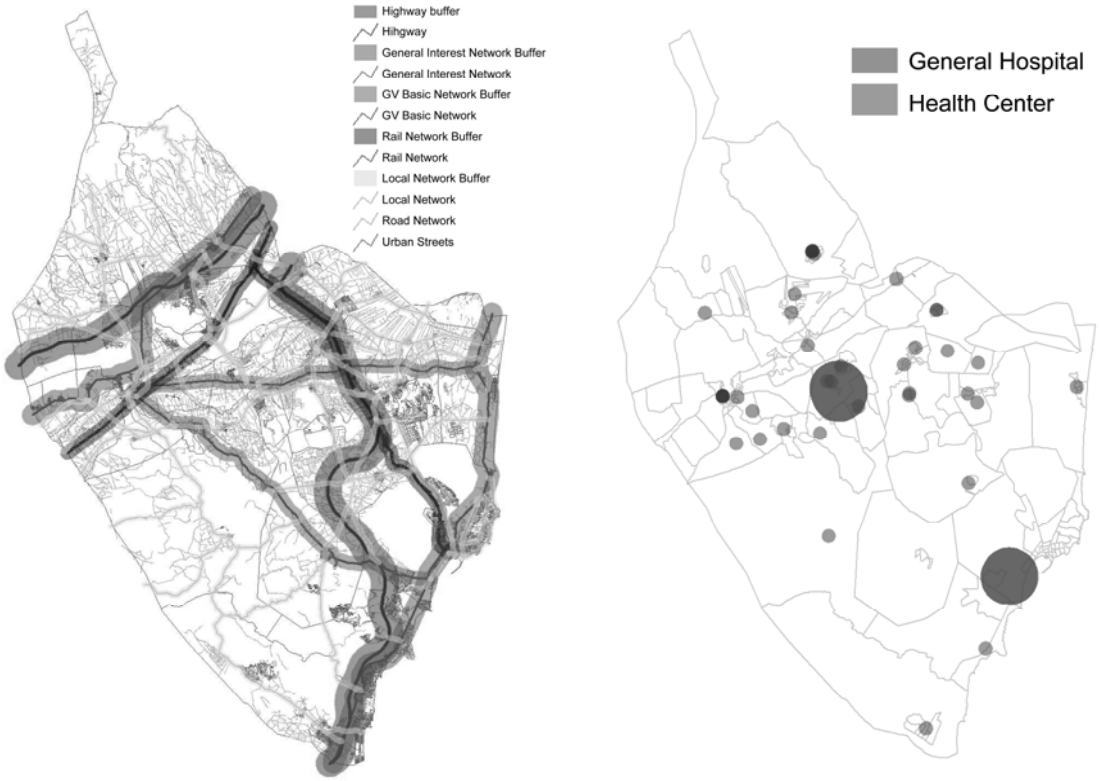
The loss of the landscape due to the "invasion" of constructed areas provokes critical situations that can be observed on the "Environmental fragility" themed map (Fig. 13). It also illustrates the need to redirect development and not stand in the way of the environmental potential, which has been significantly depleted due to the expansion practices of land markets.



Figure 13: *Thematic map showing environmental fragility. Source: the authors.*

Facilities fragility

A structural and functional analysis of the existing road network makes it possible to detect two corridors that can be considered structurally important to the area (freeway AP-7 Alicante-Cartagena, N-340 and N-332). This also makes it possible to identify the areas, which, in theory, pose more accessibility or interconnection problems, as well as the roads that present the best potential conditions from a functional point of view (Fig. 14). This analysis has been linked to the area's sanitation facilities, detecting significant scarcities in the pre-littoral strips around Orihuela Costa and Montesinos.



Figures 14 and 15: *Areas affected by the road network and sanitation facilities. Source: the authors.*

However, from a non-residential point of view, this fragility is tied to surroundings with construction activity and very high market values. Therefore, within the framework of sustainable territorial development, it is essential to conduct non-residential analysis before development. Additionally, developments cannot be planned without establishing their large-scale viability (Fig. 16).

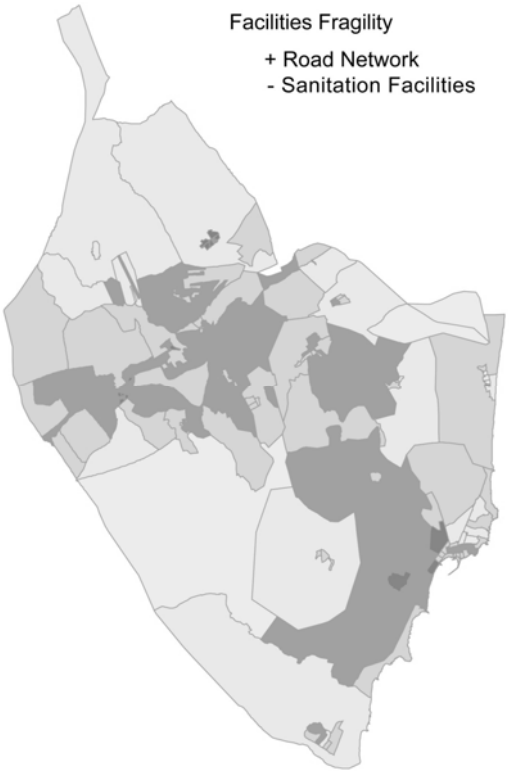
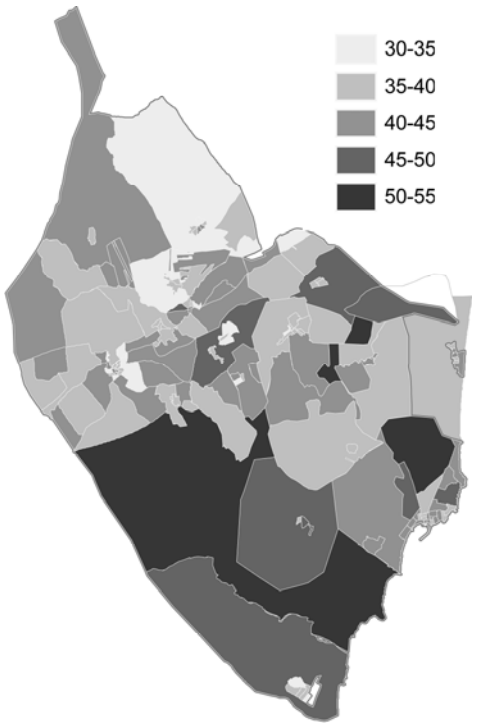
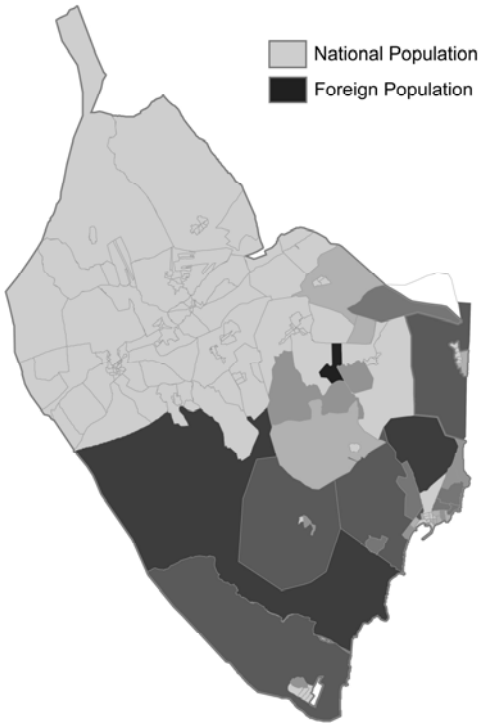


Figure 16: *Thematic map of facilities fragility. Source: the authors.*

Population fragility

The analysis of the social sphere leads to the question of whether or not we are really looking at a potentially sustainable population structure. The population features have caused a break in the economic model that clearly divides the area into two realms. The coast is crowded by a population with an average age, socioeconomic level and education level that is superior to that of the area as a whole.





Figures 17 and 18: *Average age of the population and percentage of foreign-Spanish population. Source: the authors.*

Education levels (Fig. 19) are higher near towns and the pre-littoral strip, due to older (Fig. 17), often foreign (Fig. 18), residential tourists, as opposed to local inhabitants. This structure is easily vulnerable to relevant changes, given that this type of inhabitant, while not temporary, is unstable, and has an uncertain renewal index.

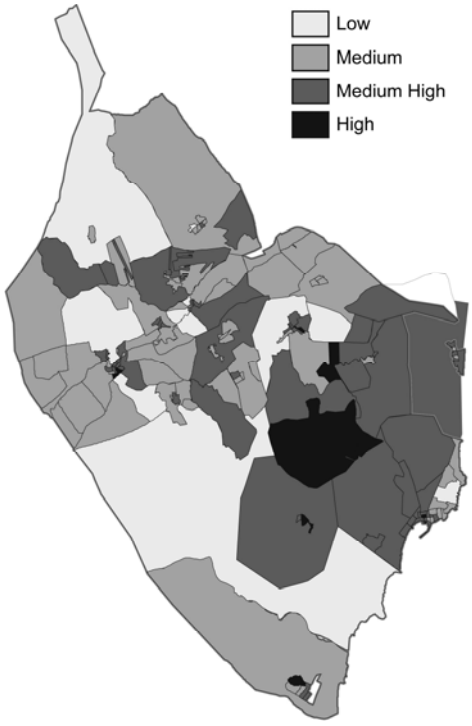


Figure 19: *Average education level. Source: the authors.*

Within this context, there are fragile areas (Fig. 20) with important issues of imbalance with regards to the modification of the population structure.

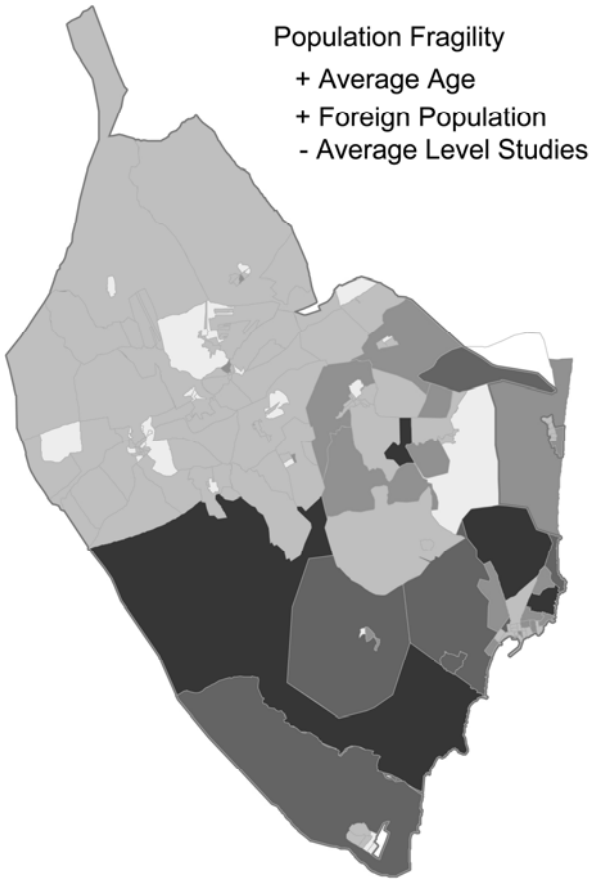


Figure 20: *Thematic map showing population fragility. Source: the authors.*

Typological characterization

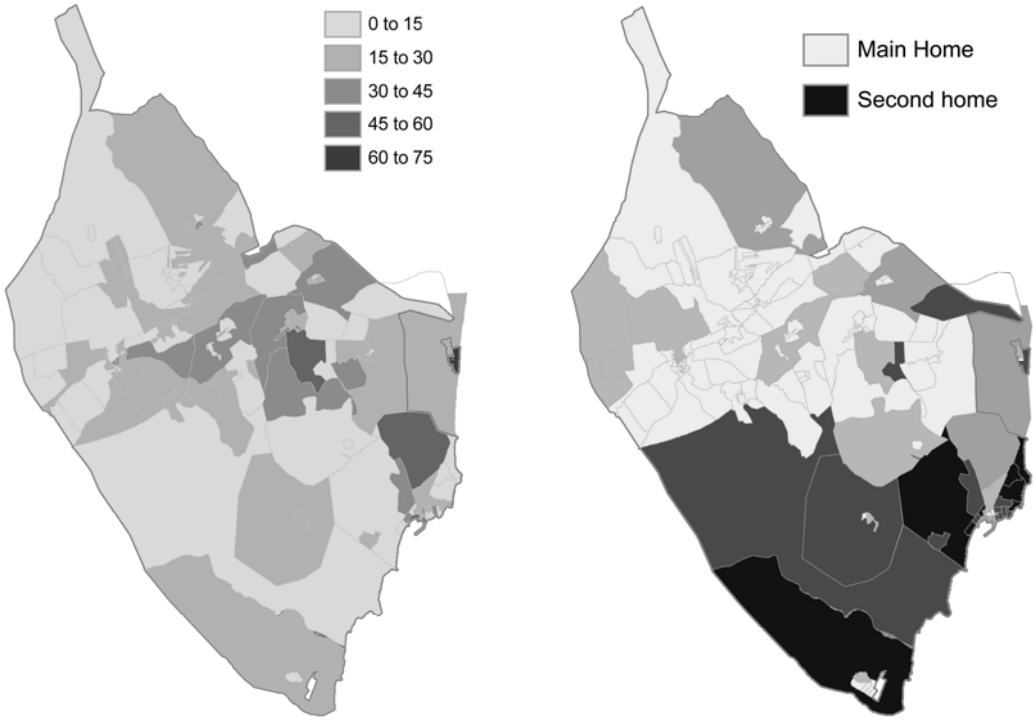
The single-family home is strengthened as the characteristic typology (Fig.21). The multi-family unit is relevant in urban centers and in the areas surrounding the town of Torrevieja. However, a trend has emerged towards a two or three-story apartment with a ground floor that has a garden, patio or solarium, imitating a single-family typology while maximizing the profitability of the land. The smallest home-size averages (Fig. 22) are located in those areas where the multi-family typology has greater significance.



Figures 21 and 22: *Characteristic building typology and average size of homes. Source: the authors.*

There is a significant percentage of empty homes (Fig. 23) in the town of Torrevieja and the pre-littoral strip where the colonization process of the countryside, through real estate promotions destined for second homes in previously unpopulated areas, has been most intense. In towns like Almoradí, Dolores, Algorfa, and Catral, the cultivation of un-irrigated crops has been substituted for urbanistic developments that have left a large percentage of homes vacant.

The seasonal variation (Fig. 24) is very apparent, given that there is a clearly discernable area destined for second homes in the southern coastal areas and another of primary residences towards the interior.



Figures 23 and 24: *Index of vacant homes and seasonal variation. Source: the authors.*

Territorial valuation and urban value

The superimposition of the thematic maps pertaining to environmental (Fig. 13), non-residential (Fig. 16), and population (Fig. 20) fragility allows create a map that shows the valuation of the territory. This evaluation will allow us to establish later the aptitude of the territory for receiving real-estate developments. In parallel, a spatial distribution has been established for both single-family and multi-family market values (Fig. 25 and 26).



Figure 25 and 26: *Spatial distribution of single-family and multi-family market values. Source: the authors.*

The highest market values are found in areas close to the coast that have been subject to intense urban developments destined for second homes. Notwithstanding, these coastal and pre-coastal zones are the most fragile from a territorial point of view. (Fig. 27)

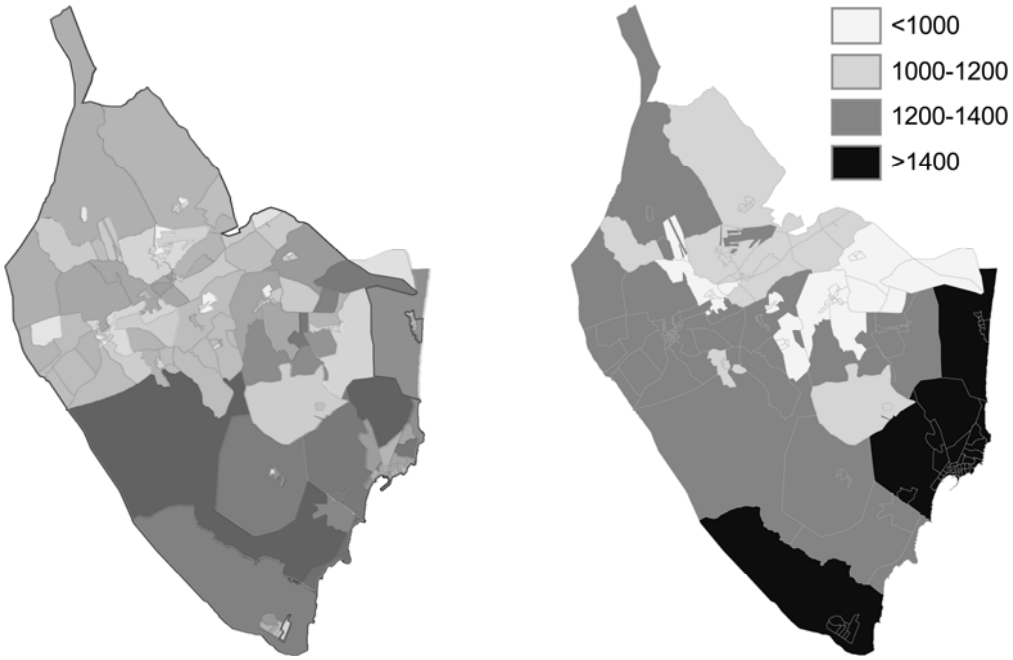


Figure 27 and 28: *Map of territorial fragility and real estate valuation. Source: the authors.*

CONCLUSIONS

The area known as the Vega Baja del Segura has undergone an intense transformation process due to the development of the real estate and tourism sectors. This has led to new demands, which are being met through a complex interaction process made up of legal statutes and political decisions, and without a clear renunciation of its "rurality". The area's development is an unequivocal example of the expansionist policies of the land market that have played out along the Spanish coast during the last two decades. The result has been a significant increase in residential land and a gradual loss of the territory's environmental values.

A justification for keeping the rural spaces alive can be found in the paradigm of sustainability, understood to be a safeguard for the environment. The medium is used as a mechanism for nature conservation and the endowment of green spaces, and as support for resources having to do with the landscape, recreation and tourism; not to mention as an indispensable space for creating areas or discontinuity between urban agglomerations.

Rural spaces are now fulfilling a new function. The different areas must be maintained in a sustainable manner a network of essential elements for achieving a balance between territory, the environmental and the landscape. This will be able to answer to an aspiration that modern societies demand as a fundamental component of quality of life.

The proposed valuation system is a tool for the global evaluation of a territory. Its usefulness is in demonstrating the territory's critical points in order to contribute to its sustainable development. The conflicts and opportunities can be evaluated through the logic of the resulting relationships. The result is a map of global valuation that points out environmental limitations, societal demands and economic potentialities. The area of Vega Baja del Segura has undergone a growing number of interventions that have been detrimental to the sustainable integration of the medium's more disturbing elements. The qualitative valuation of the territory has made it possible to detect its drastic division into two zones that are leading to a clear break in the area's structure. This break was mainly caused by factors relating to population and economic issues, which have had a decided influence on the area's development.

The obtained valuations are practically mimetic with regards to variables like the percentage of foreign-Spanish population, average age of the population and the seasonal variation. This demonstrates the clear dependence between the typological characteristics of the real estate product and the population structure.

What would be the development process for this model, based on suburban growth linked to tourism and construction, if this clear structure were drastically modified? Does this constitute a merely immediate problem, or does it open a breach in the area's structure that will be extremely difficult to resolve? Should the territorial value be protected or consumed?

It should be pointed out that the highest market values, linked to the very intense urban developments that have taken place over the last few years, are associated with those zones where they are overlapped by the greatest environmental, economic and population-based fragilities. We therefore find ourselves in a real estate market that doesn't truly respond to the territorial characterization, but rather to extraterritorial conditions that have defined both the population and economic structure.

To find adaptable solutions to the existing offer, it is necessary to make viable the renovation of the population structure or to carry out economic changes. The search for answers to these

questions points out the need to redirect development, without obviating the potentiality of the area. An indispensable tool for achieving these objectives is the designing of an urban planning that contributes to a sustainable development and adjust to the real needs of the territory. .

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IMPROVING THE DESIGN OF ADAPTABLE BUILDINGS THOUGH EFFECTIVE FEEDBACK IN USE

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Abstract

For many years the issue of how to design buildings which can adapt to changing demands has posed a considerable challenge. This debate has had renewed significance given the emergence of the sustainability agenda and the need to extract additional value from built assets through life. Developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings. This paper critically reviews literature on adaptability, together with that relating to knowledge feedback and architectural practice, in order to construct a theoretical platform for understanding how knowledge of how buildings change can be used to inform design decisions. A pilot case study is used to illustrate the ways in which buildings change could be captured to inform adaptable designs in the future. The work reveals a lack of knowledge in how buildings change and how, if this was fed back to architects, it could support design decisions that might increase the life of many buildings.

Keywords: building appropriation, adaptability, design decisions, feedback, sustainability

INTRODUCTION

Designing for adaptability has had renewed significance since the emergence of the sustainability agenda and the need to extract additional value from built assets through life. Beadle et al. (2008) argue that "adaptable buildings have the ability to change use with market conditions, enabling them to have a longer useful life". Russell & Moffatt (2001) emphasise that the building stock is a key resource that needs to be managed correctly in order for it to be sustainable - as urban areas everywhere are experiencing problems related to poor use of buildings, and high flows of energy and materials. This is supported by Bijdendijk in (Leupen et al. 2005), who claims a sustainable building has two qualities: it can accommodate change (i.e. individual values) and holds preciousness (i.e. collective values) through its exterior and shared spaces. As Graham (2005) summarizes, "A sustainable building is not one that must last forever, but one that can easily adapt to change". Thus, the

creation of a more sustainable environment can be augmented by adaptable design strategies that produce a level of building malleability, and which allow for a variety of changes to be accommodated. Thus, developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings.

The research examines the hypothesis that real accounts of change over time will provide designers with a more informed perspective towards designing for adaptability. It investigates the extent to which current feedback mechanisms provide an effective method for doing so and what new or revised mechanisms could be developed to address this need. In order to address these issues, the paper critically reviews literature on adaptability, feedback, and architectural practice, as links between the three could provide insights into improving the design of adaptable buildings by understanding what parameters are critical and how changes to them can be captured and implemented in future design decisions.

ADAPTABILITY

The section expresses an overarching understanding of adaptability, focusing on how buildings accommodate change and how this could be improved by reviewing the different parameters that allow buildings to better accommodate change. There are various definitions of adaptability, however, the overriding message of many of these reflects the ability of a building to respond to or accommodate change, whether this is specifically focused on user needs, or some wider reaching criteria, such as the state of the market (Schmidt III et al. 2010). The working definition of adaptability that will be used for this report is - *a building's ability to accommodate change throughout time, fundamentally extending its life.*

A distinction can be made between buildings that have been designed for adaptability and ones that have not. However, buildings that have stood the 'test of time' tend to be a mixture of the two, signifying that not all buildings designed for adaptability escape obsolescence and some buildings that were designed with no explicit consideration for adaptability can be adapted over time. Using a streetscape in New York City between 1865 and 1990, Brand (1994) highlights for every building that has stood the test of time there are seven that have not. This failure to survive is termed 'building obsolescence' and the cause of this can be wide ranging, including changes in legislation, technology, economic conditions or architectural style (Mansfield & Pinder 2008). Essentially the building has been unable to accommodate change rendering it no longer of use. From this, it is possible to see that there needs to be an understanding of what allows certain buildings to be adapted rather than demolished and vice versa. Understanding how buildings can or can't accommodate change will provide interesting lessons that could be fed back to help move beyond pre-described ideas of designing for adaptability, which have endured mixed success.

As a general perception in order to add adaptability into the design of a building there is a need to over specify mechanical and electrical plant sizing, floor area provision, structure, etc (e.g. Finch 2009, Ellison & Sayce 2007). This is combined with identifying physical aspects (e.g. durability of materials, span depth, floor to floor height) and specific technical solutions (e.g. moveable partitions, drop ceilings, raised floors) (Schmidt III et al. 2010, Fuster et al. 2009, Matsumura et al. 2006, Durmisevic & Brouwer 2002, Madden & Gibb 2008). In addition, understanding the configuration of a building and the interactions between its components can provide insight into how a building will endure change (Schmidt III et al. 2009). Layers provide a way of thinking about the building that link both time and the building's material form, conceiving components as different 'layers' of longevity. As Duffy (1990) clearly articulates, 'There isn't such a thing as a building… a building properly

conceived is several layers of longevity of built components'. Brand (1994) expanded upon Duffy's (1990) layers concept to include the total building (Table 1). While the table below shows the differing lifespan of components ranging from daily to eternal, it does not make any correlation with different types of change a building may go through and how architects may start to understand them.

Layer	Description	Timescale
Site	Geographic setting of building	Eternal
Structure	The load bearing elements including foundations	30 – 300 years
Skin	The exterior surfaces that provide a weather protecting layer	20 years
Services	The working guts of a building – HVAC, electrical, plumbing, sprinklers etc	7 – 15 years
Space Plan	The internal layout – internal partitions, doors etc	3 – 30 years
Stuff	Furniture, equipment, personal positions of occupants	Daily

***Table 1**: Building layers and time (adapted from Brand 1994)*

Schmidt III et al. (2010) expand the concept of layers by linking them to six different strategies or types of changes for thinking about adaptability (Table 2). This provides a more comprehensive idea of how buildings evolve over time, while not attempting to predict what may happen to buildings - it is simply linking different types of change with how often and to what parts they are likely to change.

Strategy	Type of change	Building layer(s)	Frequency of change
Adjustable	Change of task	Stuff	High
Versatile	Change of space	Stuff, Space	High
Refitable	Change of performance	Space, Services, Skin	Moderate
Convertible	Change of function	Space, Services, Skin	Moderate
Scalable	Change of size	Space, Services, Skin, Structure	Moderate/low
Moveable	Change of location	Structure, Site	Low

***Table 2:** Adaptable strategies and layers (adapted from Schmidt III et al. 2010)*

The consideration of the proposed layers and strategies suggest a framework for which specific examples of changes accrued can fit into and may enhance design decisions towards a more adaptable designed solution. It is therefore crucial that this understanding of change over time is fed back to architects.

FEEDBACK

Leaman & Bordass (1993) suggest that "Good design seemingly creates opportunities out of apparent constraints; Bad design seems to deny opportunities". But how is it possible to tell what is good or bad design without feedback?

This section explores the literature pertaining to feedback and how this has been used to inform design decisions. A number of publications examining the evaluation of buildings

(Gorgolewski 2005, Preiser 2005), show how feedback could be integrated into every stage of a building's lifecycle, for example, through building log books, Sea trials, POEs or DQIs. However, in practice most architects and contractors have shown little interest in learning how their buildings actually perform in use (Bordass 2005).

According to Bordass & Leaman (2005) there are currently five different categories of feedback techniques ranging from a type of audit where quantitative methods are used to measure the buildings technical performance, to package and process techniques which incorporate both quantitative and qualitative methods. These methods include: an in-house team to support the clients moving in and solving any small problems that may become chronic irritants such as the Soft Landings approach (Bordass 2005); a design review (Cook 2007); and a workshop with all major stakeholders (Preiser 2005). It is important also to note that the methods can also be distinguished by who they're carried out by - between users or an expert (Bottom et al 1998). User feedback offers an occupants' subjective perception of the space, where as expert feedback is aimed at objectively quantifying building characteristics. These feedback techniques are meant to gain a holistic view of the building in use; however, they do not currently include techniques that explicitly document how buildings change over time.

An example of a technique from the audit category is the CIBSE TM22 (Bordass et al. 2001). This technique, mainly aimed at service engineers, is a method of surveying and reporting the energy use of a building at any time. Given the data collected, it can also calculate the anticipated savings due to a change in use, which is valuable for engineers, but offers less value to architects, who are unlikely to use it due to its specific role in telling engineers the performance data of the building.

An exemplar from the discussion category is the Learning from Experience (LfE) handbook (Bartholomew 2003). This technique uses interviews to review and reflect on projects. Intended for large construction organisations, it is excellent at transposing tacit knowledge gained on the project to the rest of the organisation. Its main focus is on the business case and where money can be saved. It does, however, ask three main questions that could be very useful for feeding back and documenting change to architects. These are: what happened; why did it happen; and, what can be done better? These provocations could be adapted to look at change within the building, e.g. what has changed? Why has it changed? How could this improve future design?

There are many different approaches within the questionnaire category, including the AUDE POE Guide and Building Use Studies, which are aimed at the client and the users' perception respectively. The majority of these approaches are limited by the fact that a questionnaire cannot explore the building in any depth; in order to gain any depth the questions would have to be qualitative in nature. One questionnaire method that offers some insight is the Design Quality Indicators (DQI) survey (Gann et al. 2003). This user focused technique starts off as a questionnaire, but also includes workshops to discuss the findings with the stakeholders in order to gain a fuller understanding of the meaning behind the data collected. The survey is designed so that these workshops can be conducted at any stage in the project from the preparation and briefing phase to the building-in-use phase. The two most important phases for this research are expected to be the design phase and the use phase, and these are also identified as key phases in the original DQI methodology, because in these phases all of the main stakeholders are brought together to discuss how improvements could be made, allowing for a much broader remit of subjects to be explored. During the design workshop, materiality and the needs of the user are the key focus. During the use phase workshop, the

impact of the building design on the users is discussed and recorded, implicitly a workshop of this kind will produce some explanation of what has changed within the building and why. However, the DQI methodology does not attempt to understand these changes using a verified framework. Nor does it explicitly feed this knowledge back to the architect with the purpose of improving future design decisions. This could be due to the focus of the workshop relating to how to improve the users' environment, rather than how architects can improve future work.

One of the most successful feedback tools used in recent years is based on the PROBE studies (Derbyshire 2001). This tool is essentially an amalgamation of some of the approaches discussed above, mainly looking at user satisfaction, energy consumption and manageability (Blyth & Worthington 2000). What made this so successful was that it managed to publish all of its results in the public domain, meaning that the knowledge could be transferred further than just the participating companies. However, in the context of this work, because this tool is very much based in the engineering field, it is not expected to offer much insight regarding how architects design decision-making might be informed in pursuit of adaptable solutions.

The major problems with existing feedback techniques are that they are all based around two objectives; the technical performance of a building and the improvement of the users environment. They are also currently based around a single point in time, only DQIs are strategically set up to be implemented at different points in time. However, they are still based around a prescribed set of questions aimed at the user's perception none of which may be valued by architects, who instead of looking at the shortcomings of a completed building would much rather move on to the exciting task of a new assignment (Blyth & Worthington 2000). It is therefore important to understand how feedback mechanisms could match architectural values, and how this link could allow for an effective feedback tool that engages the enthusiasm of architects. It is also worth noting that in order for feedback techniques to be successful, champions of feedback need to make a more persuasive case to a broader range of stakeholders as well including clients, developers and occupants on the added value or real savings that can be gained from feedback (Zimmerman & Martin 2001).

ARCHITECTURAL PRACTICE

This section attempts to express the link between architectural practise and feedback pertaining to how buildings change. An architect's values are what set them apart from other professions when it comes to the concept of designing buildings (Cohen et al. 2005), and shape why architects design the way they do. These values can come from an architect's education or experience, and motivate the decisions and guide the behaviours of the designer. Broadly, values are defined as principles, standards, and qualities that guide actions. (Le Dantec & Do 2009).

Most architectural values are based in the visual arena (aesthetics, visual perception, beauty); this is hardly a surprise considering the nature of architectural work and what they are creating (Till 2009). The idea of timelessness or time standing still is also articulated; suggesting most architects ignore time to focus on the aesthetic fixation and immediate functional performance of buildings (Schmidt III et al. 2010). This is likely to create a fundamental barrier to the idea of learning from feedback in the conventional sense. However, it is not suggested that architects do not want to learn per se. This is backed up in their values, when Schön (1984) states that architects are always learning in the sense that architects learn by doing in order to build up their experiences, therefore they are continually

learning through experience. This is supported with what is found in modern practice where architects engage in CPD (continuing professional development) events, lunch seminars, and evening training courses typically aimed at improving computer skills; knowledge of new materials/ regulations; or learning about architectural theories, practices and buildings. Ethics and a feeling of social responsibility are also mentioned (Till 2009), which shows that architects should be open to learning in order to improve the built environment.

Clearly, these values can have a significant impact on how architects design, so it is important to understand how these values develop, in order to conceive how best to affect design decisions. Architectural education is a very important concept to explore; it sets the foundation as to how architects learn both during education and in practice, providing insight into how value systems are shaped. Cuff (1991) insists that architectural education has, for a considerable amount of time, been very much based around learning how to be creative and thinking for yourself; while Lawson et al. (2003) adds that 'knowing by doing' is a readily accepted method of educating within architecture.

A strong criticism of the education system is that "adaptive use is the destiny of most buildings, but it is not taught in architectural schools" (Brand 1994). Most programs emphasis innovation and novelty (Glasser 2000), very little education goes into how to change existing buildings, so there is no knowledge taken forward from education into practice in this area (Kohler & Hassler 2002). Perhaps an answer as to why architectural education and practice are different lies in the fact that, within architectural education it is expressed that it must not mimic the real world in all aspects, as it serves a very important creative and exploratory purpose and if they weren't taught this within education, architects would not be able to apply this conceptualisation in practise (UIA 2005). An additional argument for why education can't directly mimic practice is that the complex web of social interactions that are played out by architects in practice may be hard to replicate in an educational environment (Demirbas & Demirkan 2003).

The above arguments seem to suggest that, intentional or not, there is a missing link between education and practice. It is understood that architectural education must be used as a time to expand creative knowledge; however, the content of that exploration could incorporate an improved understanding about how buildings change. This could still match the underlying problem solving nature of the education (UIA 2005) and might generate creative solutions to current adaptability issues.

Although the value system is shaped in education, it is also instilled within practice; therefore it is also important to examine the literature surrounding architectural practice. There are many problems in practice that not only act as a barrier to learning but can also reduce the quality of the buildings that are produced. A fundamental problem with project-catered organisations is often there is a need to work with new teams, including clients and contractors (Macmillan et al. 2002), which can reduce levels of trust, and the need to build a relationship becomes key, rather than learning, as would be typical of more mature relationships.

A more recent issue is the shift in power within the construction industry from architects to contractors (Kieran & Timberlake 2004). This often means that the architect is merely a subcontractor (Krygiel & Nies 2008), which could be a barrier to 'architectural' feedback; if the client only wants the architect to create the aesthetics of the building. With re-use and refurbishment of existing buildings becoming increasingly important to sustainability (Pearce 2004), and sustainability becoming increasingly important to clients, it could be argued that

architects could regain this power if they had an increased understanding of how buildings can change over time.

A repetition of mistakes because of a lack of learning from past projects is a recurring theme within the literature (Bordass & Leaman 2005). Heylighen et al. (2007) argue that architects (and the building industry in general) have a tendency to disregard past projects in order to concentrate on future ones. This is also reinforced by the way contracts are framed and finished at the end of construction (Barlow & Koberle-Gaiser 2009). In order to incorporate a way to understand time and change in current architectural practice, it is important that lessons are learnt from the entire building stock and how it has changed, so that design decisions in pursuit of creating adaptable solutions can be better informed.

METHODOLOGY

The pilot case study served as a tool to inform and refine data collection plans (Yin 2004). The aim was to gain a holistic understanding of the building and to explore whether there were any lessons to be learnt and fed back to the architects. Qualitative data was collected for this preliminary exercise through semi-structured interviews with major stakeholders of the Nottingham science park; this included the architect, the building manager and developer.

The interviews covered a range of questions geared at uncovering stakeholder values and roles along with understanding what changes were planned for in the design process and what changes have already occurred in use. The questions were based around gaining information in relation to the six strategies presented earlier as they would be used to organise and analyse the different types of changes. Data from each interview was then coded and a thematic content analysis was conducted in relation to each of the adaptable strategies outlined in an attempt to answer the research question posed at the start of this paper - How might design decision-making in pursuit of adaptable solutions be informed?. Through analysis of the interviews the provocations presented at the end of each adaptable strategy are an initial attempt to glean lessons from the data.

CASE STUDY

Nottingham Science Park

The Nottingham Science Park is a speculative office development constructed by the developers Blueprint and designed by the architects Studio Egret West. It was completed in 2008 and is located on the outskirts of Nottingham in the area of Beeston opposite Nottingham University. The development offers a range of spatial sizes (1000 to 20,000 sq ft sized offices), fit out levels (shell & core to full lab spec), design (grade A office to bespoke solutions) and leases (flexible lease terms to suit individual requirements).



Figure 1: *Exterior perspective*



Figure 2: *Internal layout*

Adaptable Strategies

Adjustable

Most of the rooms can be reconfigured as none of the furniture is fixed. However this could be a larger undertaking than first realised as when an office is fit out electrical plugs are positioned under the desk layouts through the raised floor. If this layout was to change the electrical plugs would have to be moved also. Another related issue is the fact that fresh air comes through ducts in the raised floor so these would have to be moved away from the underside of desks for user comfort. Both of these reduce the adjustability of the office space; however, it is still feasible compared to providing fixed furniture. *Could alternative electrical and ventilation solutions been provided to ease the shifting of furniture?*

One of the changes that have already occurred within the building is the addition of a carpet to the mezzanine floor as it was found that people walking on the hard floor caused too much noise for the adjacent meeting rooms. *What is the appropriate level of acoustics for the meeting room and other areas? Could the walls been detailed differently initially to accommodate the hard wood floors?*

Versatile

The science park is very flexible as stated by the owner, “We wanted a very flexible layout with a notion of a central hub with a series of pods going off it.” The park can be split from a series of small offices of around 1000 sq ft to the occupation of a full floor.

One interesting point which could hinder versatility is the management of how the offices are split up. For example if a company wanted to expand yet the management had put another office in the adjacent section it would not be possible to simply knock down the partition wall, the expanding company would have to be relocated or given a separate office. *Is it possible for the configuration of space to be designed so that the segregation of offices is optimal? Are there different operational processes that could improve the configuration of space?*

Refittable

The science park has a very high specification of services within it, these services have been designed so they can be divvyed up into different sections, which help with the versatile aspects of adaptability; however, it could also be argued that a major refit would be aided by

the design as long as it was a similar configuration as to what is there now. The ability to add extra ventilation has already been brought into question when one of the clients requested a laboratory section to their space. This request was granted however the solution for adding additional ventilation was clearly not considered before the request as there is a ventilation tube now stuck through an open window. Reasons for this stem back to the envisaged uses of the building not including laboratories.. This request was however said to be easy in the sense that the raised floor could be removed to incorporate the additional loading strength. However another issue was the insurance implications for the building, the building itself could sustain this type of activity however the insurance was an issue as it was built predominately as an office building, this clearly wasn't thought about. *Are there any uses that would require extra services? What is the strategy for refitting the services of the building?*

The cladding could also be refitted easily as it uses a dry connection fitted to insulation, however when asked whether this was a consideration when writing the brief for this project the developer stated that it was "post rationalisation". The architect also added that it 'could' be very easy to re-clad the building, but didn't see this as a likely scenario. *As the skin of a building is envisioned to last approximately 20 years and the structure intended to last much longer (in regards to Brands layers) shouldn't there be a strategy to replace the cladding? Would an easily removable skin aid in the external maintenance of the building?*

Convertible

Convertible strategies involve changing the use of a building. In terms of the science park, it wasn't envisaged in the brief and would be very difficult for many reasons. Location would be a major reason as it is located next to another science park (opposite a university) and out of town, so there is very little demand from within the retail, accommodation, or entertainment sector. The structure itself probably could lend its self to residential in that it can be split into small sections, however there would be very limited local amenities. Planning constraints (e.g. zoning), building regulations (e.g. fire regulations), and zoning of services could also limit this. The structure could accommodate interactive classrooms with in it; however it wouldn't be able to accommodate a split level lecture theatre, so it wouldn't be ideal for an education building. In terms of other university uses, it could be converted into administrative space or a place for non laboratory research. *What functions could this building be equipped to change to with minimal effort? What is needed to accommodate a wider range of uses? What uses could the surrounding area support? Does the lack of public transport affect the diversity and livelihood of the location?*

Scalable

In terms of the scalability of this building, it is built to a set size and there is no plan to ever extend it. If the foundations were overdesigned it would be able to take an extra floor, however, the majority of the plant is on the roof meaning that it would be a major job to refit these elsewhere. *If the park is very successful how does it accommodate the additional space demand?* In terms of location and according to the master plan of the site there is a further plot that could be used to build a replica if the science park proved very successful. *Are there any planning restrictions on what can and can't be built on this site?*

Moveable

The movable strategy has no relevance to this project.

DISCUSSION

In pursuit of answering the research questions several points can be summarised from the work undertaken. It has been put forth that architects are much more interested in the aesthetics of a building rather than how it may change in the future, rendering adaptability (i.e. real appropriation/change) a still poorly understood topic by architects. Current feedback mechanisms are too focused on the building's performance characteristics and not on its physical reshaping. They do not match an architect's complex value system, which is why architects appear disinterested about learning from them. In addition, conventional education and design processes for architects don't value the building as a dynamic process, but as a static finished object.

The above points have lead to the assertion that there are no current mechanisms that communicate the changes in a building's life back to architects in a way that matches well with current values/processes. This argument has been positioned by the literature and exploratory case study by exploring how adaptability can be stratified in time as a series of strategies and layers, how current feedback mechanisms don't communicate changes in the built form, and how current mindsets and processes of stakeholders undermine attempts to feed knowledge back.

In the pursuit of adaptable solutions it remains critical that an effective feedback mechanism, which takes into account architects values and ways of working, be developed in order to better inform future design decisions. This method must support accessibility of explicit knowledge, rather than tacit knowledge, to ensure that any understanding of change has a tangible impact on the profession. The case study illustrates this by showing a number of provocations that, if thought about during the briefing/design stage, could have affected the composition of the building itself. They may not have changed the overall aesthetic of the building but may have improved the configuration and relationships of some elements. This mechanism could compliment other techniques that are currently implemented when a building is in use (e.g. DQIs) by adding an understanding of the changes that have occurred within the building through the adaptable strategies and framework. The next step in the research is to suggest a feedback technique that would best match architectural values.

CONCLUDING REMARKS

Developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings. It shouldn't be an attempt to predict what buildings may change into in the future as, "all buildings are predictions and all predictions are wrong" (Brand 1994), but rather an attempt to construct a platform for capturing and understanding how knowledge regarding the way buildings change can better be used to inform design decisions. This can be supported by understanding how buildings change - by defining different types of changes and how they relate to the different physical elements - by understanding the available methods for knowledge to be transferred from the operational phase of buildings back to the producers of buildings and by understanding the processes and values the producers hold.

Adaptability can no longer be seen as a 'one size fits all' solution and should be developed with the complexity it affords; lessons can and need to be learnt from the building stock in its entirety, which should only improve the design of adaptable buildings in the future.

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DIVERSITY MANAGEMENT: MANAGING MIGRANT CONSTRUCTION WORKERS ON CONSTRUCTION SITES IN SINGAPORE

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Abstract
It is not sustainable for construction projects in Singapore to rely merely on a Singaporean workforce due to the low participation rate of indigenous workers. A typical construction site in Singapore thus comprises migrant workers from several countries. This gives rise to the need for diversity management on construction sites to ensure social sustainability. The aim of this research is to examine styles that project managers adopt when managing multi-cultural migrant workers in construction projects. The specific objectives are to: investigate the socially sustainable managerial practices adopted by project managers when dealing with migrant construction workers from China, India and Thailand; and identify if there are any differences in management practices when dealing with migrant construction workers from different countries. The research method is questionnaire survey, and data were collected from project managers who had managed migrant workers in Singapore. In-depth interviews were also conducted to confirm the statistical results. The research found that project managers tend to use task-oriented more than relation-oriented management style to achieve social sustainability. The management practices that are significantly implemented include requiring workers to be punctual, giving assertive instructions, providing close supervision and enforcing rules so that social sustainability can be maintained on construction sites.

Keywords: Social sustainability, diversity, leadership, management.

INTRODUCTION

A construction project usually requires a large number of workers. In Singapore, relying on indigenous workers to undertake construction work is not sustainable because Singaporeans eschew this sector of the economy. Official statistics show that the construction sector in Singapore is the most reliant on migrant workers as it attracts only 6.1% of resident workforce (Singapore Department of Statistics, 2000). On a typical site, construction

workers may hail from countries like Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka and Thailand. This suggests the need for construction projects to be managed in a socially sustainable manner, taking into account cultural diversity as a result of the workers coming from different countries.

Gilbert et al. (1996) defined social sustainability as practices to ensure that the cohesion of society and its ability to work towards common goals are maintained, and that individual needs should be met. Using inappropriate management practices can render projects to be managed in a socially unsustainable manner, which would result in serious consequences such as stress among the workforce, confusion, frustration and conflict which translates into lower morale, productivity, quality problems and higher accident rates (Loosemore and Lee, 2002). It is thus essential for project managers to apply appropriate management practices in order to effectively lead a multi-cultural construction workforce in a socially sustainable manner.

The aim of this research is to examine leadership styles of project managers when managing multi-cultural migrant workers in construction projects. The specific objectives are to: investigate the socially sustainable managerial practices adopted by project managers when dealing with migrant construction workers; and identify if there are any differences in management practices when dealing with migrant construction workers from different countries. The purpose of identifying leadership styles and management practices is to inform project managers who are going to manage sites with migrant workers from several countries on the more effective practices and styles to achieve social sustainability.

The scope of research covers Singapore resident project managers' management of migrant construction workers from mainland China, India and Thailand on construction sites in Singapore. It is widely observed that the largest percentage of migrant workers come from Singapore's nearest neighbour, Malaysia, though published statistics is not readily available. Malaysians have similar culture to Singaporeans due to geographical proximity and historical links, and therefore, they are excluded from this study. Chinese, Indian and Thai workers are the next three major nationalities on Singapore's construction sites and are therefore selected for this study. The terms Chinese, Indian and Thai in this paper refer to workers' nationalities. Singapore resident project managers, who are the subject matter experts to inform this research, are project managers, construction managers and supervisors who are Singaporeans or permanent residents of Singapore who are not from India, China or Thailand, and who had personally supervised migrant workers from these countries. For brevity, they are generally referred to as 'project managers'.

LITERATURE REVIEW

The effectiveness of a project manager is a vital component in the success of construction projects (Enshassi and Burgess, 1991). Anderson (1983) defined effectiveness as the manager's ability to supervise and manage subordinates. Laufer and Jenkins (1982) suggested that management has a direct and indirect impact on the level of productivity. The direct impact can be achieved by planning and controlling construction activities while the indirect impact is attained through a good interrelationship between managers and their subordinates that may raise the motivation of the work force. In Singapore, project managers have the additional responsibility of managing cultural diversity among migrant construction workers to ensure social sustainability.

The most common cross-culture management challenge is to facilitate culturally-diverse people to work together which requires special skills and sensitivities (Child, 1994). Cross-cultural management studies have provided several leadership styles to cope with cross-cultural differences. Among these, Contingency Theories (Fiedler, 1964; Hersey and Blanchard, 1969) appear to be the most relevant.

Contingency Leadership Theories

Fiedler's (1964) Contingency Theory of Leadership asserts that group performance is contingent on the leader's psychological orientation and on three contextual variables: group atmosphere; task structure; and leader's power position. Further, group performance is a result of interaction of leadership style and situational favorableness. Leadership effectiveness is the result of interaction between the style of the leader and the characteristics of the environment in which the leader works.

Hersey and Blanchard's (1969, 1977) Situational Leadership Theory rests on two fundamental concepts: Leadership Style and the individual or group's Maturity level. It states that there is no single 'best' style of leadership. Effective leadership is task-relevant and the most successful leaders are those who adapt their leadership style to the maturity of the individual or group they are attempting to lead or influence.

Based on contingency theories, two leadership styles are identified: task-oriented leaders; and relation-oriented leaders (Enshassi and Burgess, 1991). **Task-oriented** leaders are those who are mainly concerned with planning, work organization, control, efficiency, and productivity, while **Relation-oriented** leaders are those who give priority to managing internal relationships among employees and themselves, and to an understanding of cultural differences between their subordinates (Enshassi and Burgess, 1991). Task-oriented leaders are predicted to be most effective in either highly favorable or unfavorable situational conditions while relation-oriented leaders should be more effective in the intermediate range of favorableness (Barrow, 1976).

Managing cultural diversity

Cultural diversity has been studied by Hofstede (1980, 1984, 2001). He operationalized culture into 4 dimensions: power distance; uncertainty avoidance; individualism vs collectivism; and masculinity vs femininity, and subsequently added long-term orientation. He has provided indices of these dimensions for many countries, including China, India, Thailand and Singapore. The indices for the countries are different from each other, suggesting cultural dissimilarities among these nations, leading to differing values, beliefs and practices among the migrant workforce on construction sites in Singapore.

Project managers should understand the cultural differences of their subordinates in order to be effective as cultural heterogeneity has a considerable impact on their effectiveness. Low and Leong (2001) designed an Asian organizational managerial framework to manage cultural diversity. They found that an effective leader possesses the ability to influence group members towards the achievement of goals. Thus, effective management of a culturally diverse workforce ultimately contributes to the overall effectiveness of the manager and productivity of the company.

In managing a culturally diverse workforce, differences in cultural traits among workers of different countries have to be recognized in order to understand their mindsets and behaviour, so that supervisors can manage migrant workers effectively. This calls for managers to

develop and implement practices aimed at improving the effectiveness with which the organization utilizes diverse work force, i.e. diversity management. Gilbert et al. (1999) defined diversity management as a complete organizational cultural change designed to foster appreciation of demographic, ethnic and individual differences. It is argued that the challenges within competitive, dynamic and increasingly global markets are best met by an effectively managed workforce that has a diverse experience and knowledge (McCuiston et al., 2004; Seymen, 2006). Bergen et al. (2005) found positive impact of diversity while Curtis and Dreachslin (2008) found diversity impacts performance negatively.

Gap in knowledge

Many leadership studies in construction have been undertaken. Muller and Turner (2010) examined the leadership competency profiles of successful project managers. Toor and Ofori (2008) put forward authentic leaders as a new breed of construction project leaders who possess positive values, lead from the heart, set highest levels of ethics and morality and go beyond their personal interests in the well-being of their followers. These and many other studies did not address cross-cultural management in detail, and did not study management of construction workers. Wong et al. (2007) investigated cross-cultural leadership perceptions and power relationships of Chinese and Western expatriate project managers in multinational construction firms in Hong Kong. While they studied intercultural interactions, it was at the professional level, and not how construction workers are managed.

To effectively manage migrant workers from different cultures, it is important to know what leadership styles and management practices should be adopted. Otherwise, problems such as poor productivity and communication difficulties caused by different work ethics, culture and customs between managers and migrant workers would arise (Son, 2005). However, despite the need for project managers to manage a culturally diverse workforce, insufficient studies have been done to identify the more effective practices to manage migrant construction workers from different nations and different cultures. One study by Han et al. (2008) of foreign construction workers focused on their low performance due to regulations, qualifications and management systems. The study did not investigate leadership styles for migrant workers from different nations.

It is not known if different leadership styles need to be adopted for migrant workers from different countries. There is a lack of information and empirical data with respect to the effectiveness of project managers in managing multi-culture migrant workers. The fieldwork was therefore undertaken to investigate the practices adopted to manage migrant workers and explore how project managers may be more effective in cross-cultural management on construction sites.

RESEARCH METHOD

The research adopted a two-pronged approach: questionnaire survey and in-depth interviews. The purpose of the questionnaire survey was to test whether the managerial styles identified from the literature review are adopted by project managers when dealing with migrant construction workers, and whether the practices differ when migrant workers come from different countries. The purpose of the interviews was to confirm and elaborate on the statistical results.

The data collection instrument comprised a questionnaire which was pre-tested. The first part

of the questionnaire contained demographic questions, while the second part contained structured questions relating to practices adopted in managing workers of different nationalities, developed based on the literature review. The respondents were required to rate the extent to which the practices described the way they managed migrant workers from mainland China, India and Thailand on construction sites in Singapore. The majority of the questions required respondents to rate on a 5-point scale, where 1= strongly disagree; 3= neutral; and 5= strongly agree.

The population comprised project managers, construction managers, professionals and supervisors who had supervised migrant workers in Singapore. The sampling frame was government registered construction firms. Emails and follow up telephone calls to 90 randomly selected Singapore registered construction firms were made to invite participation in the study. 32 responded via a mixture of emails and face-to-face interviews, giving a response rate of 36%.

The second research prong involved face-to-face in-depth interviews with three subject matter experts who had personally supervised migrant workers extensively. They have worked in the construction industry for more than 8 years.

RESULTS AND DATA ANALYSIS

Characteristics of the sample

The characteristics of the interviewees are shown in Table 1.

***Table 1**: Demographic characteristics of respondents*

Description	Frequency	Percentage
Designation		
Senior Management	4	13
Middle Management	20	62
Professional	8	25
Gender		
Male	32	100
Female	0	0
Experience (years)		
Up to 10	11	34
11 – 20	15	47
> 20 years	6	19
Nationalities of workers supervised		
China	31	97
India	32	100
Thai	24	75
Malaysia	30	94
Philippines	23	72

All the respondents are Singapore residents and had supervised at least 4 different nationalities of migrant workers. The majority of the respondents are in middle management (site managers, project/construction managers, site supervisors and site engineers) and had

more than 10 years of experience in the construction industry (average = 15 years). None of the respondents belong to these 3 nationalities.

Qualities of effective project managers in diversity management

The t-test results on the qualities required for the effective management of migrant workers are shown in Table 2. The results show that with the exception of 'ability to gain authority over workers by instilling fear', all the other qualities are significantly important ($p < 0.05$). Effective project managers need to, in descending order of importance: be able to give clear and firm instructions; posses high technical ability; be able to build and maintain relationship with workers; be able to understand the language spoken by migrant workers; be able to understand culture variation; and be able to motivate workers.

The findings show that the top two qualities relate to task-oriented leadership style, indicating that this style is important for managing a multi-cultural migrant work force effectively. Relation-oriented leadership styles, though important, are perceived to be of lower importance, given their relatively lower means. Gaining authority by instilling fear is not emphasized (mean= 2.44; p= 0.001). This may be due to the prevalence of high collectivism and low individualism in the cultures of migrant workers (Hofstede, 1980). High collectivism culture would place high emphasis on building relationships and therefore it is not appropriate to control these workers by instilling fear. Instilling fear is also not correct as people may find ways to get back at their managers and hide information to protect themselves from punishment (Maccoby et al., 2004).

***Table 2**: Qualities required in managing a foreign workforce*

Quality	Mean	Std. dev	T-value	Sig. (2-tailed)	Leadership style
Ability to give clear and firm instructions	4.66	.483	19.416	.000	Task-oriented
High technical ability	4.28	.634	11.428	.000	Task-oriented
Ability to build and maintain relationship with workers	4.22	.832	8.285	.000	Relation-oriented
Understanding the language used by the foreign workers	4.06	.669	8.984	.000	Relation-oriented
Understanding cultural variation within the work force	3.75	.880	4.822	.000	Relation-oriented
Motivating workers by linking rewards to performance	3.53	.950	3.164	.003	Relation-oriented
Ability to gain authority over workers by instilling fear	2.44	.878	-3.626	.001	Task-oriented

Leadership styles of project managers

Based on two leadership styles (task-oriented and relation-oriented), 14 management practices were operationalized. Respondents were asked to rate on a 5-point scale the extent to which they practiced each of these on different nationalities of migrant workers. The means and t-test results for each nationality of workers are shown in Table 3.

For the t-test, the population mean was fixed at 3 (on a 5-point scale) and the significance level for the two-tailed test was set at 0.05. If the t-test results showed that $p < 0.05$ and the *t*-value is positive, the null hypothesis is rejected. It is then concluded that the management

practice is used significantly frequently. If the *t* value is negative, and $p < 0.05$, it is concluded that the management practice is significantly seldom adopted.

To find out if project managers' use significantly different practices to manage different nationalities of construction workers, independent-sample *t* test of equality of means was conducted. Three independent-sample *t* tests were conducted to compare differences in managing: Chinese and Indians (test 1); Chinese and Thais (test 2); and Indians and Thais (test 3). Results show that there is no significant differences in the way project managers manage workers of different nationalities. This is despite Hofstede's (2001) indices showing that Chinese, Indians and Thais have dissimilar cultures. The absence of dissimilarity among people of different cultures was also detected by Wong et al. (2007) when they compared the leadership styles of Chinese and Westerners working in Hong Kong. One possible explanation for the lack of significant difference is that the migrant workers have made intercultural adjustment (Wong et al., 2007), negating the need for project managers to manage each nationality differently. Another explanation is that the project managers are unaware that they need to manage cultural diversity. This may not be the case as Table 2 shows that respondents had indicated that understanding cultural variation within the work force is an important quality for project managers. The third explanation is that project managers prefer to have one style of management for all workers on the same construction site (equal strokes for different folks) so that there is no perception of unfairness.

***Table 3**: One sample t-test results on management practices*

		Chinese			Indians			Thais		
Code	Management Practices	Mean	t-value	Sig.	Mean	t-value	Sig.	Mean	t-value	Sig.
R1	I maintain good relationship with my subordinates.	4.06	7.679	.000	4.25	7.721	.000	4.00	5.624	.000
R2	I try to make my subordinates as satisfied as possible with their work.	3.65	4.758	.000	3.25	1.312	.199	3.43	2.472	.022
R3	I try to be as approachable to my subordinates as possible.	3.77	4.509	.000	3.88	5.074	.000	3.48	2.712	.013
R4	I try to be as fair and equal as I can in dealing with subordinates.	4.42	9.790	.000	4.31	9.515	.000	4.30	7.144	.000
R5	I hold meetings to discuss work related problems.	2.90	-.392	.698	3.06	.284	.778	3.13	.514	.613
R6	I encourage good work through friendship with my subordinates.	3.23	1.650	.109	3.22	1.648	.109	3.22	1.417	.171
R7	I encourage feedbacks from subordinates.	3.61	4.249	.000	3.53	3.283	.003	3.48	2.712	.013
T1	I practice close supervision.	3.71	5.346	.000	3.75	5.906	.000	3.78	6.258	.000
T2	I give clear and assertive instructions.	4.45	11.970	.000	4.16	8.099	.000	4.26	9.766	.000
T3	I reiterate and enforce rules to maintain discipline.	4.06	7.283	.000	4.28	11.428	.000	4.39	13.371	.000
T4	I use threats and punishment to encourage good work.	2.35	-3.420	.002	2.09	-4.844	.000	2.48	-2.313	.030
T5	I put emphasis in getting a lot of work done.	3.90	6.368	.000	3.81	5.890	.000	4.00	5.624	.000
T6	I insist on workers coming to work on time.	4.32	10.493	.000	4.53	12.069	.000	4.43	10.388	.000
T7	I expect subordinates to follow instructions without debate.	3.45	2.306	.028	3.38	2.104	.044	3.74	4.715	.000

DISCUSSION

Management practices relating to task-oriented leadership style

Respondents were asked the extent to which seven management practices relating to task-oriented leadership described the style they adopt in managing migrant construction workers.

Six of these were significantly practised by project managers on the three nationalities of construction workers. These are: supervising closely (T1); giving clear and assertive instructions (T2); reiterating and enforcing rules (T3); emphasizing on getting high quantity of work to be done (T5); insisting on punctuality (T6); and expecting subordinates to follow instructions without debate (T7). The results suggest that project managers use task-oriented leadership style to a significant extent. This agrees with Giritli and Oraz (2004) who found that management personnel in the construction industry perform the authoritative style of leadership more frequently than all other styles.

Only one task-oriented management practice was significantly not applied by project managers to all three nationalities of workers – using threats and punishments to encourage good work (T4). The finding supports the concept that discipline should be the last recourse to reinforce the application of safe work practices when all else (training, guidance and encouragement) failed (Hislop, 1999). Teo and Ling (2010) have also found that introduction of penalties and punishments for offenders/ repeat offenders do not help in enhancing worksite safety.

Management practices relating to relation-oriented leadership style

Respondents were also asked the extent to which they applied seven other management practices relating to relation-oriented leadership style. Four of these practices were used by project managers to manage all three nationalities: maintain good relationship with subordinates (R1); be friendly and approachable to subordinates (R3); be fair and impartial with subordinates (R4); and encourage feedback from subordinates (R7). The finding suggests that relationship cultivation by project managers is important, which agrees with Wong et al. (2007) who also found the importance of interpersonal relationships for effective leadership.

Table 3 shows that project managers try to make their Chinese and Thai workers be as satisfied as possible with their work (R2), but do not practice this with their Indian workers. This may be because Indian nationals have higher individualism score (48) than Chinese and Thai nationals (both at 20) (Hofstede, 2001). This is discussed later.

Two practices are not significantly used by project managers for all 3 nationalities: holding staff meetings to discuss work related problems (R5) and befriending workers to encourage good work (R6). As construction sites are not immune from disputes and complaints, holding staff meetings to discuss problems may turn the meetings into a complaints session. Those who had no problems may also be affected by the complaints, leading to lower morale. One subject matter expert shared that instead of holding meetings, project managers prefer to hold face-to-face discussions with the worker who is upset. He shared that:

> "We prefer to talk to the aggrieved worker to address his complaints and get to the root of the problem. This grievance resolution method goes as close to the source as possible. It also prevents collective bargaining or class-action suit."

As for eschewing friendship with subordinates, this is consistent with the finding that project managers prefer the task-oriented leadership style. Friendship is not encouraged because project managers may fear that their subordinate-friend might try to take advantage of the friendship, or that it may be awkward for project managers to boss people whom they have social ties with (Nefer, 2008).

Power distance

Hofstede's (2001) scores for power distance for China, India, Thailand and Singapore are 80, 77, 64 and 74 respectively, suggesting that these countries are large power distance societies as compared to the UK and USA which have 35 and 40 points respectively. The people in large power distance societies accept a hierarchical order in which everybody requires no justification for his position while people in small power distance societies expects power to be equally distributed and demand justification for power inequalities (Hofstede, 1984). With the high power distance culture of Chinese, Indian and Thai workers, Table 3 shows that project managers are employing appropriate task-oriented leadership style like close supervision (T1) and enforcing rules to maintain discipline (T3). Workers from these 3 countries are more likely to uphold hierarchies and comply with authorities as they come from high power distance cultures. It appears appropriate for project managers to apply more authoritative leadership styles when managing these workers.

Even though the three nationalities have relatively large power distances, project managers still significantly try to be as fair and equal as they can in dealing with workers (R4). The results show that project managers do not encourage good work through friendships with workers (R6). This is consistent with the high power distance that the Chinese, Indian and Thai workers are used to. These workers would be comfortable with the hierarchical management structure. Singaporean project managers are also comfortable to exercise task-oriented leadership style with a vertical organizational structure because Singapore also has a high power distance index. There is therefore a good fit between the task-oriented leadership style displayed by project managers and migrant workers' acceptance of this style based on power distance indices.

Uncertainty avoidance

Hofstede (2001) found that Chinese, Indians, Thais and Singaporeans' uncertainty avoidance scores are 30, 40, 64 and 8 respectively. The scores suggest that these 3 nationalities of construction workers are more uncomfortable with uncertainty and ambiguity than Singaporeans. The findings in Table 3 suggest that Singapore project managers are well aware of this, and try to reduce uncertainty for their migrant workers by strict rules and measures such as insisting workers come to work punctually (T6) and supervising closely (T1). Insisting on punctuality appears to be very important practice as it is ranked first for managing Indian and Thai workers, and third for managing Chinese workers. Punctuality has been found to be one of the 'red flags' to indicate an employee is in serious trouble, which may eventually lead to pronounced behavior changes such as hostility toward authority, being chronically disgruntled, finding fault, blaming others for misfortunes, making destructive criticism, and threats (Magyar, 2003). Project managers' emphasis on punctuality is therefore the right management practice.

Uncertainty is also avoided or reduced by giving clear and assertive instructions (T2). This practice is ranked first for managing Chinese workers. While these migrant workers may be able to tolerate some unfairness due to the propensity to accept a hierarchical order (high power distance), project managers are mindful not to create dissatisfaction (R2) because they have low uncertainty avoidance.

The results in Table 3 support Hofstede's (2001) uncertainty avoidance findings. Chinese, Indian and Thai construction workers appear to require rigid codes of belief and behavior. People from societies with high uncertainty avoidance usually reject deviant persons and ideas (Hofstede, 1984), and favour structure and predictability and conflict is frowned upon (Gold, 2005). The findings also show that even though Singapore project managers have

very high tolerance for ambiguity, they have flexibly minimized uncertainty for their migrant workers in order to accentuate their job performance. This indicates the practice of contingency leadership style (Hersey and Blanchard, 1969).

Individualism vs collectivism

India's individualism score is 48, while China, Thailand and Singapore have the same score of 20, as against the UK and USA's scores of 89 and 91 respectively (Hofstede, 2001). The relatively low score for China, Thailand and Singapore suggests that people from this collectivism social framework expect their relatives, community, or other interest groups to look after them in exchange for unquestioning loyalty (Hofstede, 1984). They are also less individualistic at the work place. As Indians have the highest individualism score among the 3 groups, Table 3 shows that project managers do not significantly try to make them as satisfied as possible with their work. The higher individualism may cause some Indian workers to care more about themselves, leading to weak relationships with co-workers. Project managers may have therefore deemphasized satisfying Indian workers as much as possible so as not to encourage more individualist behaviors.

The interviewees shared that they have observed high collectivism within a nationality group. The workers from the same country often form their own "social clusters" and developed team spirit within the clique naturally. Very low individualism and strong collectivism is not necessarily good because it may give rise to group think (Janis, 1972). Table 3 shows that project managers significantly encourage feedbacks from all groups of workers (R7). This may help to discourage group think by providing avenues for workers to be heard. The presence of groupthink is also indicated by Ogunlana and Chang (1998). They found that good relationships with workmates are more important to workers than gaining recognition and being "distinguished from the flock".

The results show that project managers do not hold staff meetings to discuss work related problems (R5). One interviewee explained that:

> "Asian workers come from collectivist societies that exhibit more cooperative behavior. If we hold meetings to discuss work related problems, they may still not voice out their problems as they do not want to be seen as trouble makers. They are afraid their jobs may be jeopardized unnecessarily when they have many mouths to feed back home."

The finding agrees with Ogunlana and Chang (1998) who found that participating in decision making is one of the lowest ranking motivators for workers. Their study showed that "lack of communication" is not a powerful "demotivator" of work.

Masculinity vs femininity

Masculinity stands for society's inclination towards achievement, heroism, assertiveness and material success, while femininity stands for a preference for relationships, modesty, caring for the weak and the quality of life (Hofstede, 1984). China, India, Thailand and Singapore's Masculinity scores are 66, 56, 34 and 48 respectively (Hofstede, 2001). In comparison, the UK and USA's scores are 66 and 62 respectively, indicating that China and India are more similar to these societies in this aspect. The scores suggest that China and India's societies may put more emphasis on work goals and assertiveness, while Thailand and Singapore put more emphasis on personal goals and nurturance.

Table 3 shows that project managers do make significant efforts to try to make Chinese

workers as satisfied as possible with their work (R2). This is important as they have high masculinity index, and the traditional work role model of male achievement, control and power are important to these workers (Ng et al., 2009). When workers are satisfied, their performance would also improve (Ng et al., 2009).

LIMITATIONS

The main limitation of the study is that the responses were based on project managers' ratings on a 5-point Likert scale. Each respondent may apply the management practices to a different extent from another. The second limitation is that while ratings of respondents were amalgamated and a mean rating computed for each nationality of workers, it cannot be generalized that all workers from the same nation should be treated in the same way. Project managers should still treat each worker as a unique individual and find the best way to manage each of them, in accordance with Contingency Leadership theory (Hersey and Blanchard, 1969).

CONCLUSION

With a low participation rate of Singaporeans as construction workers, a typical construction site in Singapore comprises migrant workers from several countries for it to be sustainable. This study investigated the leadership style adopted by project managers in managing migrant workers from China, India and Thailand working in Singapore's construction industry using a survey research design.

Among the 3 nationalities of workers, Chinese workers would generally have the highest masculinity traits and lowest uncertainty avoidance. These suggest that they may be more inclined towards assertive and competitive behaviors, and are comfortable with unstructured situations. The implication is that to manage Chinese construction workers, project managers may need to adopt task-oriented leadership style by: giving assertive instructions (T2) and enforcing rules (T3) to control their high masculinity; and emphasizing punctuality (T6) and getting a lot of work done (T5) in order to "get the message across" effectively.

Indian workers have the highest individualism among the 3 nationalities of workers. This suggests that they are less integrated and cohesive. The implication for project managers is that task-oriented leadership style needs to be adopted and the relevant management practices include: enforcing punctuality (T6) and rules (T3) strictly.

Thai workers have the lowest masculinity and highest uncertainty avoidance scores when compared to Chinese and Indians. The generally modest and caring culture indicates the need for project managers to apply relation based leadership style. With their high uncertainty avoidance, it is recommended that project managers give Thai workers the clearest instructions at work (T2).

The findings suggest that Singapore project managers practice contingency theory leadership to a large extent. Their very low uncertainty avoidance score enables them to practice contingency leadership, by being both task-oriented and relation-oriented at the same time. There is no need for them to rigidly adhere to one style to achieve social sustainability on site. With Singapore's moderately high power distance index, the outcome is project

managers use more task-oriented leadership in the supervision of the workers. Singapore project managers are also deemed to be more feminine than masculine. They are therefore observed to also practice relation-oriented leadership.

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SUSTAINABLE TRANSFORMATION OF CITIES: THE CASE OF EINDHOVEN, THE NETHERLANDS

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Abstract
The question of sustainable urban development is linked to the issue of urban transformation; the challenge is to make use of ongoing transformation processes to achieve more sustainable urban environments. Hildebrand Frey is the main protagonist of the "urban cell theory" (UCT), focused on the redesign of existing cities, laying down important arguments for neighborhood borders and centers. For decisions to pursue the sustainability path, the pragmatic method will be a practical tool in bringing sustainable considerations in the realm of project decisions. This paper examines the sustainable transformation of cities upon a re-mapping of the existing city to identify the potential urban cells, restructuring of the actual city of districts and neighborhoods; focused on Eindhoven as a case study, specifically the District of Woensel, describing the operationalization of the UCT as a conceptual framework. This work is structured in three parts: 1- a preliminary analysis identifying the existing neighborhoods in the district to analyze how the existing parts of the city meet the criteria of UCT; 2- the description of how to join non-potential and potential sustainable areas of the existing city to create "large units" of the city; 3- The elaboration of results indicates that all the parts of the city are part of potential sustainable areas, obtaining hence a principal layer of the map of the sustainable city. The relevance of this approach is to contribute new insights to the debate of sustainable city borders.

Keywords: Urban form, Sustainable cities, Urban transformation, Pragmatics

INTRODUCTION: REMAPPING OF EXISTING CITY

Focusing on the urban redesign of Woensel area, a post-war district of Eindhoven, the goal of this paper is to make a re-mapping of the existing city to identify the potential urban cells on the study area. To achieve this goal it is necessary first to analyze how the existing units of the city meet the criteria of sustainability –UCT-, classifying them as a potential and non-potential sustainable areas of the existing city under evaluation of the UCT criteria; and second to lay down how to join non-potential with potential sustainable areas of the city to restructure the district by creating large units to optimize sustainability. Finally to remap the city based on this new structure: all the parts of the city should be part of potential sustainable areas, obtaining hence a principal layer of the map of the sustainable city. The contribution will present an example of a pragmatic design strategy to adjust form and structure of an

existing area, a method to implement new directions to achieve the challenges of sustainability.

HISTORICAL-EVOLUTIONARY APPROACH OF THE CITY

Sustainability regarding cities has many definitions and angles, however the re-making and adaptation of existing cities to sustainable objectives is an urgent double priority towards the global push for sustainability (Kenworthy, 2006). To meet the objectives of a sustainable city new methods, strategies and design tools are required as part of a pragmatic-based integrated planning, considering each factor converging in the physical, social and economical necessities of a community, connecting them to the environment (Burnett, 2007; Frey and Yaneske, 2007; Gunder, 2006). In this sense, sustainable development is concerned not only with social, economic and environmental qualities or inefficiencies of the city but also with urban form as it largely exists and the form and structure development should take for the city to become more sustainable.

Pragmatics as a way of thinking

Hence, at present we are generally confronted not with the task of planning and designing new towns and cities but, rather, with re-planning and redesigning existing cities, towns and settlements to make them more sustainable. Therefore the challenge is to redesign existing urban form (Barton, 2000; Breheny, 1992; Frey, 1999; Frey and Yaneske, 2007). This involves a pragmatic way of thinking: the pragmatic method will be an effective tool in bringing sustainable considerations to achieve these objectives. The task, then, is to address the real problem of the cities by a pragmatic thinking (Moore, 2010).

The assumption to achieve a sustainable city is to shape a resilient city, flexible structures of the city: future city is the existing city transformed into the direction of sustainability by the shaping of a flexible structure, able to create a solid community in the core of a healthy and pollution-free environment. Therefore, are there certain urban forms that contribute more than others to sustainability? In literature models and concepts of sustainable city form are identified; as well as there are seven design concepts related with sustainable urban form: compactness, sustainable transport, density, use of mixed land, diversity, passive solar design and greening; and also four types of sustainable urban forms: neo traditional development, urban contention, the compact city and the eco-city (Jabareen, 2006). City models that meet sustainability are distinguished, however existing cities never can be categorized as such in one or another model; cities are always openly developing, and do not necessarily following consequently a certain model. Models have proved to be abstract and theoretical and in the practice quit far away from realities. In this sense, the message is clear: to achieve sustainability requires not only new development to be guided by appropriate urban models and targets but also the review of the forms, structure, land use patterns and socio-economic conditions of existing urban areas (Frey, 1999; Frey and Yaneske, 2007).

This way of thinking -pragmatic vision- is not really completely new in the urban planning and design. In the history, specifically in the post-war period, many authors have made criticism about the post war planning thought in the late 1950s and early 1960s, owing to the

inflexible planning of the cities. In fact, there were two levels of criticism of postwar urban development that emerged in the 1950s: 1- on the quality of the design of the new development; 2-on the emphasis of physical planning. According to these both fundamental disagreements, town planners typically exhibited very little understanding of the cities, because they had been preoccupied with simplistic "utopian visions" instead of trying to understand and address the problems of real-life cities. Indeed, the main criticism was the lack of understanding of real-life cities and preference for a tidy, ordered view of urban structure (Taylor, 1998).

CONNECTION TO FREY: URBAN CELL THEORY (UCT*)*

Hildebrand Frey is the main protagonist of the "urban cell theory" (UCT), a theory that emphasizes pragmatism and focuses on the redesign of the existing cities~~,~~ through the promotion of urban and suburban cores. In short, H. Frey advocates a recalibration of urban components to a higher level of aggregation –urban cells- that~~,~~ might be instrumental for achieving balanced relationship among transport, urban form and environment hence a more sustainable city. Urban Cells are units of urban district level –neighborhoods- that meet certain criteria to achieve sustainability in the city. In addition, these criteria are divided in five key criteria: key planning, social, environmental, design and economic criteria. If a district meets these criteria, then the urban unit –or neighborhood- is sustainable (Frey, 1999).

From cells to modules

Nevertheless, the biological connotation in regard of a city is not really acceptable as a city is not a living thing, only the people that use it are, because the city is not able to repair itself. Also a "cell" is not alive. A cell remains or becomes alive if there are two or three live cells adjacent to it, otherwise it dies. Fewer than two adjacent cells imply the cell dies from insulation; more than three and it dies from overcrowding. Thus, the "cell" as part of a structure is not necessarily the most important element of that structure; much more important may be the links between "cells" or "modules" that generate a complex structure. Indeed, this means that all living organisms could be viewed as systems, for any organism depends on and is therefore related to its environment. For this reason, it would be interesting to represent an image of the city as an active functioning thing: as a system (Batty, 2005; Buchanan, 2002; Frey and Yaneske, 2007).

In our interconnected world there is a practical difficulty in deciding where to draw the boundary of a complex system. Nevertheless, conventional science seeks for simplifying systems to a comprehensible few interactions that still yield useful results. In this sense, this simplicity is termed modularity, which is a strong interaction among elements within a module but only a relatively weak interaction with elements outside (Frey and Yaneske, 2007).

The concept of module is referred to something that has its own structural and functional integrity while being part of a larger system (Frey and Yaneske, 2007). The existing city is

clearly complex and highly ordered (Batty, 2005); in addition, the city, as many natural phenomena, has a hidden structure that develops "unconsciously" (Buchanan, 2002). For this reason the city has to be understood as a modular construction: modules with own structural and functional integrity while being part of a larger system. This modular structure makes the existing city more resilient; having the ability to adapt to changing circumstances, while providing for the basic needs of residents and ensuring quality of life. Plans are developed for a 100 year period to ensure the city and the city region's long term survival as well as integrity, normal functioning, and self reliance (Frey, 1999; Frey and Yaneske, 2007).

Urban cells theory criteria

According to what was mentioned above, the UCT establishes key criteria for each component of sustainability in the city. Below there is a detailed explanation of the UCT criteria (Frey, 1999).

1. Key planning criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes the following:

Inclusion of open land: by 40% of developable land kept as forest and agriculture; the reason is to achieve preservation of land, local production of food and timber, and to reach a degree of self-sufficiency and local economy.

A threshold population: by a gross population size between 4.000 and 10.000, in average 7.000 inhabitants, with districts around 25,000-35,000 inhabitants; the main reason is to support local services and facilities into the neighborhoods -provided there is sufficient disposable income.

Accessibility in walking distance: Accessibility in walking distance to local services and facilities, including public transport node/stop with distances between 400-800m, says 600m. This generates areas of about 110-120 ha and with a gross population density of 60 per/ha over total land, 100 per/ha or 42 dwellings per ha over developable land; the main reasons are to improve the local access -to local facilities- and district/regional access -to city centre and other provision centers in the conurbation- for those not highly mobile, and to obtain a reduction of car dependent local and regional travel.

Mixed use: by 40% of developable land for non-residential uses, 60% for housing, which results in a net population threshold density of 167 per/ha or 70 dwelling units per ha. The main reasons are to improve access to work places, services and facilities, specifically for those not highly mobile, and give the possibility of the interaction of different uses/users generating "urbanity".

Local facilities: The presence of local facilities into those areas (neighborhoods), such as: local shops/mini-supermarket, bank auto-teller, post office counter, primary school, police station, community facilities and park, access to open green space, play areas, sport areas and workplaces. The reasons are mainly to allow an ease access to local services and facilities, as well as reduced car-dependent mobility, and to have access to city level facilities with public transport.

2. Key environmental criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes:

Energy conservation: Energy conservation by the use of clean renewable energy such as solar, wind, geothermal, among others. The reasons are mainly focused in the conservation of natural resources and the reduction of pollution through burning of fossil fuels, these could help to reduce energy consumption of a typical dwelling and create more sustainable neighborhoods.

Water conservation/management: Water conservation and management will be achieved through rainwater collection, as well as the reuse of grey water, and recycling of waste water (including sewer) after treatment. The reasons are principally to become a reduction of water waste, the preservation of water resources, and the reduction of the waste of potential fertilizers.

Waste recycling: Waste recycling by separating and reusing waste materials such as paper, glass, plastic, metal, and food products. The reason is mainly to achieve a reduction of waste mountains, as well as land fill sites.

Establish or re-establish biodiversity: Establish biodiversity through maintenance and enhancement of local fauna and flora. The reason is to achieve a symbiotic relationship between city and nature.

3. Key social criteria for sustainable neighborhoods; this principle for sustainable neighborhoods is specified as:

Social inclusion: by social mix to avoid exclusion or marginalization of socio-economically weaker groups of people. The main reasons are principally to obtain a reduction of tension between those that have and those that have not, and economically weaker groups of people benefit from the inclusion of people with disposable income that support local services and facilities.

Safety and security: by the activation of legible public spaces, laying down activated edges, good lighting and design spaces. The reasons are to improve the living quality and to get a reduction of real or perceived fear of crime.

Participation of community: by people involved in local decision making and local democracy. The main reasons are that the community holds ownership of neighborhoods, to obtain more responsibility of local people for their environment, as well as to increase the sense of belongingness, and to reduce vandalism.

4. Key design criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes:

Legibility and imageability: Legibility and imageability of the built form of the neighborhood, as well as a sense of centralization and belongingness, improved access, and a meaningfully built form. The reason is to reach a better quality of life.

Adaptability: Adaptability of the built fabric and neighborhood layout; say adaptable, expandable housing. The main reasons are to reach the possibility to adapt to changing needs and aspirations and to changing external conditions, as well as to obtain durability of buildings and neighborhood.

5. Key economic criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes the following:

Affordable housing: To reach affordable housing by a mixture of different tenure and housing types, from villa to semi-detached, terraced tenement, etc. The main reason is to be a support for social and income mix.

Keeping profit in the area/neighborhood: through credit systems in a local economy, by local production and services, both formal and informal. The reason is to reach that profit can be used for improvement to the neighborhood and its facilities rather than disappearing into the pockets of distant international companies.

TRANSFORMATION OF DISTRICTS IN THE CITY OF EINDHOVEN: UCT APPLIED TO WOENSEL

The aim is to demonstrate the existence of potential urban cells on the study area. First, it is necessary to find out which of the existing neighborhoods meet the criteria of UCT. The area selected is Woensel, a district located in the north of the city centre of Eindhoven, the Netherlands (Figure 1).

As a preliminary analysis, the district of Woensel is described as a great postwar expansion area of Eindhoven largely made since 1960 (Figure 2), being an existing environment with a clear transformation phenomenon by dispersion. Woensel is an incomparable area in relation to others in terms of population, with 101,218 inhabitants (M.L.M.G. Boumans, 2005), being the half of the total population of Eindhoven (208,000 inhabitants); in this sense Woensel is one the largest settlements in the region; not only the Eindhoven's largest district concerning population, but also even larger than some settlements of the region, such as the city of Helmond with 86,000 inhabitants, located in the east of Eindhoven.

Woensel is almost entirely a residential area with services and facilities for the community, such as schools, parks, churches, shops, post offices, trade facilities, hospital, among others. The district has its own district center -shopping center Woensel-, providing for the upper district facilities. Woensel offers few places of local interest, being almost entirely a residential area; Eindhoven's main entertainment venues and industry are in other parts of the city.





Figure 1: *Woensel district located in the north of Eindhoven city center.*

Figure 2: *The area of Eindhoven's development in 1950 inside of today's city boundaries (based on Morfologische Atlas Eindhoven, 2005)*

The first part of the analysis was focused on identifying the existing neighborhoods on the district, recognizing around of 27 urban quarters that make up the district of Woensel, divided in two main zones: Woensel-North and Woensel-South (M.L.M.G. Boumans, 2005). Neighborhoods centers are recognizable by the identification of functions: the location of post offices, police stations, primary education schools, trade and other facilities. Generally, four or five neighborhoods are grouped to form a district, four or five districts are grouped together to form towns, and over town centers are located the major transport routes between towns (Frey, 1999). In this case, Woensel district is made up by two "great areas", and each area is set up by around twelve and fifteen neighborhoods respectively. Woensel district centre -shopping center Woensel- is located in one of the main transport routes, allowing a good connection with Eindhoven city center. The connection between Woensel-center with other town centers is poor, because Eindhoven is currently a mono-centric city, the public transport connections are exclusively aimed at Eindhoven center (Figure 3).

With the identification of the existing neighborhoods boundaries, then it is possible to start with the next level of the investigation, related with the analysis of how existing units meet the criteria of sustainability –UCT.

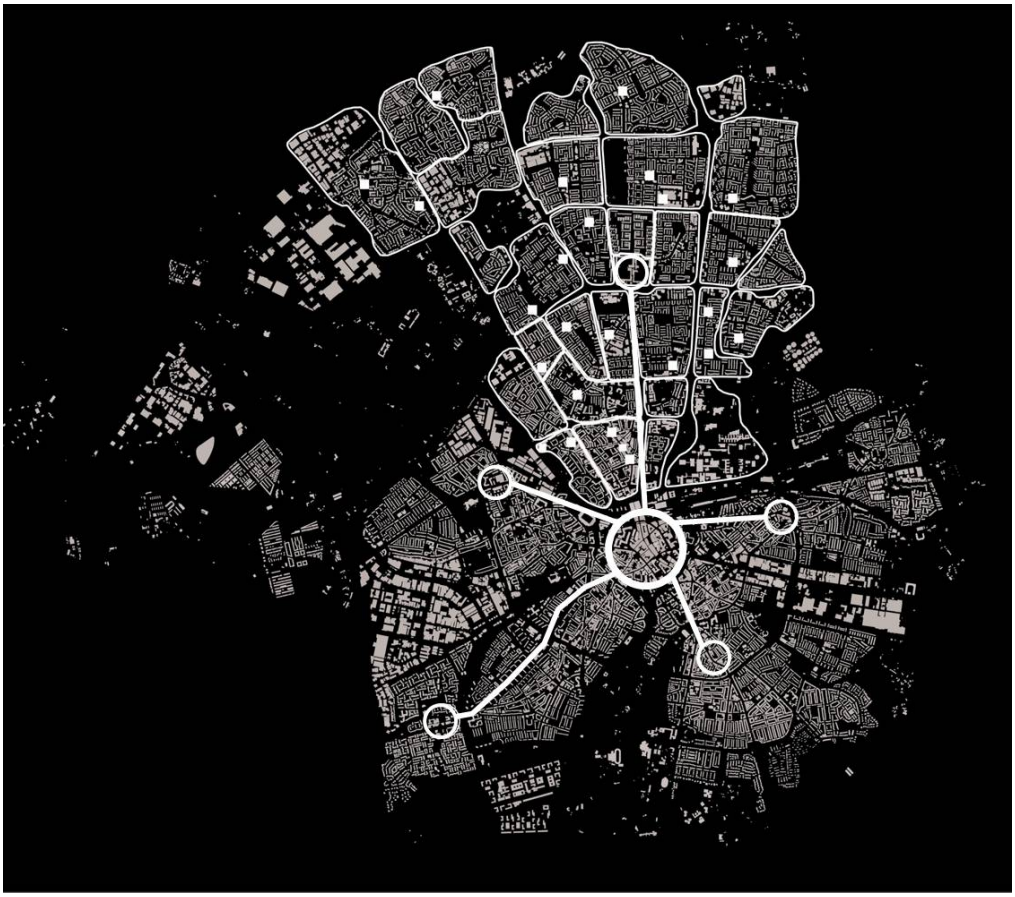


Figure 3: *Location of existing neighborhoods boundaries and centers, and main center district connections.*

Fieldwork and evaluation table

In the next level of the research, the analysis was focused on how the existing neighborhoods of the district meet the criteria of sustainability, to classify them as potential and non-potential sustainable areas according to the UCT-criteria. For the applicability of the UCT on the study area it was necessary to make an evaluation over each identified unit. In this sense, the evaluation consisted on making an analysis on the place by fieldwork and literature review from institutional and academic data by desk research. The analysis was focused on environmental, economic, social, design and planning aspects of each neighborhood of Woensel, according to UCT.

The results of the analysis were placed on an evaluation table. The table consists of assessing the aspects of each neighborhood under the criteria of UCT –social, economic, environment, design, and planning- establishing what areas meet the criteria and what areas do not meet the criteria. Then, we obtained estimated percentages of every neighborhood evaluated under each criteria of the theory, obtaining a total average for each area.

As a result of this analysis an estimative approach was obtained; describing areas that meet above 50 percent of the criteria denominated as “potential areas”, while areas that meet less than 50 percent of the criteria are “non-potential areas”. The graphic below shows a summary of this evaluation (Figure 4).

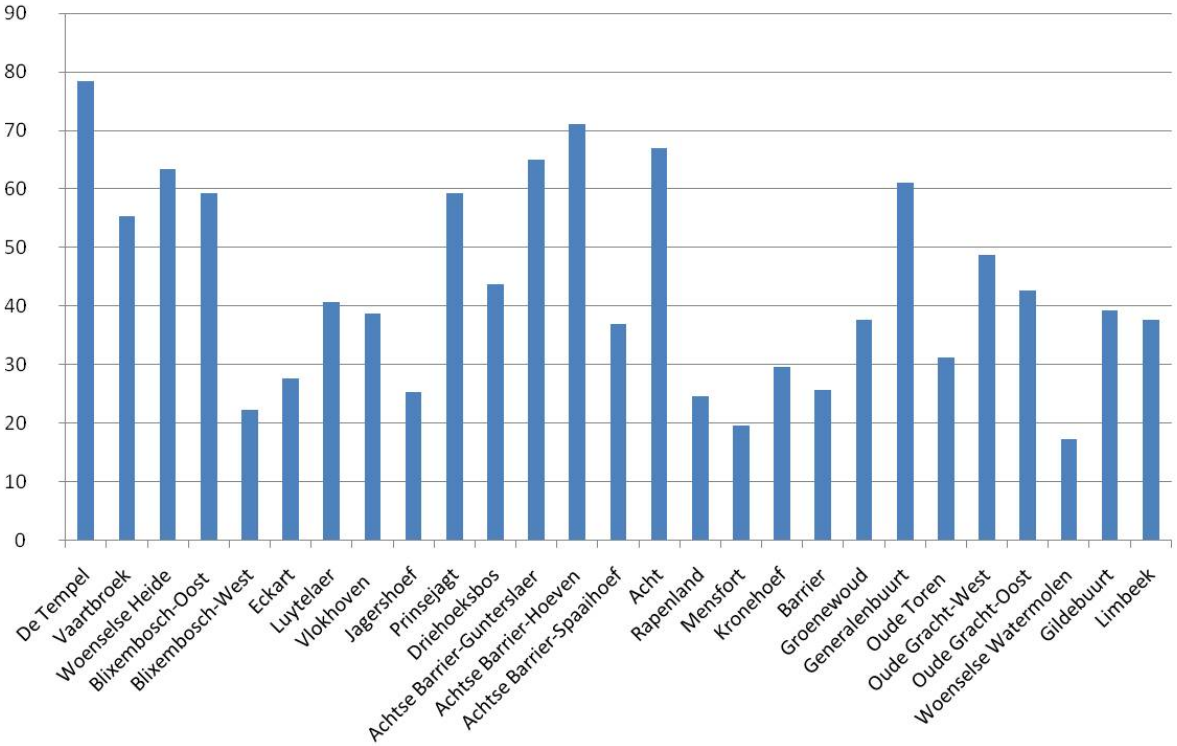


Figure 4: *This graphic shows the evaluation of neighborhoods under UCT criteria.*

Finally, the results of this analysis were translated in an evaluation map (Figure 5). The map describes the potential and non-potential sustainable areas in the district identified by different colors. Dark areas are described as potential, while light ones are non-potential, according UCT-criteria. According to figure 5, as a conclusion of this first level, nine neighborhoods are potential sustainable areas in Woensel. Those areas meet most of the 50 percent of the UCT criteria.



Figure 5: *The evaluation map showing potential and non-potential sustainable areas of Woensel district.*

As an example, the urban quarter called De Temple is potentially one of the most sustainable areas, meeting all the planning criteria; also this area presents a potential concerning green and biodiversity aspect, with the Henry Dunant Park. However concerning design, this area is a typical postwar neighborhood, with monotonous row housing development and public spaces, but with a good proximity to local services and facilities by walking distance. In relation with the UCT of H. Frey, those potential sustainable areas in figure 5 meet around three or four aspects of the planning criteria, regarding good population number, local facilities, mixed-used, good accessibility by walking distance and open land space. For instance, the urban quarter of De Tempel is one of the largest population areas in Woensel with around 5,000 inhabitants; good number to support local services and facilities. In addition, there are eleven areas in Woensel that meet this criteria; most of them have also a community organized in relation to participation in local decisions, good green areas especially in some edges of the district, as well as work places as modest business on the area (Figure 6). However, one of the most important aspects is the “green” condition of Woensel-north. Most of the urban quarters located in Woensel north meet the biodiversity criteria. Indeed, there is a good presence of green areas, such us parks, forests, and sport areas close to the boundaries. Also, green corridors are on the main avenues and streets, connecting neighborhoods.

Nevertheless, the situation in Woensel south is different. In figure 5, this area presents most of the non-potential sustainable areas of the district; mainly characterized to be residential areas, with a poor accessibility and quality of design concerning public spaces and architecture, as well as lack of green and leisure areas, unsafe public spaces, the absence of social mix and less number of inhabitants that could support local services and facilities (Figure 7).





Figures 6 and 7: *Urban quarter De Tempel; and typical neighborhood in Woensel-south*

Therefore, neighborhoods in Woensel are predominantly with residential functions and hardly with mixed-use; with just eleven urban quarters with a good base of population and presence of eligible amenities center. In the second level of the investigation, the analysis was focused in how to join potential with non-potential sustainable areas of the existing city to restructure the district by creating ‘’large units’’, to make a balance of them and to improve non-potential areas to optimize sustainability.

At this level it was necessary first to recognize principles to the process of design, applying to these areas, and thus to restructure Woensel district. These principles are derived from the UCT-framework and pragmatic redesign considerations in relation to the city, specifically to the assumption of the city as a resilient structure: the future city is the already existing city transformed into the direction of sustainability, (Frey, 1999; Frey and Yaneske, 2007; Moore, 2010). In the city, the places are important elements; people define themselves by the place they live in and value the unique characteristics which give continuity with the past and relationship with the present. Every citizen has had long associations with some part of his city, and his image is soaked in memories and meanings. Sustainability is the history of the city (Frey and Yaneske, 2007; Rossi, 1993; Tarvernor, 2007; Tweed and Sutherland, 2007). To preserve and enhance the physical and spatial balance of the existing built environment, redesign can help to promote sustainable development by improving the quality of the existing environment and sense of place.

Following the UCT-framework, strategies were made to restructure Woensel by two steps:

1- According to the UCT criteria, the interaction among urban quarters –or cells-, say four or five of them, form a district with a core which might become the focus for a much larger population of 25,000 – 35,000. The district center would be linked with neighborhood centers by public transport; such districts would have a sufficiently large catchment area to accommodate commerce and other equipment and services (Frey, 1999). In this sense, Woensel north zone has a large size and the presence of facilities is striking. The stores not only provide assistance for all typing on the large amount of housing in this area, but also for the lack of facilities. In Woensel north reside about 70,000 inhabitants. This number could be divided into two districts with potential units and own centers, with a population of 35,000 inhabitants each one. This approach would create enough support above district facilities in the area (Figure 8).

2- From the districts established, we can start to join non-potential with potential areas to create large units of urban quarters. A neighborhood needs to be recognized as an essential building unit of the city (Barton, 2000; Frey, 1999). It is important so as to know which units have relationships with each other, identifying the existing urban structure relationships. The analysis was made by examination of layers, included the existing development patterns, in terms of greening, infrastructure, density, compactness -built-up areas- and local centers of provision, in relation to cluster potential with non-potential areas. The sketch reflected in figure 8 (Figure 8) describes the overlap of both steps, via layer-by-layer the existing city form is recorded and examined; this enables the examination of the relationship of each of these layers with the overall.

A global inventory of equipment and services provides a characterization of the new districts, made up by “new large units” recognized as essential building units of the city. Thus, the lack of facilities, as well as a poor social mix and limited variation in housing types and public spaces presented in Woensel, could be improved by the revitalization and enhancing of some potential places hence transforming them into “hierarchy” centers of each new district established.





Figures 9 and 10: *Commercial Woensel center; and Woenselse markt in Woensel south*



Figure 8: *This sketch shows the overlap of the two steps of the strategy and also the creation of large units~~,~~ by the joining of potential with non-potential urban quarters.*

Three main key zones are described in figure 8, clustering Woensel-north in two districts and enhancing Woensel-south with an own main center. The first district proposed could be defined as “recreational center”: Sport Park Woensel –located in the north-west- is the current area for active recreation within Woensel. If Sport Park Woensel is upgraded with mixed uses, adding trade and culture facilities, then it could be a new center of district. In relation with the second district proposed, the existing Shopping Woensel center is joined with care facilities -Catherina Hospital in Rapeland. Thus it would become, in an improved current, the center of the district defined as “commercial center”. Both districts have own centers and will have less dependence on Eindhoven city center (Figure 9).

Finally, in the third district proposed to Woensel south the objective is to recover this place as a “cultural area”, an important place of reference in the city. In fact, some of the non-potential areas in Woensel south have “cultural potential”; this potential could help to define the character of the place; every citizen has had long associations with some part of his city. Some existing neighborhoods have important cultural value, for example Woenselse-markt. Presently Woenselse markt is located in Gildebuurt, an urban quarter in Woensel south. This area is an important trade corridor with local services and facilities and transformed into a market place some days in the week. On this area there are other neighborhoods with important culture values, such us Oude Toren, with an important historical value from around the 12th Century when Woensel settlement was founded (Boumans 2005). The proposed

district, thus, would have an important cultural character, with trade and facilities as reference into the city (Figure 10).

CONCLUSIONS

Hildebrand Frey established the UCT as a tool for the redesign of existing cities, laying down important principles for neighborhoods and districts structure. The operationalization of the theory is used as method for exploration on Eindhoven, specifically the district of Woensel. The elaboration of results indicates that Woensel could become part of sustainable areas.

The new Woensel is described in the final map (Figure 11), laid down with three different new districts, created by large units set up through the interaction among non-potential with potential sustainable areas. Every new large unit will be a resilient structure, adaptable during the time; this means that to meet better the criteria of UCT, the larger units will have the possibility to adapt to changing needs and aspirations. Also these large units provide local services and facilities within walking distance to the edge, local centers with mixed-uses and public transport stops. Main connections routes have been preserved and upgraded, used as boundaries for the large units extension, and as main links connection with the rest of the city.

The current main routes are upgraded as green corridors, allowing not only good vertical and horizontal connections among the new areas, among large units centers to district centers, but also good access among district centers, and from them to suburban municipalities of Best, Son and Breugel in the Region.

Regarding the borders of Woensel, they have been developed to improve the borders with the countryside. Borders are maintained and enhanced as a conservation green area; hence the districts are limited by natural boundaries. The reasons are:

- To keep some current uses as open land development such us forest, and agriculture.
- The objective is to create dense green areas at the district borders, as roots for the green corridors and main green points into the city.

To establish green spaces as a second structure incorporated to the existing one; to protect large urban units from the noise pollution coming from main routes connections by green corridors, as well as to provide and enhance green existing areas as “key breathing spaces” into the city; creating clear connections among the main green spaces at the larger units.

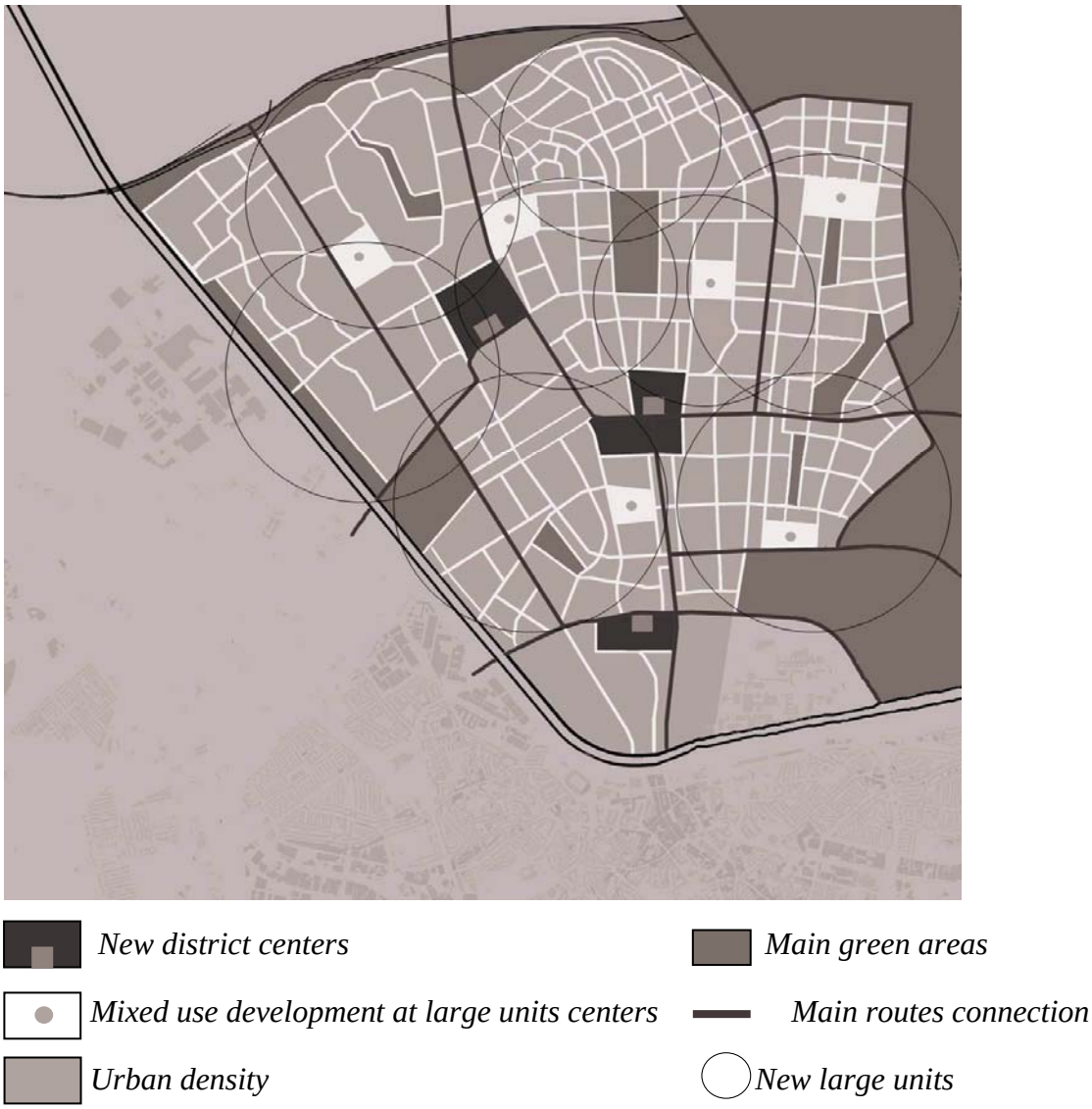


Figure 11: *The principal map of sustainable city borders.*

The design concept for Woensel attempts to generate clear district centers, assigned as mixed used development, which are linked with each other by new central routes. These routes would accommodate the major public transport line, linking the new centers with the city center as well as with the suburban municipalities in the region. Therefore, the new redevelopment structure (Figure 11) shows a clear density development, with peaks at districts centers as well as at the large units centers; which accommodate mixed use, to give each new area an identity and a sense of centrality.

In general, UCT is a useful tool for pragmatic urban sustainable redesign. This tool clearly takes as a starting point that the future sustainable city is the already existing city, establishing operational criteria to each component of sustainability in the city.

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DIVERSITY INTERVENTIONS FOR A SOCIALLY SUSTAINABLE CONSTRUCTION INDUSTRY

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Abstract
Major construction sites in Australia have an above average presence of ethnic minorities. These groups and the interfaces between them require effective management in order to meet the social imperatives of sustainable design and construction. A survey of 1155 workers and 204 managers on Sydney construction sites respectively, found a significant level of normalisation of negative forms of cross cultural interaction. Yet it was also found that anti-racism programs are not currently a management priority and that they generally lack sophisticated community relations aspects. This paper presents the results of a desk-top study of leading global companies within and outside the construction sector which have won international awards and recognition for their cultural diversity strategies. A key insight is that the companies profiled see diversity as a key resource and as an opportunity rather than a risk which is best harnessed through long-term and on-going commitment of senior management. These leading companies also recognise that cultural diversity strategies operate at three levels - in terms of its relationship with its own workforce; its relationship with its clients and; its relationships with the communities in which it operates - and if properly managed it can be a source of competitive advantage.

Keywords: Cultural diversity, strategy, best practice, racism, discrimination.

INTRODUCTION

Loosemore and Phua's (2010) review and analysis of corporate social responsibility practices in the construction and engineering sectors found that while the industry had made significant strides in advancing its ecological sustainability performance, its social sustainability performance remained a challenge. There are many dimensions to this issue including occupational health, welfare and safety, policies relating to ageism, gender and disability, community consultation in design and development, philanthropic donations etc. One major aspect of social sustainability in the industry, which has received growing attention in recent years, is the issue of managing its cultural diversity. Major construction sites in many

countries are settings of significant cultural diversity since they have a workforce which has a disproportionately high presence of ethnic minorities. This diversity largely stems from the nature of the work undertaken on these sites, and the structure of the labour force. For example, in Australia, 16 per cent of the Australian labour force is from non-English speaking background (DIAC, 2009) and the Australian construction industry is one of Australia's largest and most culturally diverse, directly employing about 9.2 per cent of the working population (ABS, 2009). It has also been found in previous research that there is some occupational ethnic segmentation on major construction sites with different trades associated with certain ethnic groups (Loosemore and Lee, 2002). For example, steel workers and scaffolders are usually of Maori and Southern Islander decent, concreters are generally of Italian decent, carpenters of Croatian decent, tilers of Korean decent and managers, designers and engineers of Anglo-Saxon decent. As different trades enter and leave sites during the construction phases, there is a rotation of specific ethnic groups. This means that over the life cycle of a project, many of these ethnic groups may have limited interaction with one another. The aims of this paper are to explore how these groups and the interfaces between them are managed and to explore the relevance of recognised best practice strategies used in other industries to the construction context.

BACKGROUND

Construction sites are not popularly perceived as sites of sophisticated cosmopolitanism. In many countries such as Australia, they are commonly seen as places of cultural insensitivity from where for example, gender incivilities emerge (such as wolf whistles to women who pass by etc). Furthermore, these settings would generally be perceived as lacking community relations programs. Indeed, there are emerging empirical evidence that demonstrates the existence of racism and ethnic discrimination on construction sites. For example, Loosemore and Chau (2002) found that 40 per cent of Asian workers had experienced workplace discrimination on Australian construction sites. Despite the high ethnic minority presence, and the labour intensive nature of the work, construction sites are often regarded as places of below average levels of education. Research on attitudes in Australia has demonstrated that those with lower levels of education are more likely to have more intolerant attitudes towards ethnic diversity and to minority groups (Dunn et al., 2004; Forrest and Dunn, 2006, 2010). So for these reasons, we could anticipate that construction sites may be places of heightened cross-cultural wariness and tension (Jupp and Nieuwenhuysen, 2007, Noble, 2009). This makes construction sites very fitting environments for testing the feasibility of anti-racism management interventions (Pedersen et al, 2005).

In response to this broad hypothesis, Loosemore et al (2010) reported a major survey of attitudes towards cultural diversity in the Australian construction industry administered between May and December 2008. The survey aimed to identify the nature and extent of cultural diversity and the boundaries of cultural groupings on construction sites. It also sought to investigate feelings about cultural diversity and other ethnic groups and experiences of intolerance and equality of treatment on construction sites. The survey was administered on twenty-eight construction sites in the Sydney metropolitan area and in the Construction, Forestry, Mining, and Energy Union (CFMEU) office. It resulted in 1155 completed and useable questionnaires and the key findings were that there is a good deal of cross-cultural interaction on construction sites (85 per cent interact with other ethnic groups during social situations and work-based activities). However, there are many perceived barriers to interaction on sites for some workers (31 per cent of respondents reported that they did not

make an effort to talk with workers of different ethnic backgrounds). The majority of respondents (76 per cent) believe their own ethnic group understands them better and 45 per cent of respondents reported that members of their own ethnic group need to stick together to 'survive' on construction sites. This suggests that ethnic groupings have some positive functions such as maintaining positive bonds among group members, group support and providing safe-havens. The vast majority of workers are comfortable with cultural diversity and think that it works well. However, they simultaneously perceive homogeneity to work well. Most respondents (64 per cent) indicated that they would like to see more opportunities to mix with people from other ethnic groups while at work. Communication problems caused by language barriers are one of the major challenges affecting work and social relations between different ethnic groups on sites. A considerable percentage of respondents (32 per cent) think that different ethnic groups should stay away from each other, thus implying that support for cultural diversity is not consistent and depends on the nature of the relationship between workers.

A second follow-up study published in Loosemore et al (in press) presented the findings of a survey of construction site supervisors and managers administered between May and August 2009. The survey aimed to identify managers' perceptions of ethnic diversity on construction sites and to map management strategies for workplace diversity. The survey also sought to compare managers' perceptions with operatives' experiences on sites from stage one of the study. The questionnaires were distributed on 16 construction sites which were mostly large commercial and residential projects in the Sydney metropolitan area. This resulted in 183 usable questionnaires and the key findings were that the majority of respondents indicated that responsibility for managing ethnic diversity belonged to site managers, supervisors and project managers. OHS and EEO policies were perceived to have more importance and be more widely implemented within the industry than affirmative action and managing ethnic diversity policies. There is also a low level of awareness about ethnic diversity policies. Most managers saw ethnic diversity strategies and affirmative action plans as discriminatory and unfair since such strategies may favour some groups over others. Seventy-five per cent of the managers reported that they did not receive any training that aimed to reduce stereotyping and ways of managing ethnic diversity effectively.

Fifty four per cent of the managers reported that they embraced a personal ethnic diversity management strategy to compensate for the lack of centralised policy. The other forty six per cent ignore the issue and rely on others to manage it for them. Thirteen per cent of the managers who did not have a personal strategy reported that having a strategy to manage ethnic diversity was not a priority. More than half of the managers did not identify any problems with ethnic diversity and did not see any need to manage it proactively. The cultural diversity of the industry is taken for granted and it appears as if the problems associated with it are accepted as an inevitable part of daily life on sites.

This paper reports the results of the third and final part of this research. The aim of this research was to explore management strategies which could be used in the construction sector to address the challenges we discovered in stages one and two.

METHOD

Data were collected via a desk-top study of global best practices in managing cultural diversity within the workplace. The desk-top study consisted of a review of a large number of

online and published sources including specialised diversity reports, journal papers, books, company annual reports, company websites and press releases. In total, 156 companies were investigated across 15 industry sectors including hospitality, apparel, pharmaceuticals, entertainment media, information technology, internet services and retailing, megabanks, construction and engineering, health care, aviation, petroleum refining, and fast moving consumer goods.

These companies were sourced from lists of the largest and most successful companies in the U.S. and overseas such as:

- ENR's Top 400 Contractor List 2009;
- Fortune Magazine's World's Most Admired Company List for 2010 (People Management; and Management Quality) ;
- Fortune Magazine's 100 Best Companies to Work For 2009; and
- Human Rights Campaign Foundation's Corporate Equality Index 2009.

A number of companies profiled were also acknowledged in the field as leaders in diversity management and some have won awards and accolades for their commitment and innovative solutions to managing cultural diversity and have been featured on award winning lists such as:

- Diversity Inc.'s Top 50 Companies List 2010;
- Diversity Inc.'s Top 10 Companies for Supplier Diversity List 2010; and
- Reader's Choice Best Diversity Companies 2009

The methodology used to assess the diversity rankings above were also studied, where available, as a guide to determine the effectiveness of diversity actions, assess their applicability for the construction industry and the practicalities of implementation on construction sites. Essentially, we only chose to report strategies that we thought were transferable to the construction sector and which could address the challenges we have discussed above.

It is worth noting that engineering and construction, or the property and developer companies rarely, if any, feature on award lists in terms of their management of cultural diversity.

FINDINGS

The following sections discuss the main findings from our research.

Senior management leadership

Strong leadership and senior management commitment to growing a culturally diverse workforce is central to ensuring the effectiveness and longevity of any cultural diversity initiatives. For example, the appointment of a senior executive to champion and lead diversity initiatives can make a critical difference to how the issue of diversity is perceived in the workplace. Senior management positions such as 'Chief Diversity Officer' or 'Global Chief of Diversity' are often found in leading companies with direct reporting responsibilities to the CEO to ensure diversity remains a strategic priority. For example, Johnson and Johnson's Chief Diversity Officer, has been appointed to champion, communicate, implement and

monitor its diversity policies across all business units, and works in parallel with its CEO to keep diversity and inclusion strategies as a key strategic priority, by for example linking top executive remuneration to their achievement of diversity goals etc (Diversity Inc., 2010). These findings align with the social science on cross cultural contact, and the conditions under which it has a productive effect on community relations.

Offices of diversity

A number of recognised leaders in diversity, such as Johnson and Johnson, and PriceWaterHouseCoopers, have established an office of diversity and inclusion as a separate business unit from human resources to reflect senior management's belief in the strategic importance of diversity initiatives in the workplace (Diversity Inc., 2010; Johnson and Johnson, 2010). Although diversity and inclusion strategies are closely related to traditional human resource management functions of hiring and promotions, they are considered to have wider strategic value that extends beyond a company's internal management to impact on its wider supply chain, the community it serves and external stakeholders. This is a key mechanism for driving institutional-level change, and for engaging with the systemic nature of racism (confronting deeply embedded stereotypes and re-thinking organisational practices that disadvantage minorities).

Measuring diversity management performance

Companies that are committed to diversity initiatives establish measurable KPIs that enables them to monitor the return on investment and effectiveness of diversity initiatives implemented (KPIs may include: number of clients from different minority groups; number of senior managers from minority groups; levels of acceptance and satisfaction among employees; grievances and complaints; workplace conflict and disputes; retention; recruitment; community and public image etc). These companies view diversity initiatives as a valuable investment in the creation of a harmonious, inclusive and productive workplace. They actively seek out, or participate in, specialist rankings as a way to gain recognition or build brand recognition in the marketplace among clients and external stakeholders, and increase their ability to attract and retain new talent. For example, British Airways measures and reports employees' perceptions of the effectiveness of its diversity initiatives through internal employee surveys, the feedback from which influences its diversity strategies (Singh, 2008).

Cultural integration opportunities

Companies are increasingly employing creative ways to promote awareness of the need for cultural diversity in the workplace. For example, Pearson publishing group organises a diversity week where members of different cultural and minority grouping are invited to share their cultural food, drinks, cooking lessons and cultural knowledge. This extends beyond immediate employees to the company's customers, business partners and supply chain, so that fellow employees, their customer base and the wider community can better understand and appreciate the unique features of their cultural background. While one often finds similar initiatives (site BBQs etc) in the construction sector, they are of much smaller scale, voluntary and typically ad-hoc. In contrast, Pearson's diversity week is a highly structured and planned event which is centrally organised and advertised by the company. It is significant in highlighting diversity as the right thing to do, and is also useful in

showcasing how diversity has commercial value and benefits beyond its employees to benefit their wider supplier chain and the communities they serve (Singh, 2008).

Diversity training

A number of best practice diversity companies, such as Colgate-Palmolive go beyond basic compliance and have made diversity training a standard and mandatory feature of their overall training process. These courses are delivered though online tools to facilitate easy access to the training resource that covers a wide range of topics such as the rights and obligations of employees, anti-discrimination legislation and strategies for dealing with workplace discrimination (Diversity at work, 2003). Other companies such as British Airways emphasise more practical day-to-day managerial approaches for dealing with diversity, such as how to overcome negative behaviours, attitudes and stereotypes. On-line diversity training programs, and those equal opportunity principles, are common within large organisations, including Universities.

Community languages

The ability to communicate in a language other than English is a quality that companies increasingly value as a resource to help bridge cultural divides and to allow them to better understand their employees, and service their clients and stakeholders. For example, companies such as Sydney Water, Australia Post and Medibank Private proactively encourage native speakers from culturally and linguistically diverse backgrounds (CALD) to undertake a language competency test so that they can become qualified translators and interpreters. The cost of the test is normally covered by the company who also provide certified CALD speakers who list themselves on a staff translator list with a linguistic allowance to reward them for assisting in communications with internal and external customers.

Cultural holidays

Different cultural and ethnic groups celebrate events and holidays that have specific cultural value and significance to them. In acknowledging this, ebay and IBM Australia for example, has implemented a ‘Floating Cultural Holiday Policy’ that gives employees the option of ‘trading’ official public holidays for a day that is of cultural significance to them (IBM Australia, 2010). For example, employees may wish to 'trade' a gazetted public holiday such as the Queen's Birthday for a day of particular cultural significance, such as Chinese New Year. A key advantage of the policy is that it effectively allows employees to strike a balance between their cultural and work commitments, while according due recognition to an employee’s cultural heritage.

Role modelling

The positive role modelling of successful and inspirational employees from minority groups can have a significant motivational impact in minority groups (Thomas, 2006). These role models are particularly important in breaking down traditional stereotypes and perceived barriers and misconceptions for entry and promotion in certain industries, such as building, engineering and technology, where visible role models are not common. For example, to retain young women employees, Shell has started role modelling successful women in senior positions, particularly those technology business units where female representation has

historically been low. From their stories, young women employees can learn important lessons about the challenges that many women experience in achieving and maintaining senior positions.

Networking

In a culturally diverse workplace, networks play a key role in strengthening diversity by providing important forums through which individuals and groups can meet and exchange ideas, experiences and embrace similarities and differences among people from different cultures and backgrounds. These networks can serve a range of functions, in providing a supportive or facilitative environment, reducing isolation increasing levels of intra- and inter-cultural interaction and providing access to promotional opportunities through mentoring programs and other initiatives (Laroche and Rutherford, 2007).

Mentoring

Mentoring programs are increasingly utilised as a tool to harness cultural diversity within the workplace and provide a valuable vehicle for promising employees from minority backgrounds to access the managerial support and identify pathways and knowledge they need to reach their full potential at work. For example, Johnson and Johnson match new employees with experienced managers through formal or informal mentoring arrangements (Johnson and Johnson, 2010). Similarly, Sodexo's 'Spirit of inclusion' mentoring program matches people from different backgrounds and provides training to mentors to help them manage this process, regularly monitoring mentor and mentee performance in achieving pre-determined diversity and inclusion goals (Sodexo, 2009).

Supplier or subcontractor diversity

Supplier and subcontractor diversity initiatives are an important way in which companies can give back to the communities they serve by reaching out to minority and women-owned businesses and are aimed at helping these businesses develop the capacity to compete on an equal basis in the market place. A number of recognised advantages of increased supplier and subcontractor diversity include improved reputation and marketing opportunities, the promotion of inclusiveness at all levels of business, better access to innovative ideas and vendors who reflect and understand the culturally diverse communities that companies operate in, and increased customer satisfaction, market share and profitability (Diversity Inc., 2010). Commonly used strategies to promote supplier and subcontractor diversity include: Supplier or subcontractor guidelines & codes of practice; Strategic allocation of a portion of contracts; Certification; Supplier Diversity Mentoring Programs; Diversity sponsorship or scholarships and; Evaluation tools.

CONCLUSION

This paper has presented a number of best practice strategies for promoting diversity in the workplace. All are derived from outside the construction sector since this is where the best practice companies appear to reside (at least from publically available information). No construction or engineering companies globally reside in the best diversity companies lists. Future research might usefully focus on why this is the case and to identify the imperatives needed in the industry to integrate such initiatives more comprehensively into firms' business

strategies. However, in a small desktop study like this, it is not possible to identify and classify every type of cultural diversity initiative being implemented. Nevertheless, we can reasonably conclude, given the construction and engineer industry's relatively high level of cultural diversity, compared to other sectors, and the evidence (provided in stages 1 and 2 of this research) that it impacts on workplace relations, productivity and safety, that firms can and should do more to harness the potential benefits of this diversity within the industry in terms of the firms and people who work in it. This will make a significant contribution to a more socially sustainable industry. More research is needed to explore, classify and test the extent of effectiveness of the full variety of diversity strategies that could be employed in the industry to achieve this end.

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ACADEMIC/INDUSTRY INNOVATIONS FOR SUSTAINABLE BUILDING DESIGN AND REFURBISHMENT

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Abstract
Development and efficient dissemination of innovations for sustainable building design and refurbishment are crucial for the competitiveness of companies operating in the construction sector which faces pressure to reduce levels of carbon emissions from existing and new buildings to zero. An overwhelming majority of companies operating in the construction sector in Scotland are small to medium size enterprises (SMEs) who do not have sufficient resources in the current economic downturn to undertake research in building design, products and processes that will make buildings more sustainable. A joint project of seven Scottish universities has been initiated to support collaboration with small to medium sized enterprises in developing and disseminating innovation for sustainable building design and refurbishment. The project concept and methods used for efficient dissemination of the project outputs to SMEs across Scotland are explained. An analysis of the outputs of completed feasibility studies and the provision of academic consultancy through the project indicates the range of problems tackled as well as trends in the development and use of innovations for a more sustainable built environment in Scotland.

Keywords: Construction innovations, academia, SMEs

INTRODUCTION

The importance of the sustainable built environment for sustainable development of Scotland was emphasised in the Scottish Government's strategy for sustainable development *Choosing Our Future* (2005) and *The Government Economic Strategy* (2007). One of the objectives of the *Scottish Construction Industry Plan 2007-2012* (Scottish Construction Forum, 2007) is to increase good practice in sustainability by sharing best practice and innovation. The Scottish Government's *Policy on Architecture for Scotland* (2006) encourages the recognition and adaptive re-use of Scotland's historic buildings rather than their replacement to meet the objectives of sustainable development of the built environment. *Climate Change Adaptation by Design* (Shaw et al, 2007) and *Sustainable Housing Design for Scotland* (Stevenson and Williams, 2007) point out that it is existing stock which can potentially make the most effective contribution to meeting sustainability objectives and reducing carbon.

The Scottish Government aims to reduce carbon emissions in Scotland by 80% by 2050 as outlined in the *Climate Change (Scotland) Act 2009*. *A Low Carbon Building Standards Strategy for Scotland – Sullivan Report 2007* recommends future revisions to the CO_2 target reductions within the Building Regulations as follows: 2010 – CO_2 savings of 30% more than 2007 building standards; 2013 – CO_2 savings of 60% more than 2007 building standards; 2016/17 – net zero carbon buildings (i.e. space/water heating, lighting & ventilation).

The above targets for carbon reduction cannot be achieved without innovations. The challenge is increased by the risk-averse attitudes of building clients, contractors and building control officers towards innovations. The WWF Scotland (2008) report *Carbon Countdown for Homes: How to make Scotland's existing homes low carbon* points out that sufficient numbers of experienced and knowledgeable building control officers and local authority planners are needed to ensure there are no bottlenecks in obtaining permissions for improvements.

The consultations with the industry organised by the Scottish Construction Centre (Scottish Construction Centre, 2008), the conference *Lifting Barriers to the Application of Construction Innovations in Scotland*, held at Glasgow Caledonian University on 25 March 2009 (The Centre for the Built Environment, 2009), and the report on *Developing Scotland's low carbon built environment* undertaken by BRE Scotland on behalf of Scottish Enterprise (Kelly, 2010), highlighted that the affordability of research for SMEs, the lack of tested innovative solutions and guidelines on how to apply them in practice are perceived as barriers to the adoption of innovations. This market failure within the above context of policies for creating a more sustainable built environment has been identified as a focus for the CIC Start Online project.

CIC START ONLINE PROJECT

The aim of the Construction Improvement Club (CIC) Start Online project is to embed innovations for sustainable building design and refurbishment into practice. The objective is to support collaboration between academia and Scottish small to medium size enterprises (SMEs) in developing and testing innovations for sustainable building design and refurbishment. The project is led by Glasgow Caledonian University (GCU) in collaboration with Edinburgh Napier University (ENU), Glasgow School of Art (GSA), Heriot-Watt University (HWU), the Robert Gordon University (RGU), University of Edinburgh (UE) and the University of Strathclyde Glasgow (USG). The project is funded by the European Regional Development Fund and Scottish Government from 1st September 2009 until 31st August 2012.

CIC Start Online runs a quarterly competition for 50 feasibility studies (FS) and 19 academic consultancies (AC) on sustainable building design and refurbishment undertaken for the benefit of Scottish SMEs. The joint academic/industry applications are assessed and approved by an independent assessment panel whose members are representatives of the Buildings Standards Division of the Directorate for the Built Environment of Scottish Government, the Scottish Association of Building Standards Managers and energy efficiency consultants.

The outcomes of academic/industry collaboration are presented at seminars, transmitted online as webinars in real time and then made available as video recordings on demand at the project website www.cicstart.org to the project members. Membership is free and open to everyone.

Three whole-day online thematic conferences are planned. The first one, on *Sustainable Refurbishment*, was delivered on 4th June 2010. The seven webcasts filmed in collaboration with academic partners are available free at the project website following registration. The second conference will deliver the project partners' webcasts on their research and innovation related to the *Resilience of Buildings, Neighbourhoods and Cities*. This conference will take place online

from 14th until 17th June 2011. Each webcast will be followed by an interactive discussion with their authors.

The project publishes a quarterly free online Innovation Review that includes case studies on innovation for sustainable building design, construction and refurbishment applied in practice, information on support for innovation and related research.

Online dissemination of the project outcomes has assisted in attracting membership across Scotland, the United Kingdom, and internationally. By the end of February 2011, the project has over 620 members from over 470 organisations, of which over 320 companies are Scottish SMEs. Online dissemination of the project outcomes reduces carbon emissions of the continuous professional development of the project members.

INNOVATIONS SUPPORTED BY CIC START ONLINE PROJECT

The following section provides an overview of the types of innovations supported through FS or the innovations that have been further refined through AC. The overview is based on the studies completed or initiated until the end of January 2011. The approved applications can be divided into five thematic groups as presented below: Sustainable building design, Sustainable refurbishment, Post occupancy evaluation, Sustainable building materials and components, and Decision making for sustainable building design and refurbishment. The competition is open to additional potential themes for FS or AC that will address other aspects of the application of innovations for sustainable building design and refurbishment in practice.

Sustainable building design

A Hybrid Solar Thermal Mass (HSTM) System Development for the Application to Tenants First Housing Co-operative's Zero-carbon Affordable Homes, GSA, ENU and Tenants First Housing Co-operative, Aberdeen.

The benefits of using the building foundation as the heat store over alternative, more common, wet (or phase change) thermal storage media were demonstrated. The study concluded that using the Ecocirc pump in combination with a 30 Wp PV module, the desired design condition of a relatively constant collector outlet temperature can be achieved in practice. Measurement of irradiance, and collector temperature and flow, has provided an accurate appraisal of the Solartwin collector thermal performance. It indicates that the HSTM system is able to deliver heat to, and store heat within, the thermal mass of the building foundation (Noguchi et al, 2010).

Assessment and Application of Zero Carbon Building in Scotland, HWU and IES Ltd, Glasgow

The study involved investigation of recently published guidelines into the definition of 'Zero carbon' by the government and a comparison with 'true' zero carbon buildings. The study uses the proposed Riccarton Ecovillage on the campus at HWU to provide the sample building used for the detailed analysis and assessment parts of the study. HWU and IES worked together using IES's Virtual Environment software to perform predictions of carbon emissions. The detailed calculations consider a range of currently available building technologies, and systems that could be used either in isolation, or in conjunction with one another. The analyses are intended to demonstrate the differences between current building standards and the improvements that will be needed in future both to meet the published regulatory guidelines and also to provide a

comparison with true zero carbon using representative domestic Scottish buildings as the basis for the analysis. The report aims to show what renewable technologies need to be employed in order to meet Zero Carbon – using both dynamic simulation methods and Building Regulations SAP software meeting the Scottish Technical Standards Section 6 requirements (Roaf and McEwan, 2010).

Tarryholme Sustainable Housing Project, USG and Assist Design, Glasgow
Assist Design is currently engaged in a sustainable housing development project Tarryholme Eco-House in Irvine in collaboration with the Irvine Housing Association and Irvine Bay Regeneration Company. The project aims to attain a higher level of sustainability than those promoted by existing assessment protocols and be reflective of contextual realities in Irvine. The study aims to demonstrate that it is possible to build an affordable, organic Eco dwelling that can optimise the conflicting demands of energy efficiency and good indoor air quality in the context that the UK has the highest prevalence of asthma in 13-14 year olds and that the last 25 years has seen the incidence of asthma episodes increase four-fold in adults and six-fold in children. The study will include the detailed design of a two-bedroom, semi-detached property including drawings, specifications, whole life cost and carbon analysis. Direct comparison with an affordable house designed to the 2010 Scottish Building Standards will also be provided (Howieson and McCafferty, 2010).

Energy Impact of different strategies of integrating PV/Thermal heat transfer, GSA and Robert Ryan Timber Engineering Limited, Saltcoats
Robert Ryan Timber Engineering Limited is developing design ideas and solutions towards the construction of two net ‘zero-energy’ healthy housing prototypes in North Ayrshire which aim to surpass the energy usage profile of zero-carbon counterparts being recognised by the UK Government. Extensive studies have been conducted on the design optimisation of photovoltaic thermal (PV/T). However, the energy impact of a PV/Thermal Heat Recovery unit integrated into housing for space heating is barely conceived or examined in today’s homebuilding industry. The goal of this feasibility study is to assess the most effective strategies of integrating PV/T Heat Recovery (PV/T HR) system in Scottish 'zero-energy' housing in the context of energy, economic and life cycle performance. It will be conducted through scale model experiments to test different installation (PV/T HR architectural integration) scenarios and the performance with aim of applying the PV/T HR system to the two zero-energy demonstration homes (Masau and Noguchi, 2010).

Enkelt Simple LivingGSA and Ballyconnelly Construction Ltd, Wemyss Bay
The purpose of study is to scope out the next stage of improvements to the Enkelt house model developed by Ballyconnelly Construction Ltd. This will include identification of minimum standards as well as improved U-values with increased insulation using a 180mm SIP panel; improved window and door specification balancing the brief to maintain cost level at typical housing construction cost; improved efficiency of the MVHR unit with e.g. integrated ASHP and Hot Water Cylinder, reviewing the potential to remove the heating system; potential for integrated renewable systems such as solar hot water, PV and heat pumps and their impact to reduce future running costs and CO_2 emissions; assessment of the responsible sourcing of materials reviewing any opportunity for improvement; assessment of the Enkelt system against recognised criteria e.g. EcoHomes, Code for Sustainable Homes, and appraisal of potential

improvement against these criteria; and a review of potential for a prefabricated modular version of the Enkelt home to improve construction time and build quality (Sharpe and Stewart, 2010).

Independent verification of a climate based worldwide building energy index, GCU and IES Ltd, Glasgow
IES Ltd has prototyped a set of energy indices that can be used to assess, classify and compare any worldwide climate (weather data or extrapolated climate change data) for the purposes of understanding climate and for the use in sustainable building design. The indices are intended as rapid and interactive holistic design tools applicable to any building type, with any design strategy, in any location worldwide and for the simple quantification of the impact of climate change on building energy progressively over a sustainable building's lifecycle. The basis of the indices is the fact that climate underlies building energy use and it is therefore possible to compare designs relative to climate, visualise where design emphasis needs to be placed and directly and interactively track the effect of design strategies. The index is applicable to both the design and operational phases of buildings and is directly usable by building professionals without the need for specialist energy knowledge i.e. architects, quantity surveyors, students, etc. The SME was in need of an independent peer review and detailed verification to prove the prototyped index performs successfully. With this need in mind the academic partner carried out a review of the Climate Energy Index and the Building Energy Index developed by the SME partner with the aim of verifying their scientific soundness and ease of applicability. The following tasks were performed: a peer review or the physics and implementation of the Index, an extensive series of tests to confirm the validity of the Index, and a series of robustness tests (Kumar and Emmanuel, 2010).

Sustainable refurbishment
Tenement Flat Carbon Reduction Shopping List, USG and Holmes Partnership, Glasgow
The study aimed to provide typical Glasgow sandstone tenement flat dwellers with a guide as to the most suitable carbon reduction measures to apply to their dwelling. In particular, it was intended to provide a cost per tonne of carbon dioxide saved comparison to demonstrate value for money for various retrofit options. A particular tenement flat was selected and surveyed. The dimensions and conditions were passed to ESRU who prepared a dynamic thermal model. Various retrofit options were agreed and applied to the model and the outcomes recorded in terms of tonnes of carbon dioxide emissions saved. Doig and Smith (Cost Consultants) prepared costs for all the retrofit options allowing the cost-per-tonne saved to be calculated (Cockroft et al, 2010).

Upgrade Strategy Development for Garrioch Residents Association, USG and Collective Architecture, Glasgow
The study has defined and demonstrated a process for assessing and communicating the energy upgrade options to a residents association, landlord or housing association. The first process step is a meeting with the client to explain the project and get their inputs on the current issues with the building and the range of upgrades of most interest. Following this consultation process the current building performance is established through a physical survey, air-tightness testing, thermography and smoke analysis in representative dwellings. The appropriate upgrade options and best practice examples for the building type are then researched and a reference database created. The carbon and energy performance of a representative sample of the existing dwellings

is then modelled; and the carbon, cost and energy impact of a range of upgrade options quantified. Based on best practice and modelling results some recommendations are provided. A customised version of the modelling tools is made available to the residents association and training offered to allow them to assess further upgrade options on an ongoing basis. The customised tools are similarly available as the starting point for future similar projects. A report of the outcomes of the work is prepared and presented to the clients allowing them to gain understanding. In this case the process was applied to the quadrangle of traditional red sandstone tenement flats in the west end of Glasgow represented by Garrioch Residents Association. As there are many similar properties in Scotland requiring similar upgrades, work undertaken in this study can be utilised elsewhere. However, the process is not restricted to these similar properties; it can also be applied to other dwelling types (Touhy et al, 2010).

Solar-Wall systems for domestic heating: an affordable solution for fuel poverty, HWU, Changeworks Resources For Life Ltd and Ormandy Ltd, Edinburgh

The aim was to test a number of key variables of a solar wall heating system currently under development, to maximise solar heat collection in the context of Scottish weather and heavy buildings built with solid walls (pre-1919 buildings account for 20% of the housing stock in Scotland). The study quantified the thermal effect of internal solid walls used as thermal storage for solar heat in tenement flats for all-day usage, optimised the device to maximise heat exchange between the wall and hot water from the solar panel, provided a modelling tool to enable a Solar Warm Wall system to be designed to suit individual buildings (either new or retrofit), and estimated costs of system implementation. In addition, this study analysed solar availability, heating demand and domestic water supply for two typical dwellings based on two reliable methods: a) a purposely developed dynamic thermal model, and b) data collected in previous studies carried by Changeworks. The tests were carried out using two methods: Computational Fluid Dynamics (CFD) and laboratory simulation. Developing the CFD model was one of the major objectives of this feasibility study. The lab tests were conducted to collect data to validate the CFD model (Wang and Roaf, 2010).

Synergy of Fabric and Energy conservation in older historic properties, ENU and The Morrison Partnership, Edinburgh

The Morrison Partnership (Architects) have a private client who wishes to convert and extend a 19th century traditional built two storey mansion house in Alyth, Blairgowrie, Scotland. The proposal is to convert the former hospital to a home. An energy efficient heating system for both space and hot water was proposed, which is not only sustainable but respects the behaviour and appearance of the existing historic building fabric. The study will identify appropriate actions in achieving minimal fabric intervention for maximum energy conservation in traditional buildings with specific reference to solid stone/ lath & plaster wall construction typical of the 19th century in Scotland. The project will aim to address: 1. Environmental issues by seeking methods of reducing CO_2 emissions and improving energy conservation and management in older, difficult to heat, stone built properties; 2. Social issues by improving health as a result of improved and balanced indoor air and heating quality; 3. Economic issues by considering whole-life energy costs in large domestic, difficult to heat, buildings in Scotland. The proposal will aim to: 1. Establish a detailed energy assessment process for the building study type that could be used in other similar projects; 2. Identify future research and improvement work in this area to develop and market an energy management process for this building type (Currie and Purdie, 2010).

Post occupancy evaluation

Development of Post Occupancy Evaluation for evaluation of innovative low carbon socialhousing projects, GSA and John Gilbert Architects Ltd, Glasgow

The study includes a monitoring programme over a 2 – 4 week period of time measuring performance in terms of temperature, humidity, air quality, general and specific energy consumption. This is supplemented by interview, questionnaire, observation and spot measurement to determine occupancy regimes, patterns of use and consumption, users understanding of systems and controls. The second stage comprises a limited number of pilot programmes to test the methodology and data capture systems. The long term aim is to enable participating housing associations to understand how the performance of their housing is in comparison to other projects, what changes they may consider making to future projects as well as addressing issues in existing projects. It will also help in the setting of realistic energy targets so that those setting the targets have a real understanding of the consequences and achievability of certain energy targets. The eventual goal is to provide a much more accurate feedback loop on performance, problem detection, remediation and avoidance, and improved design and specification (Sharpe and Gilbert, 2010).

Embedding simplified post occupancy evaluation in design process, USG and Page and Park Architects, Glasgow

The team studied: 1. information relating to existing POE methods; 2. current benchmarks to determine industry best practice and compare appropriate figures against Page & Park attainments; 3. various existing questionnaires in order to devise a simple questionnaire that clients would regard as user-friendly; and 4. the range of formats in which clients/companies receive energy data so that a meaningful POE process could be devised that would cope with a wide range of data. It was decided that the most effective way to deliver a simplified POE process, to complement the existing work practices of Page & Park, was to design and trial a software tool, named POET (for Post Occupancy Evaluation Tool). This tool was developed over the period of the project and underwent a number of revisions to deal with issues relating to compatibility with Page & Park hardware, work practices and application expectations (Clarke et al, 2010).

In-service testing of a prototype dwellings in relation to passive versus active ventilation strategies and assessment of air quality and comfort balance with fuel poverty avoidance, USG and Assist Design, Glasgow

Primary research outcomes will include construction process monitoring and post occupancy evaluation. It is proposed that a dwelling with low energy characteristics can be designed to be significantly faster and easier to construct making both time and skilled labour savings that would considerably impact the potential cost of achieving greater than 60% CO_2 reductions. Construction process monitoring of the prototype low energy house will allow quantifying such savings and making direct comparison with an affordable housing designed and constructed to the 2010 Scottish Building Standards that meets 30% CO_2 reduction commitment. It is further proposed that such a dwelling should address indoor air quality and public health. Post occupancy evaluation research outcomes will be realised within 12-month monitoring period (Howieson and McCafferty, 2010).

9-11 Gilmour's close – comparing the theoretical performance of a suite of sustainable installations in the building against actual performance and user experience, GSA and Assist Architects, Edinburgh

9-11 Gilmour's Close is a low-carbon refurbishment project for Hillcrest Housing Association, located in Edinburgh's World Heritage Site. The project addressed the difficult task of refurbishing an existing listed building to minimize CO_2 emissions and dependency on non-renewable energy sources. The project aims to gather data to compare the theoretical performance with actual performance. The context for this is the increasing need to develop design and technologies for all newly built homes to ensure that they would be carbon-neutral by 2016. Whilst predictions can be made about performance at design stages, there is very little evidence being collected about how these buildings perform in use. This gap in knowledge must be addressed if effective designs and technologies are to meet these rigorous standards (Sharpe and Jack, 2010).

Post Occupancy Evaluation of Municipal Terrace, Dumfries, GSA and Dumfries & Galloway Housing Partnership (DGHP), Dumfries

The Municipal Terrace in Dumfries was built in 1913 to house the "working classes". The block consists of eight one-bedroom workman dwellings that have cavity walls, which is unusual for the built age, with 9" outer leaf, 2"cavity and a 4½" inner leaf. The property had two large rooms and a rear scullery which was built in solid 9" brickwork (area converted into kitchen/bathroom 1962-3). DHGP developed and incorporated ways of improving four of eight homes above existing Building Regulations levels and along the ideas, principals and standards of ecological building design and refurbishment (including Passivhaus). In order to test the effectiveness of these measures, this consultancy will undertake a post occupancy evaluation to examine the performance of the dwellings (Sharpe and Trant, 2010).

Sustainable building materials and components

Developing Homegrown Natural Fibre Insulation Products, GCU and Kraft Architecture, Glasgow

Kraft Architecture has been working on in-house research into the processes and manufacturing of natural fibre products using home-grown & waste fibres. Having identified prototyping facilities, waste material suppliers and carried out market research into demand, they are now at a stage where they wish to prototype the product and have the products undergo testing. This project is focused primarily on the use the climatic chamber facility in GCU's Centre for Research on Indoor Climate and Health to test the thermal performance, vapour diffusion, resistance co-efficient of prototype natural fibre insulation product(s) consisting of various recycled waste textile and cellulose materials (Baker and Newlands, 2010).

Novel Solar Thermal Collector Design, HWU and AES Ltd, Forres

The primary objective was to improve the basic design of the AES solar thermal collector; to make it more efficient, lighter and more robust and generally a more fit for purpose and greener product. The intention is to provide an improved collector to market at a competitive price relative to the current one. Taking into account that the solar gains and heat losses are linked to conditions of operation and design of the collector, it was necessary to focus on analyzing the mechanism of energy gains and losses from the collector, such as type of material cover, material housing, insulation material properties, surface area, weather conditions, inlet temperature water,

ambient temperature, mass flow rate, position of collector, dimensions, gross area to absorber area ratio, absorber material and best thickness, and collector tilt angle. Four sample units were manufactured by AES and supplied to HWU for thermal performance testing (Roaf and MacLennan, 2010).

Decision making for sustainable building design and refurbishment
An Investigation of the Adoption of Low-Carbon Technologies by Scottish Housing Associations, RGU and Anderson, Bell and Christie Architects, Glasgow
A feasibility study was proposed as a means of investigating the decision making of housing associations (HAs) with regard to the adoption of low carbon technologies. The starting point for the study was a consideration of what impact incentivisation schemes (in this case particularly feed-in tariffs) had on the adoption of low carbon technologies. The study developed further, in that it added an objective to assess the feasibility of producing a unified business process (UBP) focused on aiding individual HAs when deciding which low carbon technologies (LCTs) are appropriate to them. The study involved two housing associations that had both considered the adoption of innovative sustainability technologies, but ultimately made different investment (in the form of "purchasing" sustainable technologies) decisions. Within the study, interview and document analysis methods were used to determine both the culture (in terms of propensity to innovate) and any filters that had strong or weak impact on the decision making of the respective housing associations (Moore et al, 2010).

DISCUSSION

The launch of the CIC Start Online project at the seven universities involved in the project in October and November 2009 provided opportunities to advise the industry on funding available to Scottish SMEs for collaboration with academia in developing innovations for sustainable building design and refurbishment. SMEs' requests for assistance are submitted online as a brief description of a problem that they wish to tackle and forwarded to the project partners. Sometimes, the assistance is provided jointly by the academics from different partners' institutions according to the expertise required and available for addressing different aspects of an innovation.

The overview of the studies approved to date indicates that there is an interest in tackling innovations both for existing and new buildings, and for assessing their true impact through post occupancy evaluation. The studies have also enabled SMEs to access laboratories at the participating universities to test innovative building products and technologies. How building clients make decisions in relation to the incentives to reduce the carbon emissions of buildings was the theme of one academic consultancy that will provide an insight not only for the architects who initiated this research, but also for the wider professional audience when the research outcomes are presented at a forthcoming seminar and webinar.

The scope of the approved studies includes not only the environmental impact of buildings such as the reduction of carbon emissions and the use of renewable energy and building resources, but, in many cases, the social and economic impacts by tackling fuel poverty, indoor air quality and whole life costs for building occupants. As only the innovations that simultaneously address environmental, social and economic impact could contribute to a more sustainable built

environment; this was one of the main conditions of the competition. As a consequence, interdisciplinary collaboration of researchers from different departments at the partners' institutions and sometimes with external consultants has been initiated.

Feasibility studies and academic consultancies have developed new knowledge regarding the technologies for generating energy from renewable resources and building materials made of recycled or renewable natural resources. They have also contributed to a better understanding of how new technologies can be integrated in existing and new buildings to reduce carbon emissions and fuel poverty. Other studies have refined some existing software tools for building modelling, or indicated the limitations in some existing assessment tools that should be considered when using them to estimate building performance, or used the tools to indicate improvements required in traditional building types to achieve zero-carbon standards. Most studies focused on real building projects, either recently completed as exemplars of sustainable design or refurbishment that need to be verified through monitoring or to suggest further improvements to achieve zero-carbon standards. Due attention was given to existing building stock by consulting building occupants on how buildings are used, applying innovative methods for assessing building performance, recommending and estimating costs of potential improvements, and providing guidelines to the building owners on how to undertake future assessments and improvements.

As the studies have been initiated by the industry, they indicate the range of issues that the industry faces in its efforts to create a more sustainable built environment, a range which will probably be extended in the future applications for feasibility studies and academic consultancy through the CIC Start Online project. The majority of studies focused on the Scottish environmental, social and economic context regarding the need for more sustainable existing and new built environment, thus assisting in solving local problems. However, some studies have tackled more generic innovations in sustainable building design and refurbishment that can be applied internationally. The results of both approaches assist in increasing the competitiveness of SMEs which have benefited from their collaboration with academia through the CIC Start Online project, and of the project members to whom the outcomes of innovations are disseminated through seminars, webinars, online conferences and an online magazine. The project has been included in the Scottish Green List 2010 as one of the top twenty projects that contribute to a more sustainable development of Scotland.

Webinars are increasingly used for the dissemination of knowledge on sustainable building design and refurbishment across the world, e.g. by U.S. Green Building Council (USGBC Webinars, 2011), American Society of Civil Engineers (ASCE, 2011), ArchDaily (ArchDaily, 2011) and Mechanical Contractors Association of America (MCAA, 2011). In comparison to the webinars provided by the above organisations, other professional associations or a range of consultancies and publishers, the CIC Start Online webinars disseminate the outcomes of academic/industry collaboration in developing and testing innovations for sustainable building design and refurbishment in Scotland's economic, social and environmental context. The collaboration between the seven Scottish universities and local construction sector enterprises accelerates the capacity building and increases the competitiveness of the local industry to apply innovations in practice, which is the project aim.

CONCLUSIONS

As the academic/industry collaboration through the CIC Start Online project has contributed to the development of a range of innovations for sustainable building design and to a better understanding of how they can be applied in practice, the project partners are planning a proposal for a project extension that will eventually include more higher education institutions and link with further education institutions to support the development of skills required for creating and maintaining a sustainable built environment. In addition, stronger links are planned with local construction fora to reach all participants in the construction supply chain.

In the context of recent policies and proposals published by the Scottish Government such as *Energy Efficiency Action Plan for Scotland* (October 2010), *A Low Carbon Economic Strategy for Scotland* (November 2010) and *Low Carbon Scotland: The Draft Report on Proposals and Policies: Scotland – A Low Carbon Society* (November 2010), interdisciplinary collaboration will be further extended to reduce carbon emissions through the research and application of integrated design, refurbishment and management of the built environment that tackles energy conservation and efficiency, sustainable transport, and waste reduction, reuse, recycling and energy recovery.

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ARCHITECTURAL DESIGN AND CONSTRUCTION COSTS, TOOLS TOWARDS TERRITORIAL SUSTAINABILITY

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Abstract
This paper is presented in CIB: Management and Innovation Sustainable Built Environment 2011, as the study and analysis of the residential model of a rural area from the Iberian Peninsula, specifically applied to the case of the province of Cáceres, in the autonomous region of Extremadura, in Spain.
To this end, from a database made up of building projects whose real costs are known, it is intended to establish the links of the different parameters studied through the corresponding functions of statistical analysis. One of the main objectives of this process is constituted by the possibility of establishing those design variables of higher economic importance, so as to keep an economic control of these parameters, generally geometrical and typological, from the very start of the project. And, in general, a higher optimization of resources in the construction of dwellings in the rural environment from their design is intended.

Keywords: Self-development, sustainability, design, costs

AIM

The characterization of a residential building pattern and its repercussions on production costs is one of the tasks which explain the particular features of the economy of the built environment. When this area is immersed within a rural environment with a context of limited economic development, as is the case in the territorial scope of this work, it is essential for the public authorities to articulate policies which encourage and support access to a decent home. Not only for the household economy but also for the public funds which finance the process.
This study takes place within the framework of Management and Innovation for a Sustainable Built Environment CIB International Conference; and its purpose is to determine the repercussions of programmatic, geometric, constructive and technological design parameters on the final cost of a determined constructed object: the owner-developed home. It is with this element that the Public Administration of the European region of Extremadura aims to make use of available land for family units, generally in small rural centres of population.

Thus, the aim is to make an own home more affordable in an environment of limited economic resources, sidestepping the burden of purchasing the land where the building is to be, and providing financial help for the building process. In terms of territorial policy, the end goal is to facilitate the stability of the population in the area and to promote permanent renovation of the built environment. By these means the aim is to achieve sustainable growth of small rural nuclei, in which traditional economic activities, such as farming and cattle raising and their associated small industries, can be integrated naturally and harmoniously.

Along these lines, the purpose of this study is to determine the ideal characteristics, from the point of view of functional and economic efficiency, of a basic residential typology for balanced development of a territorial remit undergoing emigration and depopulation, and which is a factor of social cohesion in rural communities.

THE PHYSICAL SCOPE OF STUDY

Physical and Geographic Framework.

The geographical context for this study is the Province of Cáceres, in the Autonomous Community of Extremadura, a region in the mid-west of Spain, bordering on Portugal.



***Figure 1**: Autonomous Community of Extremadura in Spain*

The climate is continental: high temperatures in summer and low ones in winter. The rainfall is fairly low and concentrated in the months of October and April.

The north of the province flanks a large mountain range and is home to several districts - La Vera, the Jerte Valley, the Ambroz Valley, Las Hurdes… made up of population centres which are close together and the municipal districts are small.
The centre of the province is a broad plain crossed by a large river: the Tagus; this area has very few, widely scattered population centres with large municipal districts. The Monfragüe National Park is to be found here.
The south-east of the province is again of considerable altitude and there are small villages set close together, similar to in the north.

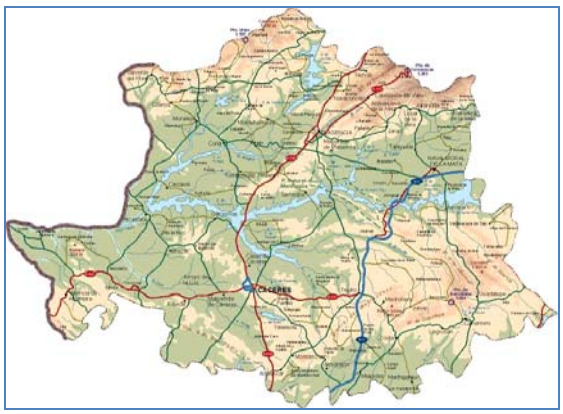


***Figure 2**: Cáceres Province, north of Extremadura*

Socio-economic Framework: Population and Main Activities
Cáceres Province has a population of approximately 400,000, of whom 69% live in population centres of fewer than 15,000. The other 31 % live in two main cities of under 100,000 - Cáceres, the capital, with a population of 94,197, and Plasencia, with 41,447. Therefore, the region can be seen to be dominated demographically by a rural structure, which characterizes the aim of this work.

The main activity of the rural population is agriculture (fruit-growing, olives, tobacco, maize, tomato, asparagus …) and free-range livestock-raising (cattle, pigs, sheep). Manufacturing industries for the farm produce only exist in district-based cooperatives.

The Owner-Developed Home of Extremadura Regional Government

Present State of Affairs: Background to Public Policies of Residential Owner-Development in Other Fields.

In the rest of Spain there is no record of any other type of housing with public subsidies until 2008, with the exception of State-subsidized community housing (VPO) on a nationwide level. In this case, although the land receives a subsidy, until recently there has been no attempt to encourage development on land of which the developer is the owner.

In the unfavourable context of the economical, financial and property crisis of 2008, the State Plan for Housing and Rehabilitation 2009-2012 funds new building work by the owner-developer for the first time.

The only record in Europe of the existence of public policies for owner-developed housing is in Greece, where, according to Maloutas (2003, 2004) they constituted a means of integrating the rural population into urban society. The latter was at a time of rapid expansion: the early post-war, after the devastation of the rural areas caused by the war and economic crises. Thus, cheap housing was made available in the conditions of a poorly developed welfare state. Furthermore, this author points out that the importance of owner-development in the early post-war is intertwined with the reduction in direct state intervention, as opposed to the important public housing schemes that dealt with the demand for housing in northern Europe. Likewise, Golland (1998), Nicol y Golland (2004) y Haartsen, Groote y Huigen (2000) have analyzed the phenomena of residential owner-development in other contexts and latitudes.

Historic Background to Housing Assistance in Extremadura
In those times repopulation schemes were carried out which built villages from scratch. However they were not as successful as hoped, perhaps due to the lack of roots in what was new, perhaps since the farming tasks on the land were so hard compared to the opportunities of the city. This meant that numerous villages were virtually depopulated by the end of the 80s. As a result of this state of affairs, by the 70s Extremadura had become one of the most depressed regions of Spain, and therefore among the least developed regions in Europe.

The coming of democracy to Spain and, later, joining the EU with its subsidy policies marked the turning point and the initiation of a process of growth in the region. In this context, Royal Decree-Law 31/1978, of 31st of October, on low-cost state-subsidized housing (VPO) gave a direct impulse to incomplete regulations which already were pointing the way to social housing subsidies.

The Spanish Constitution of 1978 sets out in Article 47 that all Spanish citizens have to the right to a suitable and decent home. Moreover, it states that public authorities will promote the necessary requirements and will lay down the relevant regulations to bring this right into effect. The Constitution itself indicates that this right is to be transferred to the various Autonomous Communities. Thus, Extremadura Regional Government, as Public Administration of the Autonomous Community, aware of the characteristics of its population, adopted subsidy measures for owner-developed housing in Decree 11/1996, which are still in force today, with slight modifications.

The table below, which records the owner-developed housing interventions in Extremadura from 1996 to 2007, shows the intervention of over 7,800 homes out of a total of 360,000 homes present in the whole region. This means that over 2% of all housing built over this time has been developed with the Administration's help, following the technical requirements of the owner-developed home.

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**TOTAL**
BADAJOZ	**1472**	**812**	**933**	**553**	**383**	**296**	**273**	**278**	**214**	**197**	**158**	**82**	**5651**
CÁCERES	**536**	**282**	**349**	**214**	**168**	**95**	**80**	**98**	**90**	**92**	**86**	**55**	**2145**
Annual total	**2008**	**1094**	**1282**	**767**	**551**	**391**	**353**	**376**	**304**	**289**	**244**	**137**	**7796**
%	**25,75**	**14,03**	**16,44**	**9,835**	**7,065**	**5,013**	**4,526**	**4,821**	**3,898**	**3,706**	**3,129**	**1,757**	**100**

Owner-Developed Housing Subsidy Regulation
Owner-developed housing, in short, possesses the following common features of subsidy and required technical conditions.

A) Maximum usable area is 95m2.
B) The beneficiary must be the owner of the land which is legally apt for building.
C) The average annual income of the developer must not be more than 2.5 times the Guaranteed Minimum Wage.
D) The promoter will receive 18,000 euros, which are non-returnable, in two payments. The first one on presenting the final design and the Municipal Building Permit; and the second on obtaining the First Occupancy Licence and the Certificate of Occupancy of the property.

As differentiating features, the homes analyzed have the following characteristics:

a) No design criteria is imposed as to number of floors, shape, volume, layout nor programme of use, apart from those laid down by the local urban planning regulations.
b) There is no compulsory specific technical or constructive solution, apart from the general ones which are obligatory in the whole of the state or autonomous community.

Regarding the particular effects that this regulation has on the owner-developed homes themselves, it is worth noting that they present differential features in terms of design and

costs, as well as similarities in the dimensions of the intervention. On the other hand, as the developer is also the user of the home, the programme of use is certain to be met, since the regulations allow certain leeway in the design.

As far as the public consequences of this kind of interventions are concerned, it should be pointed out that owner-development subsidy policies are of moderate economic development, insofar as they are applied to owners of land which is of much lower value than that in the cities. Moreover, the family situation of probate facilitates buying land. On the other hand, these public actions constitute a system of backing for the small plot-owner which prevents speculative actions.

As we are dealing with small-scale interventions, they are favoured by a local economy in which the local building contractors and subcontractors are highly competitive in this class of development. Thus, it is possible to keep out the larger building companies. This makes it possible to keep local jobs and guarantee the stability of the population in the area. Moreover the regulation prevents Transfer Tax for ten years, which ensures the stability of the population in the communities.

The Administration allows the owner-developer to choose the technicians who draw up the project and the works supervisors. This strengthens the communication between technicians and owner. Furthermore, in general, the technician is used to working in the area and knows the technical resources available to the builders.

Lastly, the fact that there is a final supervision of what the Administration technicians have done, before granting the economic subsidies, ensures that the planning and technical property regulations are met. The Autonomous Community's supervision makes sure the building takes place on urban land. This reduces the number of illegal, clearly unsustainable interventions. All this directly favours a compact growth of the centre of population: filling in gaps in the urban grid or by taking place in new-growth areas already planned for this purpose.

Moreover, the system of subsidies and assistance requires administrative legal supervision, which means the whole building process must be legalized, as the new building works must be recorded in a notarial instrument and must be publicly registered. This way, the new building is taxed according to Annual Property Tax.

Lastly but not least, it should be pointed out that the Financial Institutions feel safer giving mortgages as there are good guarantees: firstly a safe land value, since the dweller is the land-owner; secondly there are additional guarantees, like the economic help from the administration and the owner's presence as owner and inhabitant of the property for ten years.

CHARACTERISTICS OF THE SAMPLE ANALYZED

According to the information published by Extremadura Administration, during the period 1996/2001 some 5400 homes were built subject to the owner-development regulations, while in 2001/2008 over 2500 homes were developed. Therefore over 8000 administrative files of this type exist, which means that this type of owner-developments affects approximately 10 % of the population of the Autonomous Community of Extremadura. These figures increase accordingly with the promotions carried out between 2008 and 2010.

For the purposes of this study, a sample of owner-developments has been chosen which is delimited both in time and space, according to the following criteria:

- In geographical terms, the province of Cáceres has been chosen, in the north of the Autonomous Community.
- From the point of view of time, a period has been chosen to allow the works selected to be finished. And so the most recent administrative files analyzed date from 2008. Spain's entry in the Euro system in 2001 has been taken as the starting point of the study, so as to avoid any distortion of the market due to the currency change.

The sample analyzed, as a result of these two limitations, is made up of an approximate total of 800 owner-developed housing administrative files, subsidized by Extremadura Regional Government in the Cáceres province between 2001 and 2008.

SCALING OF OWNER-DEVELOPMENT COSTS

State of Affairs

In Europe the earliest applications of scaling cost methods come from the "Centre Scientifique el Technique du Batiment", Paris, with the European revival after the Second World War, when a large demand for housing required of the French government some system with which to quantify public investments.

Since then there have been several systems which have aimed to draw up a forecast of building costs; I. Paricio (1971) is the pioneer in Spain because he developed and adapted the French ARC scaling cost method to the realities of the Spanish building sector.

In the 80s some methods were published using tabulations, diagrams and parameterization which aimed to fix scaled cost systems. The Architects' Association, in turn, began to establish cost/m2 modules, which are brought up to date so as to estimate the Real Execution Budget according to use and typology. This is for setting the minimum fees of the technicians and so as to be able to reference other costs such as Municipal Licenses, Stamp Duty, the bidding terms for tenders and auctions, financial or investment evaluation etc.

The everyday use of the computer over the last decade has facilitated the fast and accurate development of the cost estimation procedures. Not only due to the appearance of very complete and easily available price books, but also because of computer applications which carry out scaled cost analysis easily and reasonably accurately.

Another important factor is that over the last few years, Public Administrations (the Councils and the Departments of Public Works within the Autonomous Community) have been compiling a great deal of information that can now be used as a research database. It has been compiled directly via statistical questionnaires, or indirectly via reception of projects for granting licences. This fact, which may seem insignificant, has had a great effect on the development of this kind of research because, until less than a decade ago, many local authorities did not ask for a final design in their remit. This has now changed considerably with the appearance of Law 15/2001 of December 14th, of Extremadura Land and Regional Development Planning. Since then, there have been a number of registered and recorded homes that permit a rigorous scientific analysis of the present situation.

As for the overview, in previous models and empirical findings on building costs estimation models there are independent variables such as location, construction year, building type, number of floors, quality, and building technology (Kouskoulas and Koehn, 1974); construction year and location, total building area, combined percent area of health center and commons, area per unit, number of floors, and percent area of structured parking (Sonmez, R., 2004), the characteristics of the functional elements (Carvajal, 1992; Yaman and Tas, 2007); risk factors inherent in construction such as underestimation, completion delays, inadequacy of cash flow, poor site investigations, changes in scope of work, defective construction works, non-availability of funds and under-valuation (Odeyinka, H.A., 2007); the cost of building materials, interest rates, property price, foreign exchange rates, labour cost, national disposable income and money supply (Windapo, A.O. and Aiyagba, R.O., 2005); or physical and typological data, such as no. of storeys, no. of columns, no. of rooms or type of foundations (Arafa, M. and Alqedra, M., 2011).

In most of these research studies, the independent variables correspond to the technological and socio-economic characteristics of the geographic area in which the research is to be performed, as well as the features of construction typology analyzed in each case. Likewise, the explanatory variables used in this work have been adapted to the particular characteristics of the rural environment and socio-economic conditions in which self-development takes place in Cáceres. Thus, as has been set out in depth in the following headings, other factors have been introduced, such as the structural characteristics of the local building industry, access to the building site, and pre-existing buildings. To these variables are to be added those which refer to physical aspects of the land, such as topography and resistance of the subsoil, as well as geometric characteristics and built housing programme, which, bearing in mind the local production methods, have a real effect on the final building costs.

Characterization of a Scaled Cost Methodology
There are three ways of predicting building cost:

- Once the final design is complete, using economic measurement and evaluation of every item and unit that compose it. This is not in itself a scaling system.
- A unit cost module estimate reached by using previous experience in real building costs in similar constructions
- Using cost modules set down by Administrative bodies or by professional organizations respected by the Professional Bodies. These are usually below the real level.

The following required characteristics of a scaling method arise from these three scaling approaches:

a) Sufficient agility so as to be able to manage as few as possible basic meaningful variables which affect the final cost. Thus it can be used in the preliminary phases of the design process, in which most of the parameters which are to define the projected building are unknown
b) The method's ability to adapt to the peculiarities of every construction, once the setting, the design variations and the derived technical building considerations have been observed
c) Enough accuracy to ensure the likelihood of getting it right and which makes it possible to detect the scattering produced in each case, as compared to the characteristics of the average building

d) The method must allow for regular updates and even be adaptable to other fields of work or other construction types
e) The method must be simple to calculate so it may be used in a basic way. Thus it will be accessible to any owner-developer or small-scale building contractor.
f) The method must allow preliminary detection of the factors which most affect the final price, in order to aid design decision-taking before starting the design phase
g) The prescaling must be included in some IT supported service. This makes data entry easier, sidestepping complex mathematical operations.

METHOD DEVELOPMENT: FACTORS ANALYZED IN COST SCALING

For the development of this study, an analysis is carried out of the design factors and parameters which determine the final cost, giving a scaling model which combines three factors:

.- One cost module M expressed per unit of buildable area
.- The buildable area S
.- The intrinsic determining factors for each building work C

The cost module M is based on the scaling systems established by the administrative bodies. This indexing allows for permanent up-dating. The buildable area S is, firstly, limited by the regulations themselves for owner-developed housing and, secondly, determined by the convenience or economic and programme limitations of the private developer.

The third factor is a multiple one, as it is conditioned by the correction coefficients set down by the particular typology of home Ci, which increase or decrease module M. This introduces a factor of flexibility into the design process. These variables stem from three differentiating concepts which are intrinsic to the building itself:

A) Circumstances brought about inevitably by the surroundings and the physical environment of the plot CS
B) Circumstances determined by the design parameters CD.
C) Circumstances which arise on account of the implementation of the building, determined by the technical solutions adopted during the building process, which we shall call CT.

Consequently the cost of implementation will be a result of the formula

$$\mathbf{M \times S \times C = M \times S \, (CS + CD + CT)}$$

Determining factors of the plot: CS.

As for intrinsic determining factors of the plot where building is to take place, the following circumstances will be born in mind:

A) Town/village: refers to the type of population centre where the building takes place. The thresholds of the different categories are:
A4: population centres which do not have builders or building suppliers.
A3: population centres which have both builders and building suppliers.
A2: which, as well as builders and suppliers, have carpenters, metalworkers and locksmiths.
A1: which, as well as builders, suppliers and the tradesmen mentioned above, have plumbing and wiring subcontractors and other essential housing fixtures.

B) Accessibility: this refers to the ease or difficulty in bringing the machinery to the building site and for storing the material conveniently. The following thresholds can be designated:
B4: difficulties in access and in material storage onsite.
B3: good access to the site but difficulties in storage of materials.
B2: difficult access to the site but ease of material storage onsite.
B1: good access from the road for supply lorries and ease of material storage onsite.

C) Building already existing: this refers to previous buildings onsite. The following categories have been defined:
C4: residential building, which would also imply the annulment of existing installations, with particular care to be taken with party walls.
C3: farm building, warehouse or similar, with low property appraisal value, whether in ruins or not, with particular care to be taken with party walls, but on the supposition there are no or minimal installations.
C2: Brickwork walls, rough stone wall or similar enclosing the plot.
C1: Plot completely empty and ready for immediate start to building work

D) Terrain: Refers to the mechanical characteristics of the ground the building is to sit on. The following categories are defined:
D1: for those whose bearing capacity is less than 1.00 Kg/cm2; in other words soils classified according to regulation as soft, fluid clay.
D2: for those whose bearing capacity is between 1.00 and 2.50 Kg/cm2; in other words: for hard clay and sand soils according to regulations.
D3: for those whose bearing capacity is greater than 2.50 Kg/cm2; in other words: for coarse sand and gravel.
D4: for those which are rocky in general.

E) Topography: refers to the slope or height difference in the plot.
E4: Height difference greater than 2.20 metres.
E3: Height difference between 1.40 metres and 2.20 metres.
E2: Height difference between 0.60 metres and 1.40 metres.
E1: Height difference less than 0.60 metres.

Design conditions CD

F) Factor of form of the building: in terms of the relationship between the area and the volume of the projected building.
F1: Less than or equal to 0.945, only an exception could be less than 0.85
F2: Value from 0.945 to 1.04 inclusive.
F3: Value from 1.04 to 1.135 inclusive.
F4: Value greater than 1.135, exceptionally greater than 1.23

G) Building annexes: refers to the inclusion of unimproved garage or premises on the ground floor, semi-basement or basement.
G4: Unimproved Garage or Premises in semi-basement or basement.
G3: Unimproved Premises on ground floor of more than 35 m2.
G2: Unimproved Premises of up to 35 m2 or garage, either concept on ground floor.
G1: Without annex, neither an unimproved premises nor garage.

H) Exterior wall openings: refers to the area of the fachade used for enclosed balconies, balconies and windows.
H4: façades with more than 17 m2 of opening.
H3: façades of from 13 to 17 m2 of openings.
H2: façades of from 9 to 13 m2 of openings.
H1: façades of less than 9 m2 of openings.

I) Plumbed room: includes the area of the bathroom, the toilet and kitchen, and the relation of this to the total built area of the home.
I4: Home with more than 20 m2 of plumbed rooms.
I3: Home with from 17 to 20 m2 of plumbed rooms.
I2: Home with from 14 to 17 m2 of plumbed rooms.
I1: Home with less than 14 m2 of plumbed rooms.

J) Transitional areas: these are the areas set aside for access, corridors, halls and landings and the relation of this area to the rest of the building.
J4: area greater than 30 m2 of corridors or shared zones.
J3: area from 20 to 30 m2 of corridors or shared zones.
J2: area from 10 to 20 m2 of corridors or shared zones.
J1: area less than 10 m2 of corridors or shared zones.

Technical specifications CT

K) Foundations
K1: of continuous ditches with lightly reinforced concrete.
K2: of continuous ditches and reinforced concrete footing.
K3: of isolated footing, party wall of reinforced concrete.
K4: of footing and ditches with retaining walls of reinforced concrete.

L) Structural System
L1: using load-bearing walls and perforated brick 1 foot thick.
L2: using load-bearing wall and perforated brick 1 foot thick and some beams or pillars with steel profile (mixed structure).
L3: using reinforced concrete porticos.
L4: using porticos with standardized profiles of rolled steel.

M) Roofing System
M1: 100% of the plot area covered with sloping roof, with no traffic-bearing roof surface
M2: 75% of the plot area covered with sloping roof and 25% with traffic-bearing roof surface.
M3: 50% of the plot area covered with sloping roof and 50% with traffic-bearing roof surface
M4: 100% traffic-bearing roof, including patio area if it exists.

N) Degree of prefabrication in the construction, determined by the existence of:
A) Lintel beams
B) Gutter channels
C) Vents
D) Steps.
E) Partition walls.

F) Eaves, balcony and external façade mouldings.
G) External chimneys and /or their chimney pots.
H) Blinds housing box

N4: low of prefabrication, at most two of the prefabricated elements.
N3: medium-low level of prefabrication, at most four of the prefabricated elements
N2: medium-high of prefabrication, at most six of the prefabricated elements
N1: high level of prefabrication, at least seven of the prefabricated elements

Sample-Taking for Statistics.
A data-gathering template is drawn up with these fourteen variables and their sensitivity levels. This is to be filled in systematically in every owner-developed housing file which is subsidized by Extremadura Regional Government in Cáceres Province. The information is gathered by means of the analysis of the final designs drawn up for application for Municipal Building Licence. They will come from the municipal archives of all the towns and villages in the province.

RESULTS

Results of the First analysis of the Data-Base.
In the initial phase a mathematical model was developed with as many equations as unknown quantities. In this case it gave a number of necessary equations of fourteen conditions with their respective four levels, with a total of 14 x 4 = 56 unknown quantities. Thus, a matrix is obtained in which each row had 56 digits or coefficients of each one of the unknowns. Of the latter, 14 were of equal value to the unit, giving the other forty a null value.

This equation system matrix was associated with a null value determinant. This implies that the proposed determining factors are related to each other, there being some kind of relation in common which joins or links them. If the determining factors are related to one another, it is important to know the degree of relationship, because determining a certain relationship could establish a scaling criterion.

Results of the Second Line of Research.
The statistical analysis has consisted of a rectilinear adjustment following the minimum squares method. In this, the aim is to construct a straight line to join Variable Y – identified with percentage increase in the building cost module of the School of Architects (M)- with each of the X Variables identified with the 14 characteristics or parameters under study. Thus, for every condition there will be a straight line of the type $Y = aX + b$, where “a” and “b” are unknown quantities to be discovered following the method above. This way, a mathematical link is obtained between the various determining factors and the percentage increase which qualifies the scaling based on the modules of the School of Architects.

The resulting equations for each determining factor are the regression lines found by the least squares method of the form $Y = aX + b$, whose values “a” y “b” are reflected in each corresponding statistical chart. After undergoing the selection implied by the real values of the boundary conditions imposed by the reality of the marketplace, once the values of the regression coefficient of each line have been analyzed, and therefore its degree of inter-relation, the resulting equations are:

For Town/ village	Y = 2,39 A
For accessibility	Y = 3,04 B – 3,04
For existing buildings	Y = 4,18 C – 4,18
For topography	Y = 3,68 E – 3,68
For factor of form	Y = 3,47 F
For wall openings	Y = 2,39 H – 2,39
For plumbed room	Y = 2,24 I
For foundations	Y = 2,42 K – 2,42
For structure	Y = 3,59 L – 3,59

Assigning the possible values according to the parameterization proposed for each of the variables - or, to put it other words, attributing the values 1, 2, 3 or 4 to each of the variables – we obtain cost increase percentages for each concept at every one of the levels. These will constitute the values gathered in the final chart which is representative of the scaling method for the various determining factors.

As a consequence of the above statistical analysis of the variables and parameters which affect the construction costs, the following conclusions may be reached:

a) There is an obvious scattering between the existing cost scaling methods and the reality of the marketplace. This can reach a variation of 20% to 55% in the case of official reference prices of the School of Architects, in comparison with the final cost of a building work.
b) The order of influence in building costs in €/m2 is as follows: Existing buildings, Accessibility, Form Factor¸ Structure, Topography, Town/ village, Wall openings, Plumbed rooms and Foundations.
c) There are five determining factors which do not affect the €/m2 of the home: Terrain, Annexes, Level of Prefabrication, Roofing System and Transitional Areas
d) A quick, easy-to-calculate scaling method has been achieved.
e) This is a method linked to official data about local building costs, like that of the School of Architects' Reference Budget. This means it can be permanently up-dated.
f) The method has an average scaling error of 7.70 %. It has been proven that it will never reach ten percent.
g) The error of the method is always positive, so there will be no unpleasant surprises in terms of the developer's investment or the contractor's offer.
h) All that is needed in order to the method is some sketches of the Design, a visit to the plot and very few technical decisions. Moreover, the scaling method makes some initial reflection necessary at the very start of the process which would not normally happen otherwise.

CONCLUSIONS

The owner-developed home in Extremadura constitutes an alternative to the speculative development system. It gives impetus to self-sufficient lifestyles in small rural communities, favouring their stability and sustainable regional development. But it is necessary to adopt efficient measures to achieve economical viability. These measures must optimize the public resources of the Administration, which backs and subsidizes the development process, as well as the private income of the owner-developer. The latter are severely limited in developing economies like that of Extremadura. The building costs scaling tool, which is proposed here, develops a mathematical model by means of statistical analysis. This model allows, in the

preliminary stages of the design, the drafters of the design to determine the characteristics that the designed building requires in order to reach the most efficient solutions.

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COUNTERFEIT CONSTRUCTION PRODUCTS FROM LOW-COST SOURCING COUNTRIES

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Abstract
Counterfeiting has been around since ancient times. Counterfeiting in modern times was once widespread and not confined to any geographic region. With the globalization efforts following World War II, counterfeiting became an international problem, much of it emanating from Japan's developing manufacturing-based economy. As Japan's economy matured in the late 1960s, the epicenter of the counterfeiting industry moved to Korea. As Korea's economy improved, the bulk of the problem moved to China, where it resides today. A research project was funded by the Construction Industry Institute in Austin, TX to answer four questions: 1) Has the worldwide counterfeiting problem extended into construction materials, equipment and other products?; If so, how large is the problem?; If so, what countries or regions are the source of the counterfeit goods?; If so, what countries or regions are the destination of the counterfeit goods? Results showed that counterfeiting of construction goods is a problem that the problem is large and dangerous, that, like counterfeiting as a whole, China is the primary source of counterfeit construction goods, and the destination of the counterfeit goods is most often the U.S., but can be any place that the counterfeiter thinks that a profit can be made. The team was also asked to make recommendations to industry to mitigate the problem.

Key Words: Counterfeit, Construction, Materials, Equipment, China

INTRODUCTION

In the mid-1980s, U.S. Customs estimated that counterfeit products comprised nine percent of total world trade in manufactured goods. Even though many countries have signed agreements to protect intellectual property rights, counterfeit products are more available than ever in both world and national markets. According to the World Trade Organization (WTO), world trade increased by 47 percent from 1990 to 1995, but during this same period the trade of counterfeit products increased by 150 percent. Since 1995, the problem has continued to grow. As of 2003, the total value of counterfeit products marketed in the world was estimated to be more than $1 trillion annually; this total includes counterfeit products that are produced and marketed domestically within countries.

A 2009 report by the Anti-Human Trafficking and Emerging Crimes Unit of the United Nations Interregional Crime and Justice Research Institute acknowledged the link between organized crime and counterfeiting. Their research indicates that organized crime benefits from counterfeiting through the use of trade routes that have been previously and successfully exploited for other illegal activities. Moreover, the globalization of markets and the widespread distribution of technologies present new opportunities for expansion of organized criminal activities through international alliances between criminal organizations (UNICRI 2009). The research revealed that the level of profitability in counterfeiting is relatively high while the level of risk is relatively low. The opinion of experts interviewed as part of this research project is that this is due to the fact that law enforcement tends to focus less on these types of crimes and penalties are less severe. While the team did not established a link between organized crime and construction counterfeiting, its research strongly suggests that the industry's global supply chain is vulnerable to infiltration by these increasingly globalized criminal networks.

In a 2009 report, the U.S. Immigration and Customs Enforcement (ICE) agency estimated that each year, counterfeiting costs U.S. industry about 750,000 jobs, with thousands more jobs at risk around the world. ICE and the Customs and Border Protection agency made more than 14,000 seizures of counterfeit goods in 2008, valued at more than $272.7 million, a 38 percent value increase over 2007.

In recent years, as news stories have surfaced on counterfeit retail products such as baby food, dog food, jeans, handbags, DVDs, and other popular items, questions have emerged as to whether counterfeiting was a problem in the construction industry. A single incident in 2006 involving the construction of a U.S. government installation in Europe by a prominent U.S. construction contractor provided the impetus for this research project.

The facility design for this installation included 48 name-brand telecommunication routers that the contractor purchased from a U.S. Fortune 500 authorized distributor of such products. Within the first few months of service, 12 of the devices progressively failed. Upon investigation of what was clearly an epidemic failure rate, all 48 devices were found to be counterfeits of Chinese origin. Not only were they counterfeit, but when the serial numbers were examined, they were all valid. The counterfeiters were so sophisticated that they had applied serial numbers of genuine identical devices that had not been registered by the original purchaser(s).

Following are other examples of counterfeiting documented by the research team:

- In 1987 and 1998, two crane accidents killed two people in the United States. In each case, counterfeit bolts were suspected. In the 1987 case, counterfeit bolts appear to have been tied directly to the death of a worker at the mammoth Saturn automobile factory, then under construction in Spring Hill, Tennessee (DOE 1992). The worker was tightening a bolt when it cracked and caused him to fall to his death. In the second case, counterfeit fasteners were used in the 700-foot-tall hoist that peeled off the scaffold of an office tower under construction in Manhattan. While counterfeit bolts were identified in the boom, investigators could not determine whether the failure of the counterfeit fasteners caused the collapse (Post 1999).
- According to an industry safety alert discovered during the research, a counterfeit steel pipe manufactured in China in 2007, stamped in the United States, and

- An insurance executive interviewed as part of the research stated that in 2007 a counterfeit cement kiln from India ruptured while in operation in Canada, killing two employees.
- In an interview with the National Electrical Manufacturers Association it was learned that in 2006, one million counterfeit Square D circuit breakers entered the United States in one shipment from China.
- The Electric Power Research Institute (EPRI) posted a report on their website of two counterfeit five-inch (5") stop-check valves being found at a Southeastern U.S. nuclear power plant in 2007. One had been installed in a non-safety application, and another was in inventory. This report was confirmed in a later interview by the research team with an executive of the company that owns the power plant referenced. (EPRI 2009)
- The research team was told by two interviewees, one with the National Manufacturers Association and one with the U.S. State Department, of the U.S. Military buying thousands of counterfeit military grade microchips for use in sophisticated weapons systems aboard nuclear submarines and fighter aircraft. The team verified the truth of these reports by discovering a 2008 videotaped investigative report by Bloomberg BusinessWeek magazine that documents this kind of military sourcing of chips (DOJ 2009).

Although there are many areas of concern related to product integrity, the potential impact of counterfeit products to plant performance, plant life cycle, safety, structural and product integrity was the focus of this investigation. While there is much literature on counterfeiting in general, there is almost nothing documented on counterfeiting relative to the construction industry. For example, the counterfeit "industry" does hundreds of billions of dollars of business annually; however, the scope of counterfeiting within construction is unknown. What is known is that counterfeit products have caused significant negative impacts to safety, project schedules, overall costs and quality of construction.

RESEARCH METHODOLOGY

Since the Principal Investigator (PI) and the research sponsor were located in the U.S., it was imperative to document any problem in the U.S. construction industry. With counterfeiting being an international problem, interests outside the U.S. must also be consulted. Canada was immediately chosen as a target for interviews. The decision was then made to assume that countries that were proven to be a source of non-construction counterfeit goods would likely be a source for counterfeit construction goods. Therefore, investigative teams were formed in the five countries reported as the source countries for the most counterfeit goods seized by the U.S. Immigration and Customs Enforcement service (ICE). These countries were China, Hong Kong, Taiwan, Pakistan, and The U.K. Table 1 shows the breakdown of interviews by country.

Table 1. *Breakdown of Interviewees by Country*

Country	No. Interviews	Percent of Interviews
United States	78	40.6
China	70	36.5
Taiwan	16	8.3
Canada	10	5.2
United Kingdom	8	4.2
Pakistan	8	4.2
Hong Kong	2	1.0

The research was carried out using face-to-face interviews almost exclusively. Five telephone interviews were conducted out of the 192 total interviews executed. No surveys were disseminated and all interviews were conducted by PIs and National Coordinators, none by Research Assistants. The interviews were carried out using interview instruments customized for both the culture and the type of organization that employed the interviewee. Interviewees were chosen by type of organization and the level within the organization held by the interviewee. Each participant answered approximately 40 questions, meaning the research ended up with approximately 8000 data points. Only individuals from large organizations were interviewed. The types of organizations asked to participate in the project were construction owners, contractors, suppliers, insurance companies, manufacturers, and government / quasi-government agencies. Table 2 shows the breakdown of interviewees by organization type.
Below are the research results, summarized by country/region. North America was a major thrust. China was a major thrust, since it was by far the number one country on the ICE list. The U.K., Pakistan, Hong Kong, and Taiwan were the subject of more limited analyses due to resource limitations.

SUMMARY OF U.S. / CANADA

Eighty eight interviews were conducted in the United States and Canada. All but four were face-to-face, with four being accomplished via telephone. These interviews consisted of suppliers, manufacturers, distributors, government agencies, insurance providers, and contractors. Seventy-six percent of these respondents identified at least one case of counterfeiting, and collectively described 141 cases of counterfeiting in the construction industry. Some of the most

Table 2. *Breakdown of Interviewees by Organization Type*

Organization Type	No. Interviews	Percent of Interviews
Contractors	66	34.3
Manufacturers	36	18.8
Government/Quasi-Government	36	18.8
Owners	27	14.1
Suppliers / Distributors	20	10.4
Insurers / Re-insurers	7	3.6

common items identified were valves, fasteners, pipe, and steel. The most common detection method was failure of the component (31% of the cases). This was followed by inspection

(26%) and testing (10%). The interviewees were asked to identify where the item entered the supply stream. Forty six percent of the respondents identified the source as the manufacturer, with the remainder listing the source as either the supplier or distributor.

Attitude of Government

Forty three people addressed the question of the local government's attitude towards counterfeiting. In these questions the local government refers to the source country of the counterfeiter. Twenty eight percent of the respondents felt that the local government is aware of counterfeiting, but tolerates it because counterfeiting produces hard currency through exports and creates jobs. Twenty six percent of the respondents stated that the local government is officially against counterfeiting, but rarely takes action to stop it unless the counterfeiting produces bad publicity or results in deaths. Twenty one percent of the respondents stated that the local government realizes the problem of counterfeiting, and actively fights counterfeiting through legislation. Twelve percent stated that the local government is not concerned with the export of counterfeit items and nine percent think that local government is unable to deal with counterfeiting.

Reaction of Counterfeiters

The respondents were asked to describe the reaction of the source of the counterfeit product when confronted with the facts. Forty five of the respondents noted that the supplier or manufacturer responded and took action to fix the problem. However, 43% of the respondents noted that the counterfeiter denied that the item was counterfeit, denied supplying the counterfeit item, or never responded to inquiries. This statistic is important to remember when dealing with an overseas supplier or manufacturer. In this situation there is little recourse for the purchaser, other than blacklisting the organization. Even blacklisting is not extremely effective, since the counterfeiter can simply not respond and then re-brand their company. It is then very difficult for a company in the U.S. or Canada to know that a new company is not the same organization that supplied them with counterfeit items earlier.

SUMMARY OF CHINA

Seventy construction professionals were interviewed in China. Of these, only one was done by telephone with the remainder being face-to-face interviews. These interviews consisted of individuals of the same demographics as the ones interviewed in the U.S. and Canada. Sixty-four percent of the interviewees had either experienced counterfeiting or knew from a reliable source of a case of counterfeiting. The results demonstrate how cultural differences can affect transactions with foreign companies.

Factors Driving Counterfeiting

Cost is one of the driving factors for counterfeiters in China. One interviewee noted that using low grade steel in place of structural steel will cut material costs in half, while another noted that using low-grade material will increase profit by 20 percent. Chinese manufacturers know that their competitive advantage in the global market is cost. This aligns with the results of the U.S. interviews that showed that companies purchase from low-cost sourcing countries to gain a competitive advantage. Even the domestic procurement market within China drives costs to rock

bottom through competitive bidding. One interviewee noted that China is not suited for the competitive bid market because a contractor will win the bid on price and then provide a "jerry-rigged" project full of counterfeit products to meet the budget.

One source of the problem is that wherever a legitimate factory is established, smaller factories producing non-branded knock-offs will soon be established near the legitimate factory. These are often started by former technicians of the legitimate factory. As these smaller factories lack the skills and equipment to produce quality products, the resulting products are substandard. Also, the smaller company cannot compete with the legitimate company unless costs are kept low through using sub-quality materials and non-skilled workers. The Chinese interview results showed that 20% of the cases of counterfeiting described by the interviewees came directly from the manufacturers. The bulk of the cases (80%) were from distributors, or stockists as they are referred to in China. This concurs with the comments in the interviews that counterfeiting is generally the result of a distributor purchasing sub-standard products from these smaller factories and re-branding them as legitimate products. One interviewee noted that the legitimate factories will purchase and re-brand products from these smaller factories when their orders exceed their capacity.

Another source of counterfeiting is a lack of knowledge and understanding of foreign standards on the part of Chinese manufacturers. Although a project may dictate U.S. or E.U. material standards, one interviewee noted that Chinese manufacturers will often continue to use their national standards regardless of whether they meet the project standards. The attitude is that products that meet national standards are good enough. Other interviewees related thoughts, one noting that Chinese manufacturers are used to supplying products according to their standards, not their clients' standards.

Most of the interviewees thought that counterfeiting would be profitable in the short-term. Counterfeit goods cost less and can be used to meet tight project schedules. However, the consensus is that counterfeiting will increase costs in the long term with increased costs of inspections and loss of buyer confidence.

Attitude of Government

The counterfeiters of low-tech products present a difficult challenge for both the government and industry. These companies produce counterfeit products as a means of economic survival. Their guerrilla tactics include frequently changing their company name and address. One government official said that "the government should lead the market and make it grow healthily. Recently, the market has become over expanded. The development of companies' management capabilities is not balanced with product quality requirements. This results in a chaotic market and disorderly competition."

Sixty-three interviewees believe that the Chinese government would like to crack down on the counterfeiting industry, but 15 of them think the government lacks the power to enforce their decisions and 18 interviewees think that government does not have enough knowledge of the counterfeiting market.

Reaction of Counterfeiters

When counterfeiting is detected within China, the most common reaction of the party responsible is to actively respond to the problem with the owner either rejecting the items, the party replacing the items, or the owner adjusting the cost to meet the quality of the item. One interviewee from an EPC firm said, "Services such as to change, recall, reconstruct, or repair

unqualified items is quite common and easy to obtain or perform in China. However, if it occurs on an overseas project, the cost will increase several times." Foreign companies need to inspect goods within China before shipping overseas.

SUMMARY OF HONG KONG, PAKISTAN, TAIWAN, AND THE U.K.

Only two interviews were conducted in Hong Kong. While these are invaluable as aggregate data, the opinions and experiences of only two experts are not sufficient to form any conclusions regarding the Hong Kong construction industry.

United Kingdom

The United Kingdom research team interviewed eight participants to gauge their understanding of counterfeiting. Of the eight, one was determined to be invalid by the U.K. team, leaving seven interviews for analysis. Of these seven, one was from a governmental/quasi-governmental official, two from insurers, and four from contractors.

The primary results of the investigation into counterfeiting in the U.K. are two-fold. First, it was determined that there is not currently a problem of counterfeit products being manufactured in the U.K. Second, the U.K. is used by international counterfeiters to "launder" their illicit goods before shipment to their final destination, most often the U.S.

When it became apparent that the U.K. was not the home of significant counterfeit manufacturing, the question immediately arose – "then why is the U.K. ranked in the Top Five Countries for importing counterfeit goods into the U.S.?" Further research led to the discovery that counterfeiters from low-cost sourcing countries commonly transship counterfeit goods from country to country, usually ending up in a western European country or Canada before shipment to the U.S. In this way, a counterfeit product is laundered and the authorities in the U.S. will be less likely to closely scrutinize the shipment than if it had come directly from a low-cost sourcing country.

Taiwan

The Taiwan team conducted sixteen interviews, fifteen of which were deemed acceptable for further analysis. Eight were an owner, design professional, or contractor. Five were a manufacturer or supplier. The remaining two were an insurer and a governmental or quasi-governmental agency. The results showed that construction customers in Taiwan are aware of counterfeiting and are concerned about this issue during procurement. Clients will choose legitimate products in accordance with the project specifications; however, it was pointed out that the low-price bid rules of procurement encourage counterfeiting.

Most participants think that the local government is officially against counterfeiting but doesn't actively take action to reduce counterfeiting. The government will only conduct an investigation if there are claims, instead of taking proactive measures to thwart counterfeiting. In regards to using third party verification, nine out of 15 participants showed a positive attitude toward using a third party to verify product integrity. Although one interviewee noted that they would exclude China as a source for certain materials, overall the interviewees tend to rely on determining if a particular company can meet national material standards rather than adopting a list of approved or banned source countries.

Fifty-three percent of the interviewees (eight of fifteen) had either experienced counterfeiting, or were affiliated with a project that experienced counterfeiting. In most of the cases where the

participants encountered counterfeit products, the counterfeiting was discovered through testing. Of the eight cases of counterfeiting discussed, two of the counterfeiters refused to take responsibility while five of the remaining cases were dealt with according to contractual terms.
The interviewees recommend that the government issue clear legal and practical standard quality control processes, implement product certification regulations, make information transparent, establish product information networks, and publicize the discovery of counterfeit items once confirmed. For individual companies, respondents advised them that more quality control measures should be put into place. Clients should be aware of counterfeiting and should procure materials from reputable and qualified suppliers. Strengthening self-inspection and quality control is important to the client.

Pakistan
The Pakistan team completed eight interviews that included two government organizations, three contractors, a consultant, and two hybrids whose companies and duties encompass two or more of the entity types. Five of the respondents (63%) had experienced counterfeiting either directly or through another party on a project they were affiliated with. The sources of counterfeit materials were noted as mostly local. Notably the Punjab province was frequently identified. China and the U.A.E. were also mentioned prominently.
The types of counterfeit materials discovered included floor tiles, water supply fixtures, steel bars, electric cable and paint. The Shershah Bridge over the Karachi Northern Bypass was referenced by one respondent. That bridge collapsed 25 days after its inaugural opening, killing five and injuring many others.
Half of the respondents noted that when the counterfeiters were confronted, the offenders behaved badly, in one instance insisting that the counterfeit product was genuine. Others, after interrogation, accepted responsibility and replaced the offending items.

RECOMMENDATIONS

The following list of recommendations were developed by the research team as a means of providing owners, contractors, and suppliers with techniques to minimize the opportunity for counterfeit and suspect goods to enter their supply chains. A second list presents a composite of key indicators of potential counterfeit and/or suspect goods and materials, and offers more comprehensive advice based on the findings of the research. Both will help industry procurement and field personnel identify any counterfeit goods that have entered their supply chains and prevent any further entry. These are presented as guidelines; following these guidelines cannot guarantee the discovery of all counterfeit goods purchased, nor can it prevent all purchases of counterfeit goods.

Training / Education

- Train purchasing personnel about the hazards of counterfeit goods and the most common ways these goods and materials enter the supply chain.
- Educate and train Customs officials and those from other law enforcement agencies regarding construction goods and materials – not just the higher-profile retail products. These agencies are open to helping the industry, but they don't know what to look for.

Supply Chain Issues

- NEVER buy anything from those not on the AVL, unless the subject of any such deviation has been afforded similar evaluation as the products of those companies on the AVL.
- Specify all base metal requirements in P.O. Requisition per project/industry code requirements.
- If possible, use distributors and/or suppliers who have documentation systems and receiving inspection systems that ensure the traceability of their parts / materials to an approved source
- In foreign countries, where there may be *state-owned* suppliers, it is recommended that the qualified source inspector should be from another country to lessen the chances of intimidation of the source inspector when making sensitive calls regarding quality.

Testing and Inspection

- Consider connections (fasteners) such as bolts as pressure equipment and not just as "commodities.''
- The PMI program should include witness and/or monitoring from a quality stand-point.
- In foreign countries it is actually preferable to have a qualified ex-patriot perform the source inspection when possible. Minimally, supervisory visits from a qualified ex-patriot should be made.
- Consult specialists (i.e., Materials and Corrosion Engineers) whenever in doubt about product integrity.
- Material Test Reports (MTR) should be requested for materials. The MTRs should be matched to the heat numbers or heat codes on the materials.
- If the investigation leads you to believe the goods or materials are counterfeit, or alternatively if the integrity of the goods or materials cannot be verified, all members of the project (purchasing, inspection, engineering etc.) should be made aware of the issue and a conscious decision must be made as to the potential risks and the disposition of the goods and/or materials. This evaluation and final determination should be documented and communicated for lessons learned.

General

- Adopt a "zero tolerance" policy regarding counterfeiting. Report all incidences of counterfeiting and NEVER fail to support any law enforcement agency's effort to prosecute.
- Caution is urged when determining that goods and/or materials will be accepted if a discount in the pricing is granted. In some low-cost sourcing countries accepting a discount is tantamount to a tacit agreement that whatever goods are delivered will be deemed suitable for service. Thus, the supplier or manufacturer will feel sufficient justification for stating that the goods provided are not counterfeit.
- Encourage *victims* of confirmed counterfeiting to share the information with others within the industry to raise awareness and to help reduce the chances of that particular counterfeiting effort to continue.
- Recommend establishment of a repository for documented cases of counterfeit goods and materials in construction supply chains. If photographs and other comparisons between real and counterfeit items are available these should be posted. These could be useful

Key Indicators of Potential Counterfeit and/or Suspect Goods and Materials

At the industry level, the corporate level, and project level, there are things that can be done to help ensure product integrity. This is different than ensuring product quality. Product integrity means that the buyer is receiving what the buyer is paying for – not something else of equal quality, but exactly what is paid for. In some situations a counterfeit item may be of equal or greater quality to the real thing. However, a supply chain that can be infiltrated by high-quality counterfeit goods is more likely to be infiltrated by low-quality counterfeit goods than a supply chain that not only checks for quality, but also checks for integrity. To that end, the research team presents the following Key Indicators that an item may be, or a shipment may contain, (a) counterfeit item(s).

Supplier Behaviors

- Supplier too eager to make sale.
- Salesman / Representative doesn't ask questions when you explain a complicated requirement, but repeatedly says "no problem," or words to that affect, when he is told what is needed. A salesman that asks a lot of knowledgeable questions, while not appearing overconfident, is preferred.

Documentation/ Supporting Information

- Generic invoices and documentation received with goods (not normal specific documentation).
- Shipment contains no, or insufficient, paperwork

Appearance

- Product appearance looks "off', something different about appearance. (Sometimes the counterfeited item or its packaging looks "better" than the real thing.)
- Items from a known supplier not packaged as usual.
- Obliteration of, or alterations to, markings or logos.
- Inconsistent dimensions against a known standard.

General

- Goods are offered from a resource outside of the normal supply chain or typical procurement methods, or from a source not known to you or an experienced procurement staff.
- Normal receiving and/or NDE (non-destructive examination) methods reveal deficiencies or other non-conformance in goods or materials.

SUMMARY OF CONCLUSIONS

Counterfeiting, as defined in this research, is a large and growing problem in the industry, and its ramifications are almost unlimited. Besides the United States and Canada, five other nations were scrutinized. The research team retained the services of experts within each of the five countries to carry out research on counterfeiting in the construction industry within the confines of their assigned nation. Each National Coordinator was also assigned the task of determining the perceived impact that the export of counterfeit goods manufactured within their country

might have on the local and international construction industries. The countries chosen were the five countries that had been the import nations for the most counterfeit goods confiscated by the U.S. Immigration and Customs Enforcement Service (ICE). The nations were China, Hong Kong, Taiwan, Pakistan, and The U.K.

China is the epicenter of today's worldwide counterfeiting industry. This is true of non-construction and construction items. Hong Kong, Taiwan, and Pakistan all seem to be places that have an illicit counterfeit manufacturing industry, though most of those interviewed in those countries fear imports from China. The U.K. seems to be a place that counterfeiters from around the world send their products to "launder" them before they are transshipped to the U.S.

The causes of the counterfeiting problem are many, but some insight can be gleaned from the interviews. Several Chinese interviewees suggested that many of the reasons for the proliferation of counterfeit goods in construction supply chains are grounded in differences in the way business is practiced in developing nations and in the developed world. Other reasons revolve around such issues as the West's focus on getting the least expensive materials and equipment to maximize profits. Whatever the root causes are, the problem is massive and the threat is potentially calamitous. However daunting it may be, the industry's best short-term defense is to question its implicit trust in suppliers, manufacturers, and distributors, and to address its ignorance of how sophisticated today's counterfeiters can be.

Ignorance can be cured by training. The research team recommends that the industry make a priority of training its procurement, quality, and field personnel in how to prevent and mitigate the damage from counterfeit items in the supply chain. The industry must also systematically train the people hired to protect the public. The port master of the largest port in the United States urged the research team to impress upon the industry their need for training. He explained that construction items were off the radar of his customs inspectors because [they] don't know what to look for. He emphatically requested assistance in training them to inspect for counterfeit construction materials.

Finally, more research is needed. Although international in scope, this research project has just scratched the surface of the problem. Indeed, many interviewees expressed their concern that this research has only been able to look at the tip of the iceberg and that the world will eventually see a series of disasters attributable to counterfeit goods.

Future research could make another attack on a broad front, as this project has done, using these results to identify and focus on the areas that need the most attention or that show the most potential for progress. Or, future research could choose a limited number of strategic areas to investigate. The areas of focus could be determined by product type, such as steel, piping, or circuit breakers. Areas of future focus could also be determined by lines of defense, such as the following:

- third-party verification
- inspection of materials or of the manufacturing process at the point of origin, during the improvement or development process, at shipping, or at delivery
- inspection of the finished product, including country of origin and country of destination
- investigation into the ways construction goods are imported into and exported out of key countries in which large international construction firms build projects. This would include U.S. Customs inspection.

Other future research should involve the development of training materials for companies to train their procurement, quality, and field personnel in how to prevent and mitigate the damage from counterfeit items in the supply chain. Training materials and courses should also be developed to train those hired to protect workers and the general population (e.g., Inspection and Customs Enforcement (ICE), the FBI, port authority personnel, and customs warehouse personnel).

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CM-AT-RISK AS A HIGHWAY CONSTRUCTION DELIVERY SYSTEM IN THE SOUTHEASTERN UNITED STATES

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Abstract
The traditional system of design-bid-build has long been the principal delivery system for horizontal construction; it has been employed by all the transportation departments in the United States for almost a century. The shift toward design-build (DB) as a time saving method has been successful in many ways, but use of the system has exposed some disadvantages in the last decade. Construction-manager-at-risk (CMR) is a delivery system often employed in vertical construction, but transportation agencies have recently begun to use it for horizontal construction. The Departments of Transportation (DOT) of eleven states in the southeastern United States were interviewed in this study. The focus was on each DOT's experience and satisfaction with the DB delivery method, as well as their experiences, knowledge, and legal status of the CMR method. Florida was the only state of the eleven that has used CMR on horizontal projects. CMR has also been used as the delivery system on some municipal and county highway projects in Florida.

Keywords: Construction, Manager, Risk, Highway, Delivery

INTRODUCTION

All construction was once performed using a form of the design-build (DB) delivery system. In the 1920's and 1930's, knowledge of construction materials and methods grew at a rapid pace due to significant research, mostly sponsored by the American Association of State Highway Officials (AASHO). With this new knowledge came specialization and with specialization came the design-bid-build (DBB) project delivery system, which dominated horizontal construction in the U.S. for decades. The monopoly of this traditional system lasted until the Transportation Equity Act was enacted. In 1998, it became much easier to procure federal funding for projects utilizing alternative delivery systems, if the use of those delivery systems was in compliance with the state's own statutes. Due to the success numerous projects have experienced with DB, the states have become increasingly receptive to these new concepts of project delivery. Now, many states allow application of alternative delivery methods to public transportation construction projects, but some states differentiate their processes of authorization for DB and other alternative delivery systems such as construction-manager-at-risk (CMR). The differences in these procurement processes show

the skepticism held by many authorities toward CMR as a reliable delivery system for highway construction.

The Construction Industry Institute has pronounced DBB, DB, and CMR as the primary methods of project delivery (CII 2003). While this might be true in vertical construction, in the transportation field, CMR projects are not common. One of the reasons for this inconsistency within the two sectors of the industry is the difference in the characteristics of the project owners. In vertical construction, the identity of the owner can be any entity or individual that is able and willing to fund the project. In horizontal construction, the type of owner is fairly limited, most being a state's DOT, or some other public transportation agency. This can result in the support of a particular system due to the owners' singularity of nature. As the owners become familiar with a specific method, the fear of change inhibits their ability to explore additional options. Another reason for the hesitation, or lack of interest in experimenting with a different method would be the size of projects. Compared to private ventures, the level of funding allocated for a state's transportation projects is substantially higher. Therefore there are more risks involved in the testing of an unfamiliar method.

LITERATURE REVIEW

The National Cooperative Highway Research Program (NCHRP) has funded many comprehensive studies in regards to horizontal construction. In this field the two most commonly employed methods of delivery are DBB and DB. Scott (2006) pointed out the problem associated with low bid in DB; instead of getting the benefits of cost control, most of the time it will result in a decrease in the quality of the final product. Scott focused on the best value approach; it places the emphasis not only on the price but also on other factors. Investigation of the legislative regulation and the nature of this contracting method were analyzed to help develop the best value procurement method in regards to highway construction. Shr (2004) studied the growing popularity of Incentive/ Disincentive bidding for highway construction. This concept is utilized for its ability to shorten the contract time by making it difficult for the contractor to not accelerate the project. Shr developed a quantified model to establish reasonable incentive or disincentive rates based on construction cost and time. But like the low bid method, incentive/disincentive contracting may cause the quality of the final product to decline.

Molenaar, et al (1999) studied the emergence of DB into the public segment of the industry, replacing the traditional DBB. His work analyzes each parties' responsibility in regard to the delivery system, and also explains the procurement process and the structure of this particular method. Marwa, et al (2006) went more in depth than Molenaar by building on his work. Marwa studied a total of 76 DB projects and identified correlations between the procurement processes and the projects' performance overall. Chan (2002) sought specific project conditions that can help increase project success rates when using DB. Chan points out that current measures of success are defined by three factors: time, cost, and quality; but he believes a more comprehensive metric needs to be established.

Gransberg (1999) conducted a survey aimed at all the Departments of Transportation (DOTs) in the United States. With the fifteen DOTs that employ DB, he reviewed the three main methods of DB, which are low-bid DB, adjusted-score DB, and best-value DB. As concluded, each of the different methods can be utilized with different types of highway construction, depending on the nature of the project at hand. Gransberg (2008) also addressed the issue of quality assurance concerning DB as it relates to transportation projects. One of the disadvantages of DB is the lack of control over the detailed components of construction, which requires the agency to form a more comprehensive method to ensure the quality of the

work. A survey from the report demonstrated the different ways in which state transportation agencies have successfully controlled quality by focusing on all the aspects of the construction phases; but this doesn't seem to be the case for all the agencies. In the same year Gransberg (2008) pinpointed the issue of communicating the quality requirements public agencies have on DB projects. The Study found that some owners tend to rely on the qualification evaluation process rather than being proactive on the issue. There are still many improvements that can help enhance the performance of DB. Many agencies still use the traditional DBB method exclusively, or have not utilized DB to its full advantage.

There has been an extensive amount of research done on the comparison of DBB, DB and, to a lesser extent, CMR - most focusing on the performance of each method in regard to the aspects of cost, time, and quality. Ibbs (2003) used sample case studies to present a result that confirmed one of DB's key advantages. Design-build does in fact perform more efficiently with respect to time than traditional DBB. Doren (2005) discovered valuable statistics regarding CMR. In this study, 35 percent of project owners believed that CMR provided them the "best value", followed by 23 percent for DB. And yet the traditional system of delivery (DBB) is employed most frequently. Doren's research combines data from the areas of vertical construction and horizontal construction. According to him, government agencies that have experience with an alternative method consider CMR and DB as the "best-value alternatives". Doren believes that CMR has the potential to become the leading method of delivery, due to positive experiences reported by so many agencies.

Rojas and Kell (2008) used data collected from states to compare the performance of the DB and CMR regarding the public schools. The result of the study conflicted with many researches that have been done before, by concluding that 75% of the circumstances exceeded the guaranteed maximum price when CMR was used. However these statistics are in regards to vertical projects, which are fundamentally different from horizontal projects. Concerning horizontal construction Touran, et Al (2009) published a paper focusing on providing an evaluation process that is able to help agencies identify the suitable delivery system to use for specific projects. The paper points out 24 key concerns that will narrow down the most ideal delivery system. The paper also includes a beneficial example that demonstrates how the evaluation should be conducted. But before the proper system can be chosen, regulations regarding each system are different amount all the states. Ghavamifar (2006) investigated all the regulations that had been set in place by states' legislations regarding public transportation projects. A list of the states' statutes that address DB, CMR, and public/private partnerships was provided.

Gransberg (2010) conducted extensive research on the topic of CMR project delivery for highway programs. According to his report, Utah's DOT (UDOT) has the most experience with this method. At the time the research was conducted, 13 CMR projects had been completed, and 16 projects were in the planning. UDOT confirms the system's ability to fast-track projects, which can result in the decrease of project cost. States like Alaska, Arizona, Florida, Oregon and Utah all have experience with CMR as the method of delivery on transportation projects. The city of Phoenix has had more than 200 projects completed by CMR (including both vertical and horizontal projects). Local transportation projects in Michigan and Rhode Island also use the CMR delivery system. Florida has used CMR on projects of multiple types and scales, from minor local projects to a 1.3 billion dollar intermodal center. Alaska tends to use CMR on projects that have a significant portion of vertical component build-in. Even though Oregan's DOT has limited experience with this system, an interstate bridge that was completed by CMR has been a successful project. They plan to employ the CMR system on future projects. Gransberg gathered a substantial amount of research that had been done on construction delivery methods. Structured interviews were

set up with the agencies to gather statistics, and clear instructions were established to help any organization with the procedure involved in implementing such a delivery system.

CASE STUDY: The Miami Intermodal Center

The Miami Intermodal Center (MIC), the first CMR project ever funded by the U.S. Federal Highway Administration (FHWA) is a $2.5 billion construction project located just east of Miami-Dade International Airport (MIA). The facility is envisioned as a state-of-the-art Grand Central Station — a transfer center for passengers using the airport, intercity and commuter trains, rapid transit, local and intercity buses, and cruise ships in and out of the Port of Miami. The project was developed by FDOT and the Miami-Dade Aviation Department, in cooperation with the Miami-Dade Expressway Authority, Miami-Dade Transit, Amtrak, and various rental car agencies that serve the airport. The MIC project is made up of a series of construction contracts, including one for a consolidated rental car facility (RCF), another for a people-mover connection to the airport, and others for road access improvements around the airport.

Even with all the emphasis on the project, as well as all the planning and funding for the project, it appeared for a while that this project would be remembered as one of the great mistakes in modern U.S. construction history. For the first four years, the project seemed unable to overcome its unfortunate start, which was caused by the terrorist attacks on 9-11-01, and exacerbated by mistakes typical of an owner using a new delivery system. In some respects, it never has recovered, but in others, it has recovered marvelously

Several things contributed to the early problems that plagued the project. For instance, the 9-11 disaster, delayed decisions, and unwise decisions caused the timing of the MIC project to get seriously out of rhythm. By allowing the design, which had just commenced when the terrorism unfolded, to continue unabated while contemplating future moves, and then allowing it to continue even further while the scope shrunk due to the drastic dropoff in airline traffic, put design so far ahead of construction that the project has never enjoyed two of the major of advantages of the CMR system; namely construction involvement in the design and full fast tracking. Other things that contributed to early problems can be seen in the literature. (Minchin 2009)

Relatively recently, the project has started to resemble what was envisioned in the beginning. Progress is being made at a much faster rate; payouts are much higher, visible progress is exponentially greater, and the project is shedding its negative image.

Phase I of the project is broken into sub-phases of work called GMPs. GMP stands for Guaranteed Maximum Price, which is the way the CM bids on each sub-phase. The CM on the project must submit a GMP for each sub-phase GMP. If the GMP for any GMP is higher than the owner can stand, negotiations commence and can be very short, or very lengthy. The owner reserves the right to terminate negotiations and either begin negotiations with another CM, or declare that the GMP for which a cost cannot be agreed upon will be let using another delivery system.

Phase I of the MIC construction project is broken up into seven GMPs. To date, three of the GMPs have been completed. GMPs completed to date were finished within contract time, but all were delayed in their commencement. As for costs, the work in GMP No. 1 was completed for 3.9% under budget and GMP No. 2 was completed for 8.4% under budget; The CM exceeded contract duration on both GMPs — by 40.7% on GMP No. 1 and 72.2% on GMP No. 2. There was a significant scope reduction on GMP No. 3, which renders that data useless for comparative purposes. The project is now progressing well, after a fitful four years that saw an almost total personnel turnover for the owner

and the project management firm retained by the owner to oversee the CM. Construction on the Rental Car Facility and bridge, known as GMP No. 4a, has turned the project around. The project suffered for four years from a lack of respect and credibility in the marketplace. GMP 4a has cured that, but many lessons have been learned. For more details, please see the literature. (Minchin 2009)

METHOD OF RESEARCH

Eleven states from the southeastern part of the United States were chosen to be part of the study. A list of state construction personnel was gathered from the American Association of State Highway and Transportation Officials (AASHTO). These served as potential interviewees. Next, Interview instruments were generated to obtain the main objective of the analysis: each DOT's experiences with DB and CMR. Then the list of interviewees was contacted by telephone. Often some redirection led to the most appropriate authority, but most of those interviewed were the State Construction Engineer for their respective DOT.

Level One Interview

The goals for level one of the interviews was to determine the level of experience that each state has with the DB delivery system. Then the interviewees were asked to identify any dissatisfaction they have experienced with DB in the years that it has been employed. The interviewees were then asked if they, or their agency was aware of the CMR delivery system, and if any dissatisfactions with DB have potentially led the DOTs to seek out or consider CMR as an alternative delivery system.

Level Two Interview

Level two of the interview is designed for states that are using or have completed highway construction using CMR as the delivery system. The objective is to study the process the DOT has established for CMR, and learn about their experiences with CMR in comparison to DBB, or DB. The final goal is to identify any advantages and disadvantages the agency may have already noticed regarding CMR.

DEPARTMENT'S EXPERIENCE WITH DESIGN/BUILD

The data collected during the level one interviews clearly illustrate the widespread nature of DB in the area of highway and transportation programs. It has become the most popular method of alternative delivery system to employ. There are many advantages that proponents of DB claim that it can contribute to a project. The main attractions are: the single point of contact for the project's design and construction and allowing the project to start before construction documents are finished (fast-track). Both of these benefits are designed to compensate for the shortcomings of the traditional DBB delivery system. But data shows only two out of the eleven states that participated in the research have no problem with DB. All the other states either dislike some components of the system or have specific concerns regarding the system.

Design-build was first introduced to highway construction as a major delivery system option in the mid-1990s; it has been employed for approximately fifteen years. But one of the biggest issues, reported by more than 36 percent of the participants, was the learning curve for this delivery system. Virginia's DOT believes they "don't have enough resources to support it". Georgia's DOT reported several issues with DB. First, the system doesn't always fit the normal process designated for DB. For example, the process of acquiring right-of-way

(ROW) can take more than a year, and during this time, construction documents will be finished, therefore not saving any time. Another is the lack of understanding of the system. Finally it's been hard for the DOT to give up control after so many years of carefully governing the design and construction processes.

Louisiana's DOT currently has five DB projects under construction. One of the criticisms they have regarding this system is somewhat opposite of Georgia's DOT; they believe they have too much control, and thus risk, in regard to the project. They believe that a main contributor to this is their state's legislation, which keeps them from utilizing a true DB delivery system. Florida's DOT points out the dissatisfaction they have with not being able to link a CEI contract to the DB method. Florida officials also expressed dissatisfaction at the lack of control afforded the owner over the design process by DB, due to the lack of direct contractual relationship between the owner and the designer.

Tennessee's and Kentucky's DOTs both are not in favor of the selection process for which projects are designated for DB contracts in their states. For Kentucky, the project must be hand picked by the state's legislature for it to be eligible for DB. Large numbers of personnel are still foreign to the idea of not paying for change orders, which is supposed to be one of the advantages to DB, and the adoption process is fairly slow. Tennessee has only been allowing the use of DB for three years, a relatively short length of time compared to the other states. The legislative limitations on the types of project that can employ the system are relatively restrictive. Any project involving ROW, utilities, and environmental issues are not eligible to be considered. This greatly limits their selection pool of potential candidates. The DOT for Mississippi has a different issue of concern, cost. Many research projects that have studied DB have pointed out cost as one of the disadvantages to this delivery system (Gransberg, 2009). In most cases the increase in cost is due to the lack of concern regarding the constructability aspect of the construction documents, or the inexperienced nature of the DB firm. Another aspect of DB that creates anxiety for some DOTs is the lack of a clear set of plans, and working with only specifications for a large part of the project is sometimes difficult.

There are two states in this study that overwhelmingly support DB and had no concerns with the system. South Carolina stated that their experiences with the system have been "positive", and Maryland, an old client of the system also likes the method of delivery a lot. Table 1 shows each DOT's experiences with DB and CMR.

Table 1. *Each State DOT's Experiences with DB and CMR*:

States	Employment of DB	Number of Years (or projects) DB has been in use	Aware of the CMR delivery system	Employment of CMR	Statutorily free to use CMR
Alabama	No	n/a	Yes	No	No
Florida	Yes	15 years	Yes	Yes	Extra approval required
Georgia	Yes	10 years	Yes	No	No
Kentucky	Yes	10 projects	Yes	No	No
Louisiana	Yes	4 years	Yes	No	No
Maryland	Yes	13 years	Yes	No	Yes
Mississippi	Yes	5 years	Yes	No	Don't know
North Carolina	Yes	Don't know	Yes	No	No
South Carolina	Yes	Don't know	Yes	No	Don't know
Tennessee	Yes	3 years	Yes	No	No
Virginia	Yes	7 years	Yes	No	Don't know

DEPARTMENTS' EXPERIENCES AND LEGAL RESTRICTIONS ON CMR

Even though all the interviewees expressed awareness of the existence of the CMR delivery system, only Florida has hands-on experience with it as a tool for highway construction. In fact, CMR has been authorized in many states to help offer a possibility other than DB as the alternative delivery method. It's designed to help decrease the amount of oversight that normally takes place on construction projects. It reduces the amount of performance risk for the owner and transfers it to the construction manager (CM). A constructability review by the CM becomes part of the design phase of the projects. This, and a direct contractual relationship between the owner and the designer allow the agency to remain in control of the design process. Of course, his method still offers the advantage of fast tracking the project.
Since Florida is the only state in the study to utilize CMR for highway construction, FDOT was the only DOT to participate in a Level Two Interview. Ten FDOT projects have been done using CMR. In addition to the list of projects and the state's statute, the interviewees were able to provide more in-depth assessment of CMR by submitting to the Level Two interview. The Level Two interview is mainly composed of three components, one being the process the DOT has established for CMR; second is the experience with CMR; finally to note any overall advantages and disadvantages the agency may have noticed with the system in comparison to DBB and DB. Table 2 shows how FDOT views the risk/ responsibilities distribution for DB and CMR.

Table 2. *FDOT's Risk/Responsibilities Distribution for DB and CMR:*

Risk/ Responsibility	Design/Build Project		Construction manager at risk project		
	Owner	Design/Builder	Owner	C.M.	Designer
Final Alignment Geometry		✓		✓	
Geotechnical Data		Depends		✓	
Environmental Permits	✓		✓		
Design Criteria	✓		✓		
Design Defects		✓		✓	✓
Constructability of Design	✓			✓	
Obtaining ROW	✓		✓		
Coordinating with utilities/ railroads		Depends		✓	
Quality Control		✓		✓	
Quality Assurance	✓		✓		
Acceptance		✓		✓	

As part of the Level Two Interview, FDOT provided Florida's statute enabling FDOT to use CMR. The statute is shown here in its entirety:

> "337.025 Innovative highway projects; department to establish program.
> (1) The department is authorized to establish a program for highway projects demonstrating innovative techniques of highway construction, maintenance, and finance which have the intended effect of controlling time and cost increases on construction projects. Such techniques may include, but are not limited to, state-of-the-art technology for pavement, safety, and other aspects of highway construction and maintenance; innovative bidding and financing techniques; accelerated construction procedures; and those techniques that have the potential to reduce project life cycle costs. To the maximum extent practical, the department must use the existing process to award and administer construction and maintenance contracts. When specific innovative techniques are to be used, the department is not required to adhere to those provisions of law that would prevent, preclude, or in any way prohibit the department from using the innovative technique. However, prior to using an innovative technique that is inconsistent with another provision of law, the department must document in writing the need for the exception and identify what benefits the traveling public and the affected community are anticipated to receive. The department may enter into no more than $120 million in contracts annually for the purposes authorized by this section.
> (2) The annual cap on contracts provided in subsection (1) shall not apply to:
> (a) Turnpike enterprise projects, and turnpike enterprise projects shall not be counted toward the department's annual cap.
> (b) Transportation projects funded by the American Recovery and Reinvestment Act of 2009."

FDOT'S EXPERIENCE WITH CMR

The main reason FDOT decided to employ CMR was the system's ability to shift risk and fast track, while allowing the department to retain control of the design process, which was not possible with DBB or DB. They plan to continue using CMR on horizontal projects because of this unique characteristic. But not all projects are suitable for CMR. Here are some of the project traits that FDOT believes can help identify the appropriate project for CMR (FDOT 2011):

- Building type projects where construction methods and specifications vary between professional groups (i.e., engineer/architect and construction trades).
- Innovative funding scenarios, where multiple owners may dictate final project criteria.
- Projects where limiting (limited) budgets (budget) threaten (threatens) the delivery of the project and where the CM alternative can help maintain costs.
- Other projects where construction input is required during the early phases of design.

Table 3 shows the projects chosen to date by FDOT for CMR.

Table 3. *FDOT CMR Projects, Project Identity and Type:*

Project Description	Work Description	System Description	Program Description
I-75 Ramp Renovation at AG Station	Miscellaneous Construction	Intrastate Interstate	Roadway
I-75 @ MP 26.861 Welcome Station	Welcome Station	Intrastate Interstate	Roadway
I-10/ Madison Co Rest Areas/Both Sides CMAR	Rest Area	Intrastate Interstate	Roadway
I-95 Agriculture Station Building Modifications	Building Repair/Rehabilitation	Intrastate Interstate	Roadway
ITS /Regional TMC Traffic MGT Center JAX Transportation Center	Traffic Management Centers	Multimodal Facility	Intermodal Access
SR-814/Atlantic Blvd Bridge #860157 Bascule Rehab/CM @ Risk	Bridge-Repair/Rehabilitation	Non-Intrastate State Highway	Bridge Repair
SR-5/US-1 Bridge#930004/Parker BR Bascule Bridge/CM@Risk	Bridge-Repair/Rehabilitation	Non-Intrastate State Highway	Bridge Repair
Miami Intermodal CTR (MIC) MIC Central Station	Intermodal Hub Capacity	Interstate State Highway	Intermodal Access
I-75 Pasco (NB) Rest Area Rehabilitation by CM@Risk Contingent	Rest Area	Intrastate Interstate	Roadway
I-75 Pasco (SB) Rest Area Rehabilitation by CM@RISK Contingent	Rest Area	Intrastate Interstate	Roadway

Once the project has been selected for CMR, FDOT has their own set of contracts and specifications. They have experience with both in-house and outsourced design staff. This process of selection for the design staff or any pre-construction service is sometimes project specific, but overall the more traditional way is to use the qualification method. One of the issues that have most DOTs concerned is the amount of agency administrative time they think this system will require. According to FDOT, CMR consumes less time than the traditional DBB, and about the same time in comparison to DB. In regard to the three delivery systems, small businesses in the state tend to be more involved with DBB than with CMR and DB, with DB being the least preferred of the three. Table 4 shows the performance of the CMR projects build by FDOT to date. Note that some projects are ongoing at the time of publication.

Table 4. *Cost and Duration Variations of CMR Projects Conducted by FDOT.*

Project Description	Cost			Duration	
	Original (Engineers) Cost Estimate ($)	Low Bid or Awarded Bid Amount ($)	Final Cost ($)	Original Contract Duration (days)	Final Contract Duration (days)
I-75 Ramp Renovation at AG Station	3,769,137.94	3,294,096.00	TBD	270	TBD
I-75 @ MP 26.861 Welcome Station	8,170,189.86	13,240,420.00	13,101,578.00	509	519
I-10/ Madison Co Rest Areas/Both Sides CMAR	8,030,191.94	6,966,982.00	6,919,424.00	291	296
I-95 Agriculture Station Building Modifications	2,491,925.00	3,310,500.00	3,318,723.70	215	TBD
ITS /Regional TMC Traffic MGT Center JAX Transportation Center	17,460,000.00	TBD	TBD	TBD	TBD
SR-814/Atlantic Blvd Bridge #860157 Bascule Rehab/CM @ Risk	3,402,669.49	4,164,652.11	TBD	210	302
SR-5/US-1 Bridge#930004/Parker BR Bascule Bridge/CM@Risk	8,153,297.80	10,186,066.98	TBD	330	TBD
Miami Intermodal CTR (MIC) MIC Central Station	None	78,000,000.00	TBD	822	TBD
I-75 Pasco (NB) Rest Area Rehabilitation by CM@Risk Contingent	13,394,134.46	25,137,883.11	TBD	477	TBD
I-75 Pasco (SB) Rest Area Rehabilitation by CM@RISK Contingent	12,102,611.74	25,137,883.11	TBD	477	TBD

FDOT uses the method of reimbursable basis to a guaranteed maximum price (GMP) to compensate the CM for both pre-construction and construction services. In addition, FDOT requires open book accounting for the CM's pay applications during construction for all subcontractors and vendors. The method of negotiation has been employed to help handle

general conditions, contingency and allowances. Normally when it comes to the issue of unused contingency, there are two types of solutions. One approach allows the owner and CM to split the unused funds, while the other lets the owner claim sole ownership. In Florida, the CM is allowed to self-perform part of the work, but it must not exceed 50 percent of the entire workload. And to get the work, it must bid the work against the interested qualified subcontractors, and be the low bidder. FDOT's process of procuring subcontractors and suppliers requires competitive bid; this is the only way to receive federal funding for any project. To this point, FDOT has not identified any specific aspect of the CMR program that has worked best or has fallen short of its intended purpose. Figures 1 and 2 illustrate the performance of two FDOT CMR projects. Note that in each case the engineer's estimate was inaccurate in predicting the low-bid amount. In one case the estimate was high and in the other the estimate was low. Note also that in each case the actual final cost was below the originally submitted GMP.

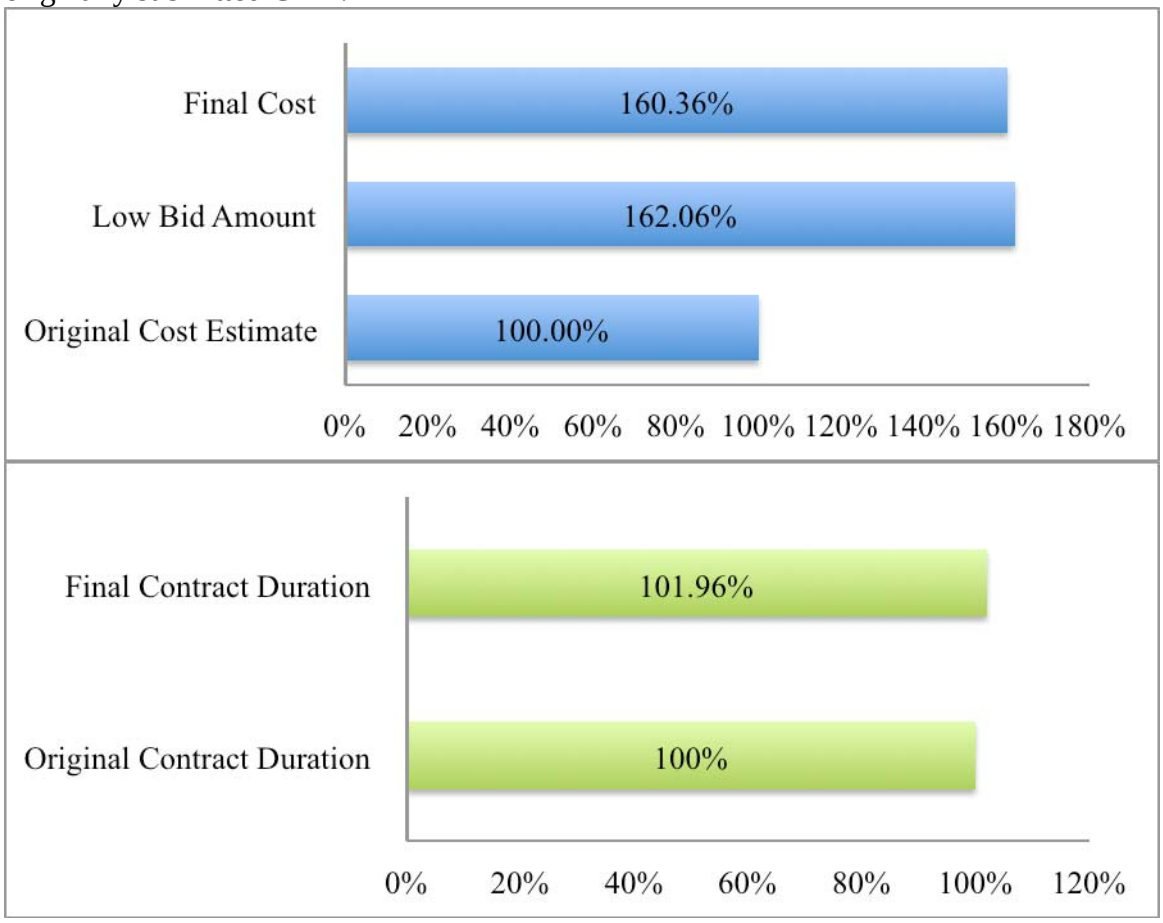


Figure 1. *Cost and Duration Analysis: I-75 Welcome Station*

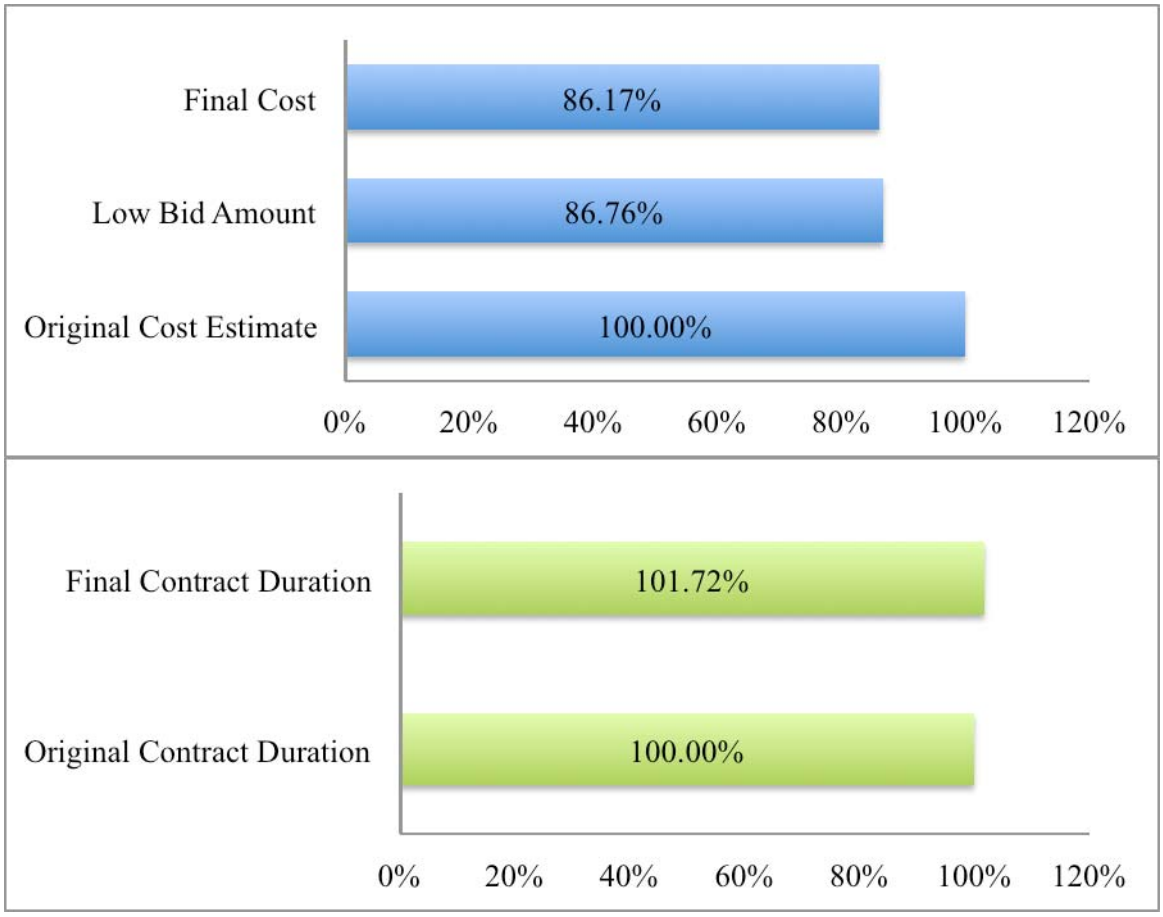


Figure 2. *Cost and Duration Analysis: I-10/ Madison Co Rest Areas/Both Sides CMAR*

CONCLUSIONS

Construction manager-at-risk is a construction delivery system that has been tried and found effective for years in the vertical construction industry. Its relatively recent introduction into the world of highway and bridge construction has been a slow process. Though the first CMR projects were let just after the turn of the 21st century, year 12 of that century yields a scenario that shows only two states have really used the system as a regular course of business. Some others have dabbled in it, but only Florida and Utah have used it extensively. To gain information on CMR, the team thought it important to compare the performance of CMR to DB, as well as to DBB. It is well known that all DOTs use DBB more than any other delivery system, so no questions were asked regarding DBB except how it compared to CMR in some way. The questions to the DOTs began with inquiries regarding DB. All the DOTs have used DB. Florida, Maryland, and Georgia have used it for 10 years or more (Florida 15, Maryland 13), while Tennessee, Louisiana and Mississippi have used it for five years or less (Louisiana 4, Tennessee 3). Since FDOT is the only DOT to use both DB and CMR contracts on horizontal transportation projects, their opinions regarding the two systems are of interest. The Interview Instrument broke the construction project into 11 categories; Final Alignment Geometry, Geotechnical Data, etc. When it comes to responsibility and risk in a DB contract, FDOT believes that majority of the responsibility and risk resides with themselves for five of the 11 categories. They believe that the majority of the responsibility/risk lies with the DB firm for four categories, and for two of the categories, they believe that it depends upon the circumstances of the individual project.

After discussing DB, the interviews discussed CMR. As for the responsibility/risk in a CMR contract, FDOT believes that they bear the majority in three of the 11 categories, the CM bears the majority in seven categories, and the designer bears the majority in one category.
FDOT has used CMR on a variety of projects. The majority of projects could be categorized as "combination" projects due to the fact that they contain substantial work in both the vertical and horizontal construction areas. In fact, six of the projects are of this variety. These six combination projects include an interstate highway Agricultural Station, three interstate Rest Areas, an interstate Welcome Center, and the massive MIC. There are two vertical construction projects - an FDOT office building and a building at an interstate highway Agricultural Station on a different interstate highway than the one mentioned above. Finally, there are two wholly horizontal construction projects, both bascule bridges.
The FDOT CMR projects ranged from $3.2 million to $78 million, based on accepted GMP. The $78 million is the MIC rental car facility, which may grow based on decisions for further GMPs. The entire MIC will not be built using CMR. Of the eight projects that have had an engineer's (preliminary) estimate and an awarded GMP, six have been awarded for GMPs above the engineer's estimate; two for GMPs below the engineer's estimate. Of the three FDOT projects that have reached the Final Estimate stage, two were completed at slightly under the GMP and one at slightly over the GMP. Both underruns and the overrun were less than one percent. All three completed projects went over the original duration, two slightly (less than two percent) and one substantially (almost 44 percent).

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EXPLORING THE BUSINESS CASE FOR MORE ADAPTABLE BUILDINGS: LESSONS FROM CASE STUDIES

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Abstract
This paper explores the business case for designing more adaptable buildings, an issue that has, for the most part, been overlooked in the literature. It reviews some of the existing literature on adaptability and discusses the drivers for and barriers to designing buildings that are more adaptable. In doing so, it draws upon lessons from the developing market for 'greener' or more sustainable buildings. The costs and benefits of designing more adaptable buildings are explored through a workshop with industry stakeholders and illustrated with evidence from case studies. The findings of this research highlight the circumstances that would need to change, in terms of industry mindsets and market conditions, in order for adaptable buildings to become more widespread.

Keywords: Adaptability; cost-benefit; obsolescence; risk; sustainability.

INTRODUCTION

In recent years there has been growing interest in the issue of adaptability in the built environment. This interest has been stimulated by a number of factors, including increasing rates of technological change and a desire to make the built environment more sustainable by extending the life of our existing building stock. However, most of the academic literature on the subject has tended to focus on *how* to design buildings to be more adaptable, rather than trying to understand the reasons *why* some buildings are designed to accommodate change, while others are not. This paper therefore explores the business case for designing and constructing more adaptable buildings. In doing so, it examines the potential costs, benefits and risks of designing adaptability into buildings and the social, economic, political, legal and

commercial conditions under which greater adaptability would either be a more desirable or less desirable design objective.

This paper begins by discussing what is meant by adaptability in the context of the built environment and by exploring the economic and environmental drivers for more adaptable buildings in the United Kingdom (UK). In doing so, it looks at the reasons why designing buildings for adaptability is not part of mainstream property development and draws parallels with the emerging market for 'greener' or more 'sustainable' buildings. A range of different adaptable design strategies are then introduced, each relating to a particular type of change in the built environment, and the costs and benefits of each strategy are explored through a workshop with industry stakeholders. Case studies are then used to unpack the reasoning behind particular adaptable design solutions and illustrate their implementation. This paper concludes by looking at what would need to change, in terms of current market conditions and industry mindsets, to create a greater demand for adaptable building design solutions.

BACKGROUND

> *"Almost no buildings adapt well. They're designed not to adapt; also budgeted and financed not to, constructed not to, administrated not to, maintained not to, regulated and taxed not to, even remodelled not to..." (Brand, 1994)*

Definitions of what constitutes 'adaptability' in buildings vary widely in the literature, but most tend to imply a capacity to accommodate change (Schmidt III *et al*, 2010). The idea of designing buildings that can accommodate change is by no means new: in the 1960s Weeks (1963 and 1965) talked about 'indeterminate architecture' and in the 1970s Alex Gordon, the then President of the Royal Institute of British Architects, put forward the principle of 'long life, loose fit and low energy' buildings (Anon, 1972; p26). In the last two decades, the terms 'flexible' (e.g. Gann and Barlow, 1996; Slaughter, 2001; Gibson, 2003; Steiner, 2006; Finch, 2009) and 'agile' (e.g. Joroff *et al*, 2003) have become increasingly common in the literature on buildings, perhaps reflecting developments in other business and management disciplines, such as manufacturing, where the capacity to embrace and manage change has become seen as critical strategy for surviving in an increasingly dynamic business environment.

The argument in favour of designing more adaptable buildings has a number of strands. One is that by designing buildings to be more adaptable, designers can help to reduce the whole life costs of owning and using buildings by making them easier to change post-construction (Slaughter, 2001; Arge, 2005). This is particularly important in sectors where occupier needs change frequently and where maladaptive buildings can impose costs on occupiers by constraining their activities (Iselin and Lemer, 1993). More recently, the case for adaptability has been underpinned by concerns about the environmental impact of the built environment, the notion being that buildings that are more adaptable are more sustainable (Kendall, 1999; Graham, 2006). Designing buildings that can be changed with minimal disruption to their existing fabric (Engel and Browing, 2008) could help to mitigate the risk of obsolescence and retain the energy, natural resources and carbon dioxide emissions that were embodied in their structure and fabric during construction.

Nevertheless, despite these compelling arguments, designing buildings for adaptability is still not common practice in the UK and elsewhere. Parallels can be drawn with the slow adoption of 'green' or 'sustainable' building techniques in the UK. As is the case with adaptability, many of the technical solutions to designing more sustainable buildings have been around for

years but it is only recently that these solutions have begun to be adopted by the property development industry. Some authors have attributed this slow up-take to a 'circle of blame' (Figure 2), whereby constructors do not produce 'greener' buildings because they claim that developers do not want them, who in turn claim that investors will not fund them because there is no demand from occupiers (Keeping, 2000). For years, the lack of a clear business case for more sustainable buildings meant that the property development industry was unable to break out of this circle of blame, a situation that has only recently started to change, for reasons discussed below. However, as yet no comparable business case has been articulated for designing more adaptable buildings.

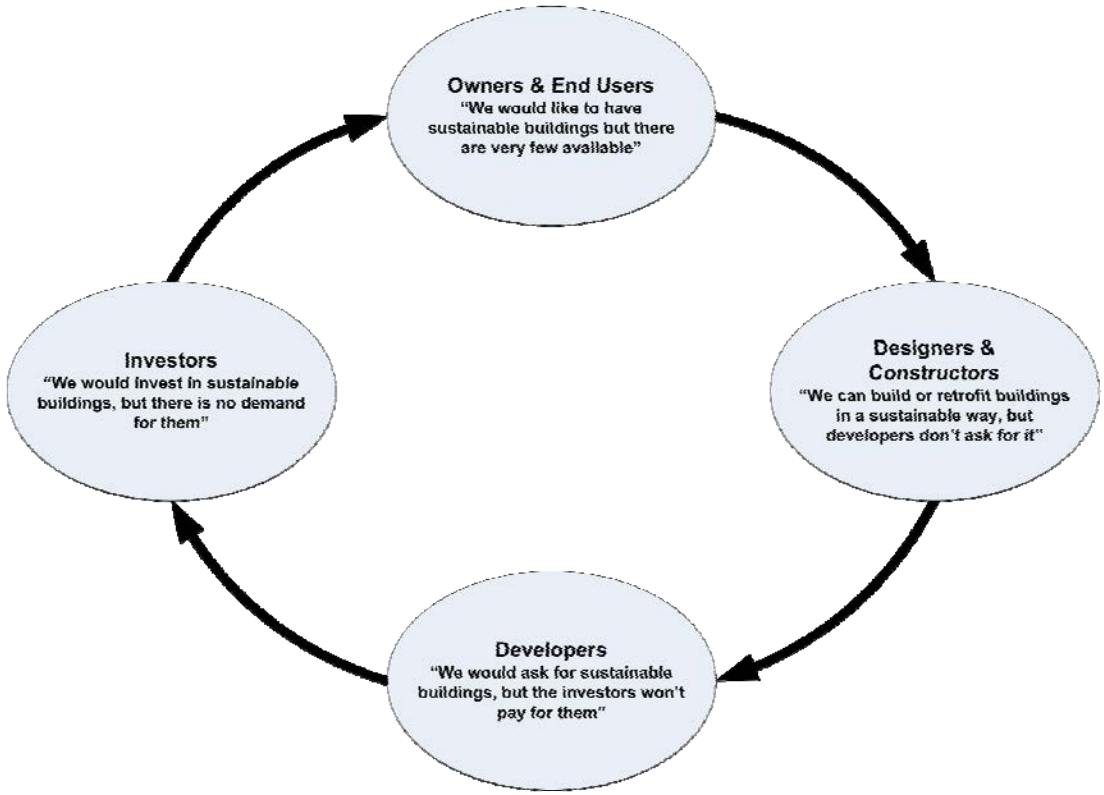


Figure 1: *The circle of blame (from Hartenberger, 2008; p.3)*

As with any other business decision, articulating the case for designing more adaptable buildings requires an analysis of the costs, benefits and risks involved (Gambles, 2009). It is often assumed that adaptability gives rise to higher initial construction costs, an assumption that has been fuelled by previous attempts at 'future-proofing' buildings. For instance, in the UK in the 1980s and 1990s it was common for developers to over-specify the mechanical and electrical services and floor loadings in their office buildings in order to cater for possible future changes in occupier requirements, even though such levels of redundancy were rarely utilised. The costs of such over-specification were ultimately passed on to occupiers through higher rents and service charges (Guy, 1998). In the United States (US), Slaughter (2001) examined the costs of implementing adaptable design strategies in 48 construction projects and found that there was a median increase of one percent in initial construction costs. However, the median cost savings at the first refurbishment cycle were estimated to be two

percent of initial construction costs, although it is not clear whether these costs and savings were discounted and, if so, at what rate.

Some of the potential benefits of designing more adaptable buildings were alluded to earlier in this paper, however understanding who receives the benefits is a key part of developing the business case for adaptability. For owner-occupiers, institutional investors or developers with a long-term interest in buildings, investing in adaptable design strategies can be justified, even if this involves a marginal increase in initial construction costs, because they may recoup the benefits in the future, in the form of lower adaptation costs. However, for developers that construct buildings for sale, the incentives to design for adaptability are less clear, because the cost of changing the building in the future will fall on another party. This thinking was borne out in research undertaken in Norway by Arge (2005), who found that office buildings developed by owner-occupiers incorporated more adaptable design features than those that were developed to let and manage; the office buildings that incorporated the least number of adaptable design features were those that had been developed for sale.

For developers that are procuring buildings to sell, more adaptable buildings will only be worth investing in if they are easier to sell and/or command a premium over less adaptable buildings, which in turn will be dependent on them being more attractive to investors and/or occupiers. Moreover, the attractiveness of adaptability to occupiers and investors would need to be reflected in the calculations of worth used by valuation professionals. Research by Ellison and Sayce (2007) suggested that only a very limited interpretation of adaptability, relating primarily to the flexibility of internal spaces, was currently factored into commercial property valuations. Consequently, valuations fail to reflect other forms of adaptability, such as the ability to accommodate changes of use. Ellison and Sayce (2007, p.298) concluded that:

> *"An appraisal that fails to reflect a property's potential to adapt is likely to be proved erroneous over time by not accurately reflecting the extent to which one property may represent a higher risk in terms of depreciation than another. This is of growing importance to investors as lease lengths shorten, making re-lettability a more critical issue, and as discount rates fall, increasing the significance of cash flow over the lifetime of the asset."*

Again, comparisons can be made with the developing market for more sustainable buildings, where a frequently asked question has been: do more sustainable buildings command a price and rental premium over less sustainable buildings? The ability to answer this question has been facilitated by the development of voluntary 'green' building certification schemes, such as the BRE Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED) and Energy Star, which provide a proxy measure of 'sustainability' in buildings. A recent study by Fuerst and McAllister (2010) examined the sale price and rental differential between buildings in the US that were certified through LEED or Energy Star and buildings that were not. They found that LEED certification resulted in a 5% rental premium and a 25% sale price premium, with Energy Star certified buildings commanding a 4% rental premium and 26% sale price premium. Such premiums will send price signals to funders and developers that it is worth investing in more sustainable buildings.

When considering the costs, benefits and risks of designing more adaptable buildings it is useful to distinguish between the different types of change that occur in the built

environment. Schmidt III *et al* (2010) identified six different types of change, each of which they associate with a particular type of adaptability (Table 1). For instance, the 'stuff' inside a building, such as furniture, fixtures and equipment may be designed to be adjustable in order to facilitate changes in the tasks of users, something that may occur relatively frequently. In contrast, a building may change in size very infrequently; nevertheless the building's space, services, skin and structure may still be designed to be scalable. In some cases, one particular type of adaptability may affect another. For example, many contemporary 'open-plan' offices are designed to be versatile, but the ability to change their spatial layout is often constrained by the inability for users to easily adjust the location and configuration of the furniture and equipment within the space.

Table 1: *Adaptable building design strategies (adapted from Schmidt III et al., 2010; p.7)*

Type of adaptability	**Type of change**	**Building layer(s) affected**	**Frequency of change**
Adjustable	Change of task	Stuff	High
Versatile	Change of space	Stuff, space	High
Refittable	Change of performance	Services, skin	Moderate
Convertible	Change of function	Space, services, skin	Moderate
Scalable	Change of size	Space, services, skin, structure	Moderate/low
Moveable	Change of location	Structure, site	Low

WORKSHOP

In order to explore in more detail the costs and benefits of designing more adaptable buildings, the authors undertook a workshop with a range of stakeholders from the construction and property development industry. Further details about the workshop and the outcomes arising from it are described below.

Approach

The workshop participants were divided into two groups, each consisting of an industry representative from the seven stakeholder categories in Table 2 (e.g. funder, owner, designer etc.), and were presented with a project scenario (Scenario A: private office building; Scenario B: public building) in which to contextualise their ideas. The scenario data included local and national context, briefing notes, procurement information, details of the built solution, highlighting the different systems and components used, and an insight into how the users had appropriated the building over time. Each group was then asked to work through a stakeholder specific sheet of costs and benefits for each of the six types of adaptability, and indicate whether the costs and benefits were relevant to them in their particular scenario.

They were then asked to work through the sheet a second time and rate the significance (high, medium or low) of each cost and benefit, after which the high responses were marked on a large matrix for all stakeholders to see and discuss the advantages and disadvantages of the

six design strategies and the potential alliances and conflicts between stakeholders. Table 2 provides a condensed version of the sheets illustrating the costs and benefits for each stakeholder (in parenthesis, with the costs marked in red) related to higher-level costs and benefits that cut across stakeholders and adaptability types. For example, designing buildings to be scalable has the high-level benefit of extending their life spans, which may ultimately bring future costs for constructors, in the form of less construction work. However, such buildings are likely to be easier and cheaper to adapt, thereby giving rise to benefits for constructors, in the form of more adaptive re-use work and lower levels of risk during such projects.

Outcomes

The workshop exercise served to highlight the motivating factors behind different stakeholders when it comes to the development of new buildings. Funders conveyed a desire for simplicity and the use of traditional construction methods to reduce risk, costs and tenant churn. Owners were driven by a desire to minimise risk and initial capital expenditure, while being able to sell or lease the building was a key motivator for applying any type of adaptability. As shown in Arge's (2005) research, there was also a clear distinction in the motivations between the different development models (develop to sell, manage or occupy), with owner-occupancy driving a greater interest in adaptability. This was complimented by end-user preferences for a versatile and refittable building that provides fewer disruptions, improved service and better quality of space.

From the supply side, designers saw the adaptable design strategies as a means of improving their reputation and as a basis for generating future work opportunities. They were positive about an increased shift away from new build work and viewed scalable buildings as the most likely source of future work opportunities. Contractors saw themselves not as initiators of adaptability, but as a service, only focused on the speed and cost of initial construction. While they did see potential to improve quality and competitiveness in response to client demands it was not a huge motivator in changing practices. Manufacturers felt more removed from the decision-making process, but were interested in balancing the tension between reducing costs and extending component lifecycles. Overall, society was seen to be one of the main beneficiaries of designing buildings that are more adaptable; keeping buildings occupied and reducing waste, resource use and disruption to the community were all seen as positive benefits for society. However, there was a realisation that these benefits would be dependent on strong local activism and/or government regulation.

One of the major outcomes of the workshop was the greater sense of clarity amongst stakeholders, due to an improved understanding of the full spectrum of stakeholder motivations. This helped the dialogue to avoid 'muddy waters' by enabling stakeholders to clarify their own position, even to the extent that it allowed them to be more selfish or focused. In addition, it was agreed that designing for alternative uses should not compromise the initial use: future benefits cannot be applied if it is at the cost of a sub-optimal first use. However, there was also an agreement that many of the costs and benefits are context specific and need to be evaluated on a project-by-project basis. The mapping exercise would therefore be a useful tool for a client when trying to determine the extent to which a building should be designed to be adaptable.

Table 2: *Summary of the costs and benefits of different adaptable building design strategies, by stakeholder group*

Stakeholders	Costs/benefits	Adaptable design strategies					
		Adjustable	**Versatile**	**Refittable**	**Convertible**	**Scalable**	**Moveable**
Constructors	Overdesign buildings for initial use (increase construction costs/revenues)		x	x	x	x	x
	Easier to construct buildings (quicker construction/lower construction risk)			x		x	x
	Easier/cheaper to adapt buildings (more adaptation work/lower project risk)		x	x	x	x	x
	Extend the life of buildings (less new build work)		x	x	x	x	x
Designers	Easier to lease/sell buildings (develop good reputation/generate more business)		x	x	x	x	x
	Overdesign buildings for initial use (develop bad reputation/lose business)				x	x	x
	Easier/cheaper to adapt buildings (more adaptation work/lower fees)		x	x	x	x	x
	Extend the life of buildings (less new build work)		x		x	x	x
	Increased user control over buildings (loss of design control)	x					
Funders	Overdesign buildings for initial use (increase construction costs/capital required)		x	x	x	x	x
	Easier to construct buildings (quicker construction/lower construction risk)			x			x
	Easier/cheaper to adapt buildings for initial use (reduced demand risk)		x	x	x	x	x
	Easier to sell buildings (quicker exit from projects/lower financing costs)		x	x	x	x	x
	Higher sale prices for buildings (increase return on investment)		x	x	x	x	
Manufacturers	Easier to construct buildings (develop good reputation/demand for products)	x		x		x	x
	Easier/cheaper to adapt buildings (more adaptation work/demand for products)	x	x	x	x	x	x
	Extend the life of buildings (less new build work/reduced demand for products)	x	x	x	x	x	x

Stakeholders	Costs/benefits	Adaptable design strategies					
		Adjustable	Versatile	Refittable	Convertible	Scalable	Moveable
Owners	Increased building values (more capital/larger mortgage loan required)		x	x	x	x	x
	Easier/cheaper to adapt buildings to new demands (less demand risk/voids/cost)	x	x	x	x	x	x
	Easier to lease buildings (higher occupancy rates/fewer voids/greater cashflow)		x	x	x	x	x
	Easier to sell buildings (quicker to sell/reinvest capital)		x	x	x	x	
	Higher rents/sales prices for buildings (increased return on investment)		x	x	x	x	
Society	Overdesign buildings for initial use (increase resource use/embodied energy)		x		x	x	x
	Easier to adapt buildings (reduction in resource use/waste/environmental impact)		x	x	x	x	x
	Extend the life of buildings (less demolition waste/maintain embodied energy)		x	x	x	x	x
	Less demand for new buildings (reduction in resource use/environmental impact)		x	x	x	x	x
	Easier to sell/lease buildings (fewer vacancies/less urban decay/more taxes)		x		x	x	x
Users	Overdesign for initial use (higher rental costs/service charges)	x	x	x	x	x	x
	Easier to adapt buildings (buildings stay fit for purpose/less downtime)	x	x	x		x	x
	Cheaper to adapt buildings (lower service charges/churn costs)	x	x	x		x	
	Increased user control over buildings (lower churn costs/better productivity)	x	x				

CASE STUDIES

The issues arising from the workshop have been investigated in further detail through case studies of existing buildings in a range of sectors, including offices, schools and retail. The case studies have involved interviews with developers, designers, owners and other project stakeholders in order to unpack the reasoning behind the use of particular adaptable design strategies. Two such case studies are presented below.

Case study 1

The first case study building is located in the Brianza region of northern Italy. Completed in 2009, the building was designed to be convertible, in that it can be fitted-out for use as an office, warehouse, laboratory or storage space. The three-storey building (Figure 2) has two adjacent wings that are connected by two separate lobby areas, to enable the building to be sub-let more easily. Sub-letting of the building is also facilitated by the fact that the building has four separate service cores, two in each wing of the building. The building's external cladding was designed to be more easily refittable, for example to enable warehouse doors to be retrofitted, and floor loadings are sufficient to accommodate light-industrial activities. However, the desire for a convertible building has involved some compromises. For instance, the building is fitted with a building management system, the performance of which can be affected when occupants open windows, a feature that had to be included because, according to the architect, local planning regulations dictate that buildings used for industrial purposes must have operable windows.

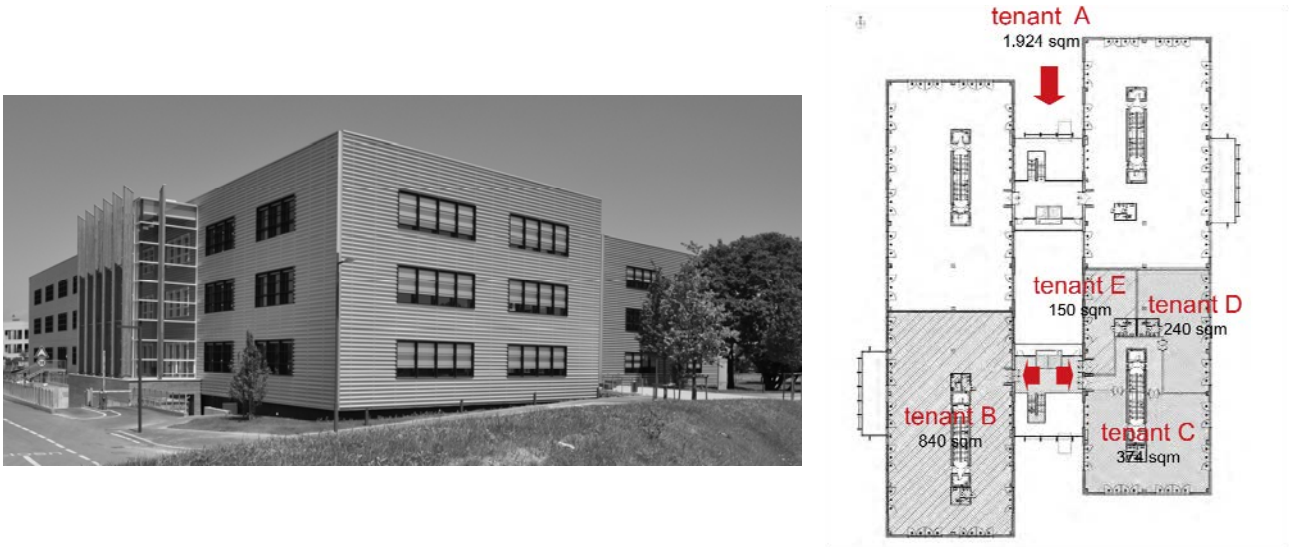


Figure 2: *An external view and floor plan of case study 1*

The construction costs for the building were higher than those for comparable Grade A office buildings that the developer had constructed elsewhere, although some of these costs can be attributed to the fact that the building was designed to achieve LEED certification. However, as an investor-developer with a long-term interest in the buildings that it constructs, the developer views adaptable design as an intrinsic part of its business strategy in response to

changing occupier demands and achieving higher levels of sustainability. By procuring a building that can be converted to different uses more easily, the developer is attempting to mitigate demand risk and reduce its exposure to future adaptation costs. The design of the building also raises a number of interesting questions, not least about whether the building could, in practice, accommodate mixed-uses. For instance, would a corporate office tenant be content to see adjacent spaces being used for light-industrial purposes or would their lease preclude such an arrangement? The interplay between such non-physical factors could therefore potentially limit the adaptability of the building (even though it is technically feasible).

Case study 2

The second case study is a speculatively developed science park building that was constructed on a brownfield site in the East Midlands region of the UK. The building (Figure 3) was completed in 2008 and comprises approximately 3,000 m^2 of floorspace that can be used to accommodate a mix of offices and laboratories. Serviced workspaces range from 90 m^2 to 1,800 m^2 and can be occupied on flexible lease terms by organisations involved in research and development, science and technology industries. The rationale behind the development was to provide 'grow-on' space for such companies. Adaptability was designed into the building through the provision of a central hub, with pods feeding from it, enabling the floorspace to be divided up to meet the needs of different occupiers. Other adaptable design features included raised access flooring, refittable external wall cladding and services that can be adjusted to meet different space layouts. Such design features are common in speculative office developments in the UK.



Figure 3: *An external view of case study 2*

The developer behind the science park building is half owned by the UK government and half by an investment fund that was specifically set up to be a catalyst for regeneration and sustainability. This enabled the developer to take risks that other private developers would

not normally be willing or able to take. Whereas the funding structures of most commercial developers are normally based around short-term returns, the developer of this building had a longer-term outlook (based on a 5-6 year business plan). As the developer confessed, conventional property development models are not good for encouraging innovation and adaptability, as they are all about finding a formula and replicating it as much as possible, in order to mitigate risk. Nevertheless, despite its longer-term business model, it was not the developer's intention to retain ownership of the development and the scheme will eventually be sold to a property investor. Ultimately then, the design of the building needed to conform to the expectations of the mainstream property market, something that might have precluded the use of more innovative adaptable design strategies.

CONCLUDING REMARKS

Despite the fact that adaptability in buildings is considered to be a desirable design characteristic by many in the construction and property industry, it is still not common practice for buildings in the UK to be designed with adaptability in mind. So what would need to change in the industry for adaptability in buildings to become more commonplace? Figure 4 presents an archetypal view of a property and construction industry in which adaptability in buildings is the norm due to an alignment in the interests of different stakeholder groups: developers procure buildings that are more adaptable because they attract higher prices from investors, who in turn find that they are more attractive to occupiers and end-users because they are easier to change. This 'virtuous circle' is reinforced by a series of other influences: valuers factor the benefits of adaptability into their appraisals and industry bodies encourage their members to think about adaptability when procuring, designing or constructing buildings; similarly planners encourage developers to develop more adaptable buildings and banks lend to investors and occupiers at more favourable rates because more adaptable buildings are seen as less risky.

A number of factors could help to bring about such a change in industry mindsets. One would be to develop a better understanding of the costs, benefits and risks of adopting different adaptable design strategies. In the construction and property industry, existing attitudes towards adaptability are, to some extent, epitomised by a comment from the architect of one of the two case study schemes, who suggested that:

> *"I completely concur and I like buildings to last 500 years. I'd like them to change uses ten times. I'd like to be able to dismantle an office façade and put another kind of façade and respond to the climate and all of that. I guess the problem is that the more flexibility you create… the more cost there is"*

Providing more robust evidence as to the real costs and benefits of adaptability and the way in which these play out in practice could enable clients and their advisors to make more informed decisions about which, if any, design strategies to deploy in their buildings. Learning from examples of existing buildings can be a useful way of understanding the costs and benefits of adaptability and the authors of this paper are therefore engaged in ongoing case study research in this area.

There is also a need for a clearer articulation of what constitutes adaptability in buildings, so as to overcome some of the misconceptions that surround the issue. Evidence from the related field of 'sustainable' buildings suggests that being able to certify or label a building as

'green' can help to improve transparency in the property market and help occupiers to make more informed decisions about which buildings to purchase or lease. Moreover, such certification schemes can help valuers and investors to factor the benefits of sustainable design features into their appraisals of worth and send positive price signals to developers. A useful goal for researchers and industry bodies might therefore be to develop a similar scheme for the adaptability potential of buildings or to see how adaptability potential can be factored into existing 'green' building certification schemes, such as BREEAM and LEED. Indeed, there have already been moves in this direction. For instance in the UK, the *Lifetime Homes* standard – a set of design criteria for ensuring that new homes are adaptable for lifetime use – has been incorporated into the *Code for Sustainable Homes* (DCLG, 2006). In the US, the American Institute of Architects has adopted the "long life, loose fit" principle as one of its ten measures of sustainable design in its annual top ten green projects competition, in which entrants are asked to describe, amongst other things, the adaptive re-use potential of their buildings (AIA, 2004).

Government regulation may also play a role in changing industry mindsets towards adaptability in the built environment. One of the key principles of sustainability is that development today should not compromise the ability of future generations to meet their own needs (WCED, 1987). However, buildings that are difficult to adapt pose a problem for future generations, because the buildings either need to be demolished, undergo costly and potential environmentally damaging refurbishment or remain vacant, which itself can have indirect negative social and economic consequences. Rising land fill taxes in the UK and other countries mean that waste from building demolition and refurbishment will be increasingly costly to dispose of in coming years and although the principle of extended producer responsibility is unlikely to be applied to whole buildings, it could potentially be applied to particular building elements and components (Guggemos and Horvath, 2003). Such changes could give rise to greater demand for buildings that are more adaptable, particularly in terms of the ease with which they can be retrofitted, scaled up or down in size, or converted to a new use.

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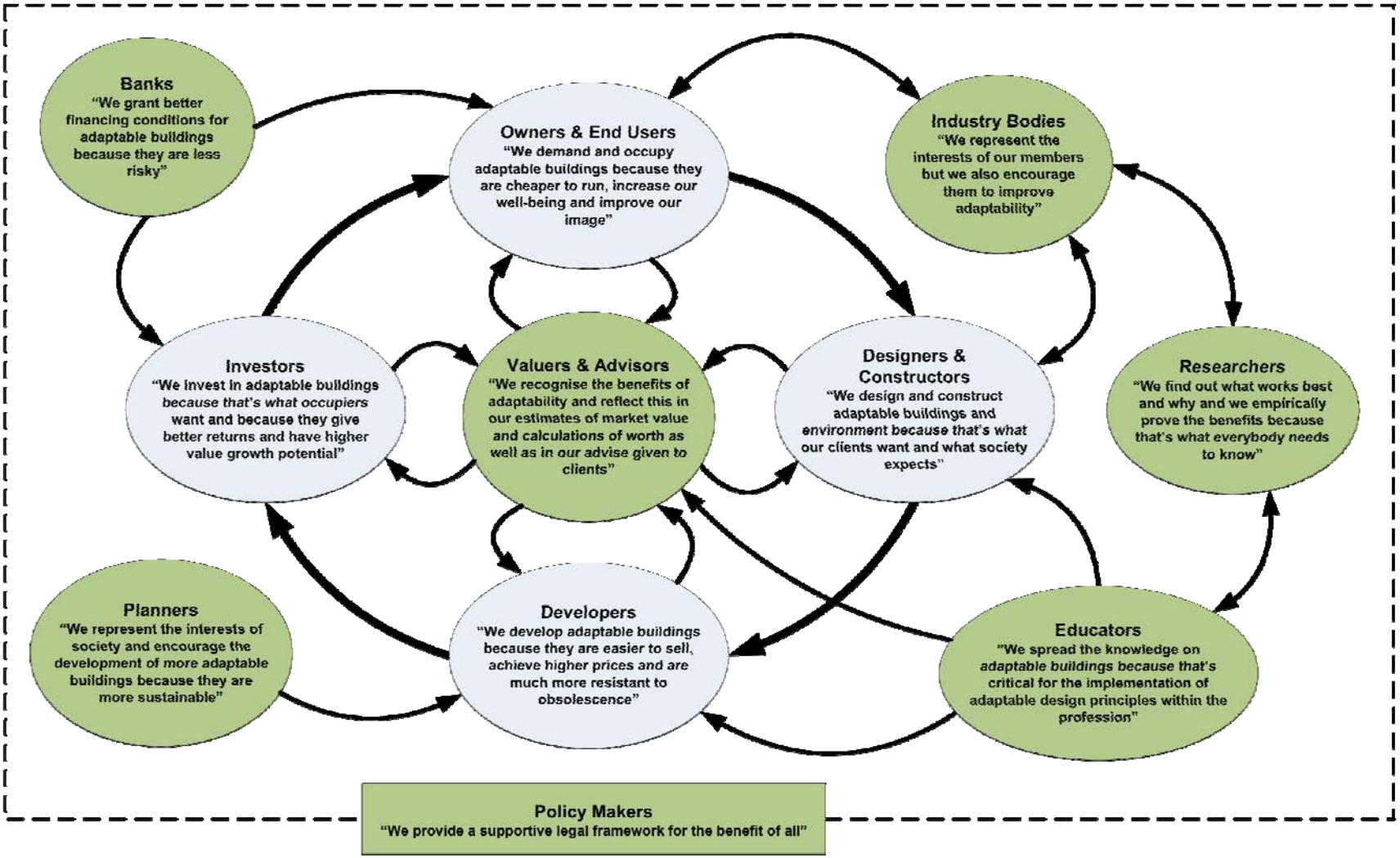


Figure 4: *Creating a virtuous circle for more adaptable buildings (adapted from Hartenberger, 2008; p.6)*

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FACILITIES MANAGEMENT: PROPOSALS FOR PRACTICE IMPROVEMENT AND DEVELOPMENT SUPPORT THROUGH EDUCATIONAL PROGRAMMES IN SOUTH AFRICA

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Abstract

Purpose

Globally the development of property, being part of the creation of fixed investment and wealth, is taking place unabated. The development of an universally acknowledge profession, designated to manage and optimise the utilisation of the ever compounding fixed investments in the products of the collective built environment, is observed. However, in South Africa this is still in an early formative stage. The objectives of this research are to contextualize facilities management by defining it, to identify bodies of knowledge/competencies and to establish a suitable educational knowledge framework and to address existing shortcomings. From a sustainability perspective serious shortcomings exist in many parts of the world and particularly so in South Africa and the rest of Africa. The sustainable utilization of buildings and infrastructure is seriously jeopardized due to underdeveloped facilities management.

Design

The problem at hand is to extract, from the present international practice of facilities management, a body of knowledge and secondly to formulate the results in terms of suitable tertiary and continuing education programmes to address shortcomings in South Africa.

Findings

The results of this research found application in the enhancement of an existing short continuing education programme and the introduction of a new three-year tertiary education programme in a school for the built environment.

Value

The value to be realised out of the structuring and presentation of formal educational programmes in facilities management is that a neglected area of the built environment family of disciplines are being addressed and elevated in South Africa, to what is fast becoming the norm elsewhere in the world. Professional facilities management can make a key contribution to create sustainable utilization of the products of the built environment.

Practical implications

By offering formal education in facilities management a meaningful contribution will be made to satisfy the obvious dire needs of the private, and particularly the public sector, to

optimize the utilisation of the products of the built environment through continuous improvement of those facilities in a scientific and sustainable fashion, to the best advantage of all the stakeholders.

Keywords:, Body of knowledge, built environment, facilities management, sustainability, tertiary and continuing education.

INTRODUCTION

Investment in properties, as fixed assets, is growing continuously internationally. These property development activities are served by a multitude of highly skilled professionals such as engineers, architects, quantity surveyors, construction managers, project managers, town planners, land surveyors and others. The development of a universally acknowledged profession of the same standing, designated to manage and optimise the utilisation of the ever compounding fixed investments in the products of the collective built environment (buildings, engineering structures and infrastructure), is necessary. This situation may be explained by the fact that, in the present day accepted vocabulary, facilities management as a managerial concept developed in the United States of America only during the 1970's, when a Facilities Management Institute was founded and the first known formal symposium was held in Washington DC in 1989 (Binder, 1989). Though these events started approximately 30 years ago, the development and spread were slow, and in comparison with the other built environment professions, it is still in its infancy. However, although perhaps lacking some of the prestige associated with other professions, there are reasons to believe that facilities management is one of the fastest growing "new professions" in the built environment. Sustainability in ensuring that buildings and infrastructure are fit for purpose is paramount. Furthermore, it is becoming evident that facilities management is in the process of becoming a driving force, not only of scientific management and optimisation of fixed assets, but as an initiator of development in the built environment.

Perhaps not adequately acknowledged in the past, is that facilities management deals with 57,5% of the life cycle costs of a building. See Figure 1. Although this % is not universal for all facilities, it underscores the importance of facilities management as discipline. Although life cycle costing is often sighted as a knowledge area in facilities management, it could be argued that the extend to which life cycle costing rests with facilities managers may be under estimated and warrants further research.

Although facilities management is a "new" profession, it is observed that comprehensive sources of literature are constantly being developed. Also noteworthy is the associations that have been established globally. Although in its infancy in South Africa, in some countries tertiary education in facilities management is developing rapidly, supported by research activities.

The terms facility (singular) and facilities (plural) will be used synonymously, as will also be evident from referenced sources, although "facilities" will enjoy preference.

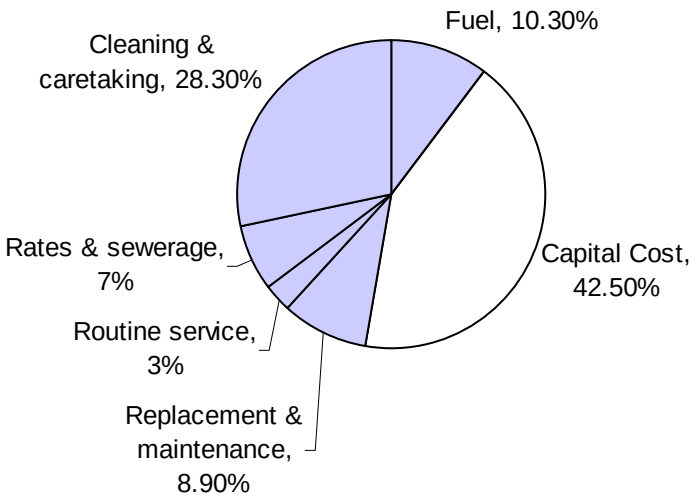


Figure 1: *Local authority school life cycle cost (Cloete, 2001a: 178)*

LITERATURE SURVEY

Literature was selected by undertaking a web search in order to identify and obtain suitable works regard facilities management and by identifying and utilising known local South African works, commonly used by training and education providers. For obvious reasons "all" literature available internationally has not been reviewed. A selection was made of those sources regarded as presenting a fair overview related to this study. The contents of the following literature have thus been analysed in order to establish what appears to be representative of a general knowledge profile in literature: Barret and Baldry (2006), Bender (2002), Best, Langston and de Valence (2003), Cloete (ed) (2001a), Cloete (ed) (2001b), Cloete (ed) (2002a), Cloete (ed) (2002b), Collins and Porras (2000), Cornwell (1973), Cotts and Rondeau (2004), Crocker (1990), Gross (2002), Friday and Cotts (1995), Hauptfleisch (ed) (Volume 1&2) (1999), Hauptfleisch and Sigle (2009), Magee (1988), Means Company (1996), Occupational Health and Safety Act (2003), Owen (1993), Pearce and Robinson (2000), Project Management Institute (2004), Robinson (1999), Rondeau, Brown and Lapides (2006), Seeley (1987), Wang (2010). To this was added those knowledge areas regarded to be of importance in continuing education programmes and in formal academic degree programmes.

Table 1 (placed in later section) provides an analysis flowing from surveying the sources as described above, divided into three categories: Firstly dealing with the "contextualising of the managerial challenge", secondly with the "practice" of facilities management and thirdly with "property maintenance". The topics contained in Table 1 are in main heading format, synthesised from comprehensive subdivisions.

It should be noted that the literature survey covers sources from 1973 to 2010 but that the bulk of it has been published since 2000. For this reason no attempt was made to place the

development of a knowledge profile on a developmental time scale. Figure 2 therefore represents an attempt to provide a contemporary "balance sheet" rather than a "developmental pathway".

METHODOLOGY

The problem at hand is to extract a body of knowledge from the present practice of facilities management, and secondly, to formulate suitable tertiary and continuing education programmes. This was done through literature study, web-searches and by obtaining feedback from facilities management practitioners attending continuing education short courses (in order to create a limited statistical sample), and from non-quantified observations in practice. A qualitative and quantative survey was conducted amongst stakeholders in order to obtain their views regarding a proposed three-year tertiary education programme on under-graduate (degree) level. Figure 2 shows the generally perceived position of facilities management, in context of overall asset management, within an enterprise that holds built environment assets. This diagramme was tested for general correctness by subjecting it to assessment by 12 different groups of facility management practitioners taking part in continuing education short courses over a period of four years.

The general support that it received was taken as indicative of actual facilities management practice in South Africa, offering some guidance in the creation of a primary body of knowledge for education.

From Figure 2 (own diagramme) it is clear that the research done was not hypotheses testing. The intention was to establish current thinking regarding where facilities management could be placed in the bigger context of asset management, thus contributing towards the development of academic programmes, pre-empting the needs of industry, resulting in a structured knowledge profile, validated by a broad group of stakeholders.

DEFINITIONS

Facilities management is defined and analysed in a variety of ways by associations and authors of books. The following selected definitions are based on a survey conducted via internet to provide an overview of "what facilities management" is perceived to be internationally by facilities management associations:

International Facilities Management Association (IFMA)
IFMA is a very comprehensive association, providing comprehensive input and educational opportunities in the discipline. Its head office is based in the United States of America (USA), but it also covers Canada as a North American body. IFMA also has chapters in other regions in the world. The IFMA (2010) web-page contains the following definition:
"Facility management is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology."

The IFMA (2010) web-page also provides a comprehensive structure, summarized below, of nine competency areas (others may call it knowledge areas, or a body of knowledge):

I Operations and maintenance

a. Oversee acquisitions, installation, operation, maintenance and disposition of building systems

b. Manage the maintenance of building structures and permanent interiors
c. Oversee acquisition, installation, operation, maintenance and disposal of furniture and equipment

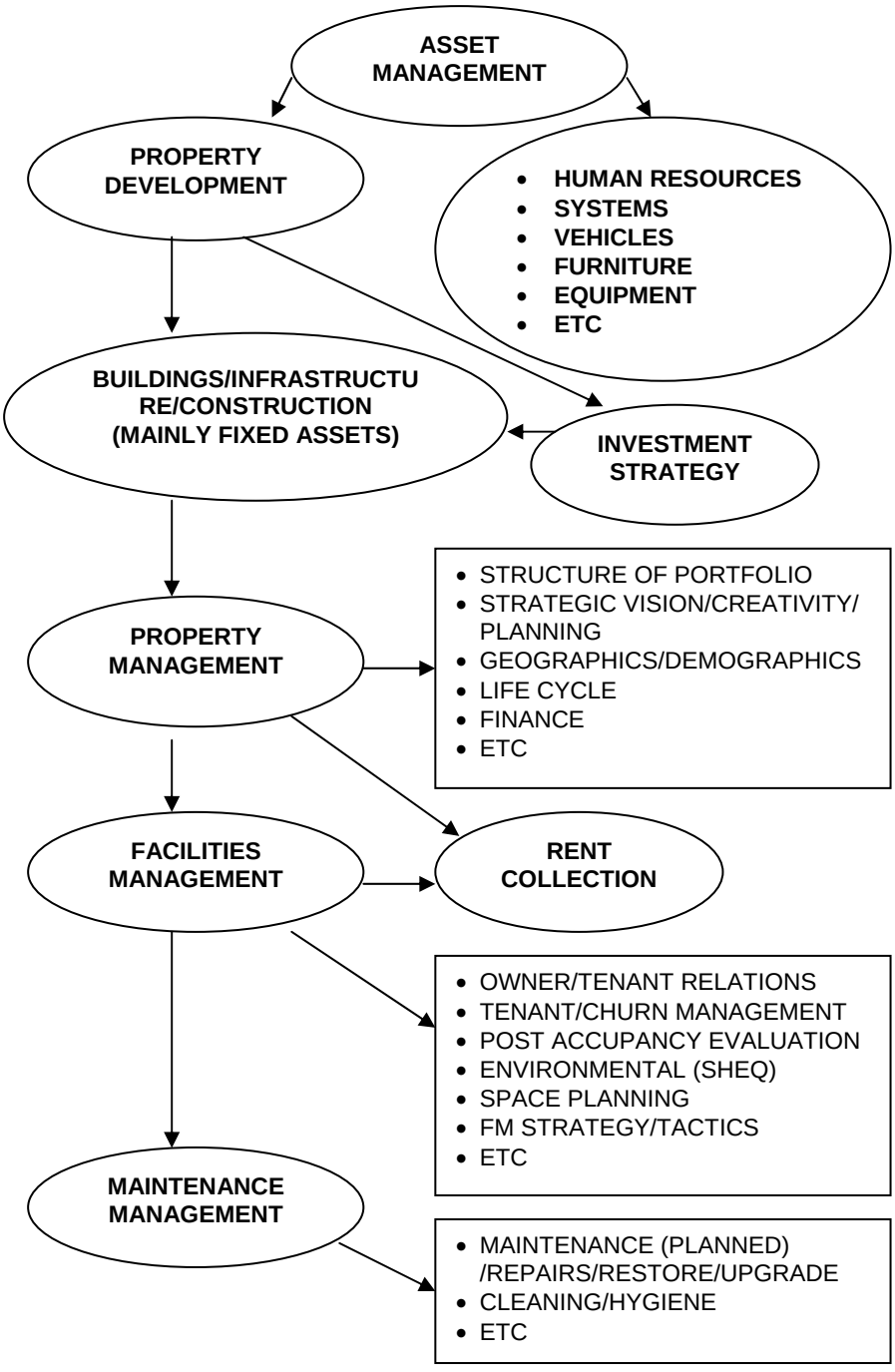


Figure 2: *Facilities Management in Context of Asset Management (own diagramme)*

d. Oversee acquisition, installation, operation, maintenance and disposition of grounds and exterior elements

II *Real estate*

a. Manage and implement the real estate master planning process
b. Manage real estate assets

III *Human and environmental factors*

a. Develop and implement practices that promote and protect health, safety, security, the quality of work life, the environment and organisational effectiveness
b. Develop and manage emergency preparedness procedures

IV *Planning and project management*

a. Develop facility plans
b. Plan and manage all phases of projects
c. Manage programming and design
d. Manage construction and relocations

V *Leadership and management*

a. Plan and organise the facility function
b. Manage personnel assigned to the facility function
c. Administer the facility function
d. Manage the delivery of facility services

VI *Finance*

a. Manage the finances of the facility function

VII *Quality assessment and innovation*

a. Manage the process of assessing the quality of services and the facility's effectiveness
b. Manage the benchmarking process
c. Manage audit activities
d. Manage developmental efforts of facility services to make innovative improvements in facilities and facility services

VIII *Communication*

a. Communicate effectively

IX *Technology*

a. Plan, direct, and manage facility management business and operational technologies
b. Plan, direct, manage and/or support the organisation's technological infrastructure

Facilities Management Association (UK) (FMA)

FMA (2010) information from its web-page is limited, but the following definition is provided:

"Facilities Management is located in the Support Services Sector of the UK economy and is the efficient integration of support activities within the business environment which is essential to the successful performance of any organisation."

British Institute of Facilities Management (BIFM)

BIFM (2010) defines facilities management as follows on its web-page:

“Facilities management is the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities.”

The BIFM (2010) web-page provides the following 20 “strategic and operational” competencies:

- The Business Organisation
- Management Principles
- Risk Management
- Information and Knowledge Management
- Project Management
- Personal Leadership
- Human Resources Management
- Relationships with Suppliers and Specialists
- Quality Management
- Customer Service
- Management of Property
- Property and Building Services Maintenance
- Space Management
- Support Services Operations
- Sustainability and Environmental Issues
- Energy and Utility Management
- Financial Management
- Procurement, Contracts and Contract Management
- Legislation, Codes, Directives and Regulatory Issues
- Facilities Management – Development and Trends

Facility Management Association of Australia (FMAA)

The FMAA definition of facility management is stated by Best et al (2003:1) as follows:
“Facility management is the practice of integrating the management of people and the business process of an organisation with the physical infrastructure to enhance corporate performance.”

FMAA competencies are categorized as follows by Best et al (2003:3): “The broad categories are:

- Use organisational understanding to manage facilities
- Develop strategic facility response
- Manage risk
- Manage facility portfolio
- Improve facility performance
- Manage the delivery of services
- Manage projects
- Manage financial performance
- Arrange and implement procurement/sourcing
- Facilitate communication
- Manage workplace relationships
- Manage change”

The range of skills and knowledge required of facility managers, if they are to successfully carry out all of these functions, is quite alarming as it includes everything from computer networking and mechanical engineering to human resources management theory, occupational health and safety legislation, contract negotiation, future financial planning (eg budgeting, life costing, discounting), subcontract administration, construction management – the list is endless."

Euro FM

Although no specific definitions or core competencies occur on the EuroFM (2010) web-page, it is noteworthy that it networks 80 organisations based in 15 European countries. These organisations represent professional associations, education and research initiatives and corporate organisations.

Hong Kong Institute of Facility Management (HKIFM)

The HKIFM (2010) web-page defines facility management as follows:

"Facility Management is the process by which an organization integrates its people, work process and physical assets to serve its strategic objectives. As a discipline, facility management is the science and art of managing this integrative process from operational to strategic levels for promoting the competitiveness of organizations."

HKIFM (2010) identifies professional core competencies as per Figure 3.



Figure 3: *HKIFM (2010) Professional core competency*

Japan Facility Management Promotion Association (JFMA)

The JFMA (2010) web-page defines facility management as follows:

"It is a comprehensive management approach for the optimization of the ownership, utilization, operation, and maintenance of the business real properties (land, buildings, structures, equipment, etc.) and maintain them in optimal conditions (minimum costs and

maximum effects), so that they could contribute to the overall management of the business." Core competencies are not provided.

South African Facilities Management Association (SAFMA)
The SAFMA (2010) web-page provides the following definition:
"Facilities management is an enabler of sustainable enterprise performance through the whole life management of productive workplaces and effective business support services."
SAFMA however does not list the required core competencies required by facilities management on its web-page.

Other definitions
As previously noted, a large volume of literature exists and is growing rapidly regarding facilities management. A limited number is reflected below, being indicative of general points of view.

Best et al (2003:12) provide the following descriptive statement:
"Facility management is therefore about empowering people through provision of infrastructure that adds value to the processes that they support. Facility managers are charged with the responsibility of ensuring that the infrastructure is available, operational, strategically aligned, safe and sustainable. Above all, however, facilities must encourage high productivity through a continual search for ways to improve quality, reduce cost and minimize risk."

Atkin and Brooks (2009:3-4) provide the following descriptive statement:
"Facilities management can therefore be summarised as creating an environment that is conducive to carrying out the organisation's primary operations, taking an integrated view of the services infrastructure, and using this to deliver customer satisfaction and best value through support for and enhancement of the core business. We can develop this definition to describe facilities management as something that will:

- Support people in their work and in other activities.
- Enhance individual well-being.
- Enable the organisation to deliver effective and responsive services.
- Sweat the physical assets, that is, make them highly cost-effective.
- Allow for future change in the use of space.
- Provide competitive advantage to the organisation's core business.
- Enhance the organisation's culture and image."

Barret and Baldry (2006:xiii) provide the following definition of facilities management:
"An integrated approach to maintaining, improving and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of that organisation."

Although the *International Council for Research and Innovation in Building and Construction (CIB)* is obviously not a trade association, it is of value to review its position as a contributor to the creation of knowledge. The CIB (2010) web-page does not provide specific definitions, nor does it list core competencies. But, as a highly regarded international research facilitator (the work done, and reported through its work commission: CIB W070), its contribution to the creation and dissemination of best professional practice in education, research and practice is of high standing.

UNDER-EMPHASISED KNOWLEDGE AREAS

The knowledge areas that are perceived as important for practicing facilities managers and the relevant emphasis of each in the surveyed literature are reflected in Table 1. The table therefore represents an "emphasis" evaluation, based on the extent to which various knowledge areas receive attention in literature. This analysis is not substantiated by quantitative and triangulated research procedures, but has value as an attempt to observe general tendencies to emphasise knowledge areas, required in a primary body of knowledge for the development and practice of facilities management. The table was compiled by the authors after scrutinizing what knowledge areas receives more or less (how much) emphasis in the surveyed literature.

KNOWLEDGE AREA	COVERAGE IN LITERATURE			
	OFTEN → SELDOM			
	1	2	3	4
A. FACILITIES MANAGEMENT: CONTEXTUALISING THE MANAGERIAL CHALLENGE				
1. INTRODUCTION TO FACILITIES MANAGEMENT	●			
2. AN OVERVIEW OF FACILITIES MANAGEMENT	●			
3. DEVELOPMENT OF FACILITIES MANAGEMENT	●			
4. FACILITIES MANAGEMENT PRACTICE MODELS	●			
5. GENERAL MANAGEMENT FUNDAMENTALS				●
6. STRATEGIC MANAGEMENT		●		
7. PROJECT MANAGEMENT				●
8. HUMAN RESOURCES	●			
9. LAW AND CONTRACTUAL ARRANGEMENTS		●		
10. FINANCE	●			
11. MARKETING OF SERVICES			●	
12. TOTAL QUALITY MANAGEMENT				●
13. SERVICE LEVEL ARRANGEMENTS	●			
14. INFORMATION TECHNOLOGY	●			
15. SUCCESSFUL FACILITIES MANAGEMENT		●		
B. FACILITIES MANAGEMENT: PRACTICE				
1. STRUCTURING THE ORGANISATION			●	
2. CLIENT AND/OR USER NEEDS EVALUATION	●			
3. DESIGN TO SATISFY CLIENT AND/OR USER NEEDS	●			
4. SPACE MANAGEMENT	●			
5. CONSTRUCTION TECHNOLOGY, BUILDING SERVICES AND COMPONENTS		●		
6. QUANTIFICATION AND TENDERING				●
7. PRINCIPLES OF LIFE CYCLE COSTING		●		

8. GENERAL SERVICES				●
9. CAPITAL PLANNING		●		
10. PROCUREMENT & OUTSOURCING			●	
11. RISK MANAGEMENT		●		
12. POST OCCUPANCY EVALUATION	●			
13. BENCHMARKING	●			
14. THE STRUCTURE OF THE BUILT ENVIRONMENT				●
15. OCCUPATIONAL HEALTH AND SAFETY ACT AND REGULATIONS	●			
C. FACILITIES MANAGEMENT: PROPERTY MAINTENANCE				
1. INTRODUCTION TO MAINTENANCE MANAGEMENT	●			
2. MAINTENANCE CATEGORISATION	●			
3. PLANNING AND PROGRAMMING OF MAINTENANCE EXECUTION	●			
4. OPERATIONAL MANAGEMENT		●		
5. PEST CONTROL IN BUILDINGS			●	
6. MAINTENANCE FINANCE	●			
7. CONSTRUCTION, RENOVATION AND MAINTENANCE WORK		●		
8. INTELLIGENT BUILDINGS	●			

Table 1: *Facilities Management Primary Body of Knowledge (own table)*

ANALYSIS OF CONTINUING EDUCATION SHORT COURSES (5 DAYS) AND TESTING OF THE PROPOSED CONTENTS FOR AN ACADEMIC PROGRAMME (3 YEARS)

The researchers have substantial experience in presenting short courses (5 days) in facilities management. As part of the structuring of a three-year tertiary education programme it is regarded valuable to source the views regarding the introduction of an academic programme from short course delegates. Their evaluation of the short courses was seeked to test their acceptance / rating of the contents. This was further extended to also test their evaluation of the proposed contents of the three-year academic programme. Further enhancement of this was done by surveying two selected organised industry groups in the facilities and property industries. A final ongoing evaluation has been regularly conducted since introduction of the three-year programme by continues surveying of the importance attached to 20 core competencies selected by the authors.

ANALYSIS OF CONTINUING EDUCATION SHORT COURSES EVALUATION

Table 2 is based on the results obtained from a limited quantified 100% covered survey, assessing broad disciplines covered during continuing education short courses, soliciting recommendations regarding course content. Delegates are also prompted to make alternative suggestions. This survey has been conducted six times (from 2004 to 2007) amongst delegates, after they have completed a five-day continuing education short course offered to middle (and top) management practitioners of facilities management. Table 2 contains the results that emanated from the last three courses offered during 2006 and 2007, before

structuring the reported academic programme. These courses are always well subscribed. Delegates that are required to take part in the above survey are also evaluated by way of assignments, in order to support continuous quality improvement. These evaluations have subsequently also been conducted from 2008 to 2010, with no noteworthy different result.

KNOWLEDGE AREAS	ACTUAL LECTURE %	RECOMMENDED LECTURE %
Management (assets, property, facility, general)	35	34.1
Client care	6	7.1
Finance	15	13.9
Legal	18	17.2
Quality	13	12.9
Maintenance	13	14.8
Total	100	100

Table 2: *Recommendations for Continuing Education Programme Content Weighting*

From the results reflected in Table 2 it is concluded that the respondents that have attended continuing education short courses, are satisfied that the course content is on target.

ANALYSIS OF SURVEY REGARDING PROPOSED ACADEMIC PROGRAMME OBJECTIVES AND OUTCOMES

Based on all the data obtained, a three year academic programme has been structured, to be offered in a distance learning format, as follows:

- Year One: Facilities Management Introductory Certificate (NQF Level 6: 80 Credits)
- Year Two: Facilities Management Intermediate Certificate (NQF Level 7: 80 Credits)
- Year Three: Facilities Management Advanced Certificate (NQF Level 7: 80 Credits)

Note: Some of the course contents/subjects may be offered as credits towards obtaining a BSc-degree.

The proposed contents of the above programmes/certificates have been subjected to a quantitative and qualitative survey in order to assess the validity thereof. Three stakeholder groups that could contribute to this process were identified and requested to take part in a survey. The quantitative results are reported in Table 3.

- Group 1: Practitioners that have participated in Continuing Education Short Courses.
- Group 2: The South African Property Owners Association (SAPOA) Facilities and Technical Services Committee members.
- Group 3: The South African Facilities Management Association (SAFMA) management committee requested prominent members to participate.

All participants in the survey were provided with details of the proposed course content, including the objectives and outcomes of each subject.

The focus of the survey was to determine to what extent the curriculum content was regarded as important. This assessment of a primary body of knowledge for a three year educational programme was conducted regarding the following quantitive data:

QUESTIONNAIRE ON PROPOSED THREE YEARS COURSE CONTENT FOR CERTIFICATE PROGRAMMES IN FACILITIES MANAGEMENT

1. Your response (x) should please indicate the importance of each subject as per the attached proposed modules for certificates in facilities management over a three year period.
2. Not important: 1
   Most important: 5

			GRP 1	GRP 2	GRP 3
FIRST YEAR: FACILITIES MANAGEMENT INTRODUCTORY CERTIFICATE (NQF 6:80 credits)					
1.1	DQF 104: 16	Descriptive Quantification	4.12	4.25	3.50
1.2	COE 104:16	Building Economics	4.47	4.00	4.25
1.3	SBE 102:8	Structure of the Built environment	4.41	4.00	4.00
1.4	FAM 100:40	Facilities Management	4.88	4.75	4.75
	AVERAGE		**4.47**	**4.25**	**4.13**
SECOND YEAR: FACILITIES MANAGEMENT INTERMEDIATE CERTIFICATE (NQF 7:80 credits)					
2.1	DQF 204: 16	Descriptive Quantification	3.58	4.00	3.50
2.2	COE 204: 16	Building Economics	4.29	4.00	4.00
2.3	CSC 304:16	Construction Science	4.17	4.25	4.00
2.4	EGS 202: 8	Engineering Science	3.76	3.25	4.00
2.5	FAM 206: 24	Facilities Management	4.88	4.75	5.00
	AVERAGE		**4.14**	**4.05**	**4.10**
THIRD YEAR: FACILITIES MANAGEMENT ADVANCED CERTIFICATE: (NQF 7:80)					
3.1	COE 304:16	Building Economics	4.17	3.75	4.00
3.2	CCM 306: 16	Construction Contracts and Management	4.35	4.00	4.67
3.3	BSC 304:16	Building Science	3.76	4.00	4.25
3.4	PDE 302:8	Property development	4.29	3.25	4.00
3.5	FAM 308: 32	Facilities Management	4.52	5.00	5.00
	AVERAGE		**4.22**	**4.00**	**4.38**

Table 3: *Responses by stakeholder groups*

NOTE:

Group 1: From the 213 questionnaires delivered 19 responses were received (8,9%)
Group 2: From 22 committee members 4 responses were received (18.2%)
Group 3: It is unknown how many questionnaires were circulated, from which 4 responses were received.
Although the response rates are not high, it may be regarded as adequately indicative, coming from prominent interest groups.

RESPONDENTS	VALUE
Group 3: Course Participants	4,28
Group 4: SAPOA Committee members	4.10
Group 5: SAFMA members	4,20

Table 4: *Average arithmetic results from all respondents on a 5-point scale*

From Tables 3 and 4 it can be concluded that the proposed three year courses enjoy comprehensive acceptance and that the courses' contents are on target.

The qualitative data that was obtained is not reported on in detail. It basically constitutes guidelines/suggestions and does not distract from the outcomes of the quantitative surveys.

Following the initial data collection reported above, both the 5-day continuing education programme and the 3-year certificate programme candidates have consistently been surveyed since, in order to strengthen the facilities management knowledge base, core competencies required, and to develop the relevant definitions supporting understanding of this multi-disciplinary profession. Table 5 reflects the outcomes of further surveys conducted amongst the 3-year academic students and the 5-day continuing education delegates during 2009-2010. A limited list of 20 knowledge areas/competencies was drawn-up and surveyed on a 5-point Likert scale. None of the delegates are school leavers, all are in full-time occupations. It is noteworthy that overall the 3-year students (people who have elected a serious study commitment), rate the overall importance of the knowledge areas higher then the 5-day continuing education participants. However, all assessments are higher than the 2,5 midpoint, indicating the general perceived importance. The 3-year students' evaluation produced a mean score of 3,86, whilst the 5-day delegates produced a mean score of 3,20.

NO	KNOWLEDGE AREA	3-year students	Short course delegates
1.	General management	3.72	3.12
2.	Strategic management	4.22	3.42
3.	FM Specific management skills	4.00	3.54
4.	Project management for facilities managers	4.22	3.31
5.	IT Utilization	3.61	2.54
6.	Contract law	3.67	3.19
7.	Construction technology, building & infrastructure services	4.11	3.35
8.	Space planning	3.61	3.12
9.	Energy efficiency and environmental control	4.06	3.50
10.	Support services	3.56	3.08

11.	Maintenance management	4.28		3.96
12.	Hygiene and cleaning	4.00		3.42
13.	Total financial management	4.11		3.27
14.	Procurement and outsourcing	3.89		2.88
15.	Post occupancy and continuous evaluation	3.78		2.77
16.	Front desk/reception services	3.33		2.81
17.	Human resources	3.61		2.96
18.	Marketing and public relations for FM services	3.50		2.73
19.	Enhancement of FM practice	3.89		3.35
20.	Total quality management	3.94		3.77
	Mean	**3.86**		**3.20**

Table 5: *Facilities management generic knowledge areas evaluation of importance in practice*

CONCLUSIONS: DEFINITIONS

From the variety of definitions observed and the various surveys that were made, the notion develops that facilities management comprehensively deals with the creation of fit for purpose working environments, or workplaces. The latter is rapidly expanding to become "places of business/work and centres of experience". People globally preferably interacts in optimally created physical environments, whilst some may "live" only in cyber space, away from the physical workplace. The ability to serve these "customers" in the most efficient and sustainable fashion will be the future norm against which FM "services" will be measured.

A unified international definition nor unified core competencies however exist. From the contents of this paper the following definition has been created as focal point for future research: *Facilities management is the process that creates and continuously optimizes the productive utilization of physical operational spaces, services and infrastructure for its intended purposes*.

It is noteworthy that many formal associations apparently have not identified "core competencies" required to structure a unified body of knowledge. Unlike for instance project management, facilities management internationally has not developed a consensual body of knowledge. This is an important deficiency, placing providers of education in a position where each has to select its own, often in isolation.

The knowledge base of the traditional built environment professions offers an excellent point of departure in order to address the challenges offered by facilities management. Facilities management is a "new profession" in the built environment family of professions. It has however been neglected in this regard in South Africa, thus developing in "isolation".

The knowledge gained from offering continuing education short courses, expanded with the analysis of a literature survey, non-quantified observations of academia and practice, and quantitive and qualitative surveys, this attempt in assessing a proposed primary body of knowledge for facilities management rendered useful information. Being a "new" discipline makes it a moving target that requires continuous evaluation and development, particularly regarding the structuring of tertiary education programmes.

The knowledge gained by the University of the Free State from offering continuing education short courses and a three year tertiary education programme have now lead to the structuring of a BSc-degree programme. This is a work in progress, of which the final curriculum will be developed during 2011, with first enrolments envisaged for 2012 or 2013.

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THE POTENTIAL IMPACT ON PROPERTY AND SOCIO-ECONOMIC DEVELOPMENT RESULTING FROM ROAD TRANSPORT CORRIDORS IN AFRICA: A CASE STUDY

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Abstract

Description of the paper

A development corridor is important, particularly regarding its impact on future property development and socio-economic growth. The objectives of this study include the following:

- *A theoretical overview on development corridors;*
- *A literature review on economic wealth creation within a broader region. The South African-Mozambique Development Corridor is used as a case study;*
- *An overview of the planned comprehensive extension of existing corridors and its impact;*
- *The influence that a corridor development could potentially have on property development.*

Application

An entire region must take part in the development process of corridors in pursuance of stated objectives. For a development corridor two primary development centres must be linked by means of an axis, preferably with other secondary development centres in between. There must be mutual dependency between the centres in order to achieve development objectives.

Results, observations and conclusions

Nodal points are important for a corridor in order to provide property development and employment opportunities that stimulate growth and spatial interaction within the corridor. Recommendations could be made regarding the requirements for sustainable development.

Keywords: Development corridor, nodal points, property development, socio-economic development, spatial development initiatives.

INTRODUCTION

In mid-2008 Trans African Concessions (Pty) Ltd (TRAC) requested a multi-disciplinary research team of the University of the Free State and the Council for Scientific and Industrial Research (CSIR), Built Environment Division to initiate a socio-economic impact study on the Maputo Development Corridor (MDC) along the N4 toll road. TRAC is, since 5 May 1997, the Concessionaire of the R3 Billion ($1=R7.50: April 2010) project to build, finance, operate, maintain and expand the 590 km N4 toll road stretching from Pretoria in the Gauteng Province, in South Africa, through the Mpumalanga Province to Maputo in Mozambique (Figure 1 refers). It runs through some of the more industrialised and productive regions in Southern Africa, including mining and agricultural areas and large concentrations of manufacturing, processing, mining and smelting industries, which are located in the cities of Johannesburg and Pretoria on the western end (nodal points) of the corridor (Nathan

Associates Inc: 2008). The other nodal point is the city of Maputo, which also contains the harbour port of Maputo on the east coast of Africa.

The MDC is presented as a case study regarding the probable impact on property and social-economic development.

The vision of the MDC is to rehabilitate the core infrastructure, i.e. road, port and dredging, electricity and the border post within the corridor, through public private partnerships (PPPs), thereby re-establishing key linkages and opening up inherent under and unutilised economic development opportunities. Underlying the vision is the desire to see this initiative contributing to other key policy areas – notably regional economic integration, international competitiveness and a broadening of the ownership base in the economy of the corridor. In order to facilitate the implementation of the project in partnership with the private sector, protocols were signed between the Governments of South Africa and Mozambique (TRAC N4 Toll Road: online).

The Southern African Developing Community (SADC) is interested in the possible positive outcomes of corridor development: "The SADC Secretariat intends to undertake a study to develop the Corridor/SDI program as a development strategy to accelerate regional economic integration and development. The success of this development is dependent on the cooperation and political commitment of member states on the Corridor/SDI Program" (SABC News: Online 05/06/2007).

The objective of the National Physical Development Plan (RSA, 1975:17) was to link existing metropolitan areas with identified or future growth poles by means of development axes. Geyer (1986:163) found that some of these axes were not supported by secondary development centres or were stretching over too long distances to make development realistically viable. The greater the distances between centres, the stronger these secondary centres must be as a propelling force. In some cases these so-called axes were not axes at all but rather finger developments with no equilibrant pole at the other end. The development of a good road network which provides better interaction with the hinterland in many cases led to the decline of economic activities in small towns as the threshold "time" to bigger centres was changed. The Spatial Development Initiatives (SDI's) of the South African Government, conceived in 1995 by the Cabinet was an attempt to improve investment in those areas where the greatest potential for growth exists (Jourdan, 1998:717). The MDC is a typical axis development between two big centres, taking economics into consideration, as Maputo is the closest harbour to Gauteng. In the 1970s 40% of the export from Gauteng went through this port, but this faded away due to socio-political reasons. (Jourdan, 1998:720). However, strong growth has subsequently been experienced, following new political dispensations.

The analysis indicates that areas closer to the N4 corridor (axis) had higher growth than those further removed. This is the case for total output as well as for several sectors. Gross Value Added (GVA) per capita also indicated a similar situation – areas close to the road corridor had a higher growth rate than those further removed.

DELIMITATION OF THE STUDY

Figure 1 provides an indication of the physical extent as geographically defined at the start of the Maputo Corridor Project. The MDC is a major import/export route that connects the

North-East provinces of South Africa with the capital and main port of Mozambique. It serves Gauteng (industrial heartland of South Africa), Swaziland and South-West Mozambique. Reference is also made to the potential of other development corridors in Africa, more particularly Southern Africa. The MDC is used as case study in this paper.

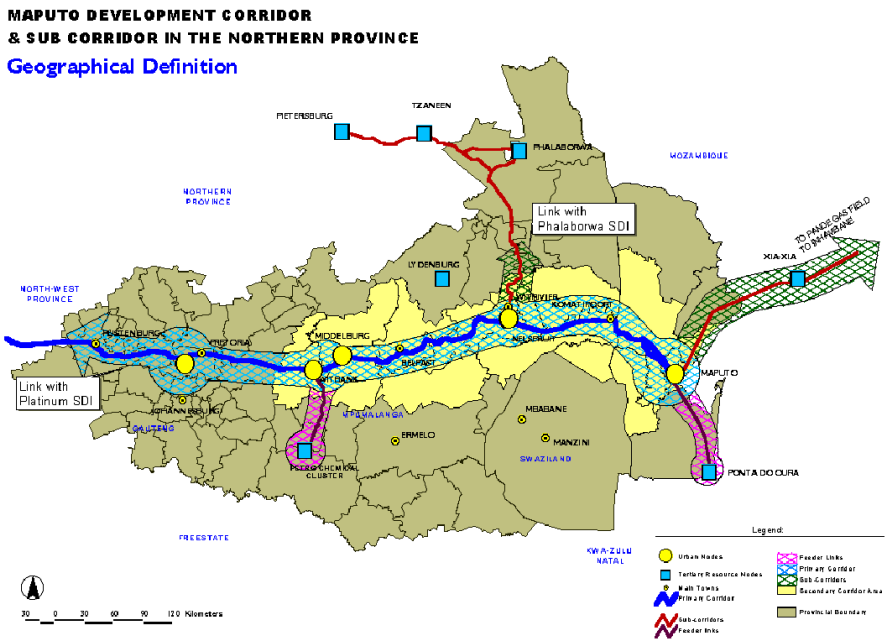


Figure 1: *Geographical definition of the Maputo Development Corridor (MDC) (Source: Technical team to the ICC, 1996)*

RESEARCH METHODOLOGY

This paper revisits concepts related to corridors and their theoretical foundation. Some sectors and components of socio economic development have been included as well as main activities that occurred since the inception of the MDC. Although some studies investigated the impact of the MDC it is clear that subsequent deductions are matters of interpretation. Some changes cannot clearly be related to the MDC. There are clear deficiencies and constraints (example: the coverage of Mozambique and Swaziland) currently. A literature comparison is made regarding the interim perceived unsuccessful outcomes of the corridor, the present positive aspects, areas that may be improved upon, and the viewpoints of a stakeholder forum. The focus of this study is mainly on the road component of the corridor, whilst acknowledging that it is not possible to divorce it completely from for instance the rail linkage.

PROPERTY DEVELOPMENT

Throughout this research it was found the "property development" as an outcome of corridor development is not isolated by researchers and other commentators. Although emphasis is often placed on socio-economic development, the measurable outcomes are likewise poorly quantified in specific terms. This also applies to other industries such as agriculture, mining, etc. There are thus very little available regarding industries specifically. What is however abundantly available is data regarding measurable outcomes in certain nodal/centre developments, such as increases in harbour activities, freight movements through border posts, etc. A quantified data survey was launched, with continuous pressure applied, to obtain specific quantified data regarding property development. The limited results are reported in

this paper. However, though there could be subscribed to the view held by some researchers that "a corridor is a corridor", it is clear from the research reported in this paper that comprehensive "overall" impacts are abundantly visible. This is described elsewhere as "trickle down" effects, acting as catalyst for each other. It appears as if "tools" have not yet been developed to measure specific overall industry outcomes, other than those very directly measurable, as stated above.

THEORETICAL ASPECTS OF DEVELOPMENT CORRIDORS

Development corridors are difficult to define spatially as they are often based on the use of transport infrastructure. Such road or rail connections, though development corridors, cannot be restricted to the narrow band where such infrastructure is located. Its developmental linkages are much broader than the area adjacent to the transport infrastructure. It is clear, from literature that different approaches exist. For the purpose of this study it is important to consider the corridor as originally envisaged and conceptualised. Geyer (1988:123) sees the development corridor or axis as a dynamic phenomenon that evolves in different stages over time, which can be seen as a concept to elevate an area to a certain level of development. Four stages are identified and shown in Figure 2, namely:

- The potential axis (A) or the development finger with the potential for the establishment of a development centre at the other end (B);
- The axis in an infant stage with a well established communication axis between two primary centres (C);
- The mature stage with the corridor or axis having one or more secondary centres in between (D) and
- The axis in its old age or dormant stage where an over-concentration on the axis may lead to the development of agglomeration, diseconomies or polarization reversal (E).

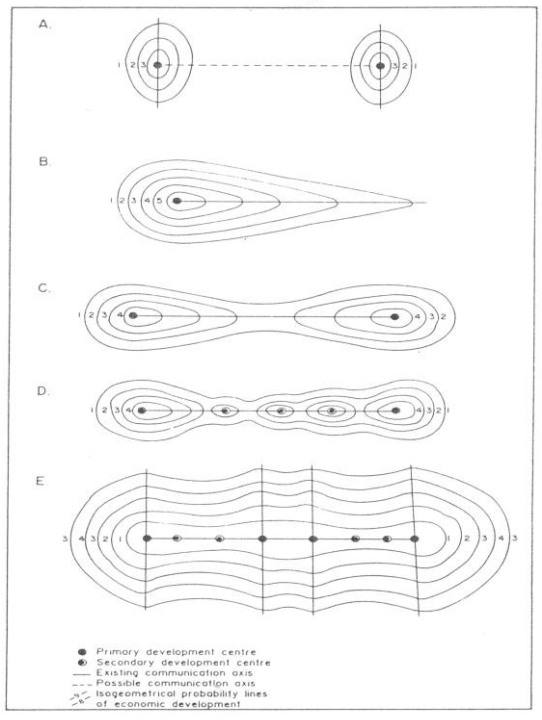


Figure 2: *The evolution of the Development Corridor (Geyer, 1988:123)*

Geyer (1986:163) found that some of these axes were not supported by secondary development centres or were stretching over too long distances to make development realistically viable. The greater the distances between centres, the stronger these secondary centres must be as a propelling force. In some cases these so-called axes were not axes at all but rather a finger development with no equilibrant pole at the other end. The development of a good road network which provides better interaction with the hinterland in many cases led to the decline of economic activities in small towns as the threshold "time" to bigger centres was changed. An understanding of economic forces is vital to any development planning as people and businesses will only locate in areas where it is economical viable. The MDC could presently be rated as a Figure D corridor development.

GOVERNMENT INITIATIVES: SPATIAL DEVELOPMENT INITIATIVES

The regional Spatial Development Initiatives (SDIs) are projects identified on the basis of their inherent unutilised economic potential. Their developmental objective is to create sustainable jobs in these areas by identifying and facilitating new investment. The mechanism by which this is achieved is focused, co-ordinated action at all levels of government and by all relevant line functions within the spatially defined area, in order to remove blockages to investment. SDIs are a key industrial policy committed to foster sustainable industrial development in areas where poverty and unemployment is at its highest. This objective is carried out through the SDI, which focuses high-level support in areas where social-economic conditions require concentrated government assistance and where inherent economic potential exists (South Africa: 2007, online).

Primarily all the major projects in the SDI are based on a partnership between the public and private sectors such as the MDC, and are set to provide opportunities for participation in sectors such as agriculture, mining, tourism, environment, forestry, infrastructure and ports. The MDC was expected to create more than 68 000 new jobs. A key component of this initiative is the move towards international competitiveness, regional co-operation, and a more diversified ownership base (South Africa Information/doing business/economic development: 2007, online).

Certain SDIs are also beyond the confines of the borders of a country where the economic imperatives of the strategy dictate that the SDI includes part of a neighboring country. The MDC between South Africa and Mozambique also affects Swaziland, Zimbabwe and Botswana.

In order to investigate the impacts resulting from a development corridor this report is thus further structured to provide a "mid-term" overview, followed by an African continental perspective, MDC nodal acknowledgement in future planning, and 2010 observations, supported by some empirical data. The research findings are provided under conclusions.

A "MID-TERM" OVERVIEW

Söderbaum and Taylor (2003) compiled, with the aid of seven co-writers, a book, Regionalism and uneven development in Southern Africa, providing an in depth analysis on the topic, concentrating primarily on the MDC. The perspective that they hold provides an important balance sheet, reflecting, albeit negatively, on the impact of the MDC. The following page referenced abstracts, in some instances re-worded and/or abbreviated for this paper, bear relevance:

P6: The MDC is based on four key objectives:

1. To rehabilitate the primary infrastructure network along the corridor, notably road, rail, port and dredging, and border posts, with the participation of the private sector in order to have minimum impact on the fiscus.
2. To maximise investment in both the inherent potential of the corridor area and in the added opportunities which infrastructure rehabilitation will create, including the provision of access to global capital and facilitation of regional economic integration.
3. To maximise social development, employment opportunities and increase the participation of historically disadvantaged communities; and
4. To ensure sustainability by developing policy, strategies and frameworks that ensures a holistic, participatory and environmentally sustainable approach to development.

Concluding remarks by Söderbaum and Taylor (2003) summarize the outcomes as follows:
P107-108: The uneven development impulses reinforced by the MDC and the ineffectiveness of its governance radically undermine the potentiality of the MDC as a "model" SDI for the rest of the Southern African region. We are sceptical that such a spatially focused framework engineered, in the main, by the private sector can stimulate genuine long-term and sustainable development. In a region characterised by a labour surplus (albeit largely unskilled), highly capital intensive and "big-bang" development projects do not seem particularly apposite.
P108: In effect, the prevailing paradigm, which the MDC is founded upon, contains a very strong emphasis on the notion that the state is inefficient and needs to be deregulated and made more competent.
P108: It is this reconfigured posture that confirms that the MDC has seen the state in both Mozambique and South Africa reduced to what can be seen as a transmission belt for capital, neglecting in the main questions pertaining to social and participatory development.
P109: Building on general insights from critical international political economy, many of the chapters in this volume draw attention to the reality that the political purpose behind the state's involvement has not been to promote development and public goods or needs, but has rather been first and foremost to promote an enabling environment for the private sector.
P110: …, it is thus clear that the governance structures and the Public Private Partnership (PPP) operating in the MDC have had a mainly negative effect on governance, democracy, ownership and participation.
P110: As a matter of fact, the political support provided by the "political champions" and the specially designed SDI methodology has not worked satisfactorily. The important thing here is that despite concerns expressed by the private sector to government to take the MDC initiative more seriously, the MDC has increasingly become characterised by a lack of political leadership in South Africa.
P112: For sure, the MDC is officially held to be a development corridor, but in practice it is an investment and "market guidance" initiative with the hope that it will create jobs and somehow lead to "development". In fact, certain leading government officials behind the MDC admit that the MDC is not about development at all: it is to be understood as the Maputo *Investment* Corridor.
P113: In short, just because regional elites proclaim the MDC to be a "development corridor" does not make it so.
P114: The "market" cannot be left to its own devices if development and empowerment within the MDC (and indeed other SDIs) are to be realised.
P114: It is not good enough to predicate the micro-region simply around "growth" and "big-bang" investment, and then simply *hope* that "trickle-down", job creation and empowerment will occur.

P115: It is thus very unclear whether the spatially focused approach, driven by private investment, will be able to trigger genuine "development" in the targeted areas. Indeed, the SDI strategy is a highly capital intensive development strategy that may not be suitable for regional economies whose main endowments are labour and natural raw resources.

The foregoing, overly negative perspective published in 2003, seven years after the launch of the MDC in 1996, fails to acknowledge or fundamentally evaluate the real effect of the "trickle down" impact. In fact, it also fails to recognize or provide guidance as to how the stated objectives 3 and 4 should be practically brought to fruition. Guidance is also not provided regarding how the desired social development and employment resulting from the MDC is measured, or measurable. The positive outcomes regarding key objectives 1 and 2 are evaluated, for thinly disguised reasons, by Söderbaum and Taylor (2003) as negative, probably because 3 and 4 are emphasized as failures.

AFRICAN CONTINENT

Jourdan (2008: 20) reports as follows, further reflected in Figure 3: "An African Development Corridor desk-top study was undertaken by the RSDIP[1] & Mintek (for NEPAD) in 2006 to investigate the potential and status of continent-wide development corridors, examined in a preliminary fashion the potential of DCs across Africa. It makes the case that Africa's physical and social infrastructure needs are so large that they cannot be met in any reasonable timeframe without substantive contributions from the private sector."

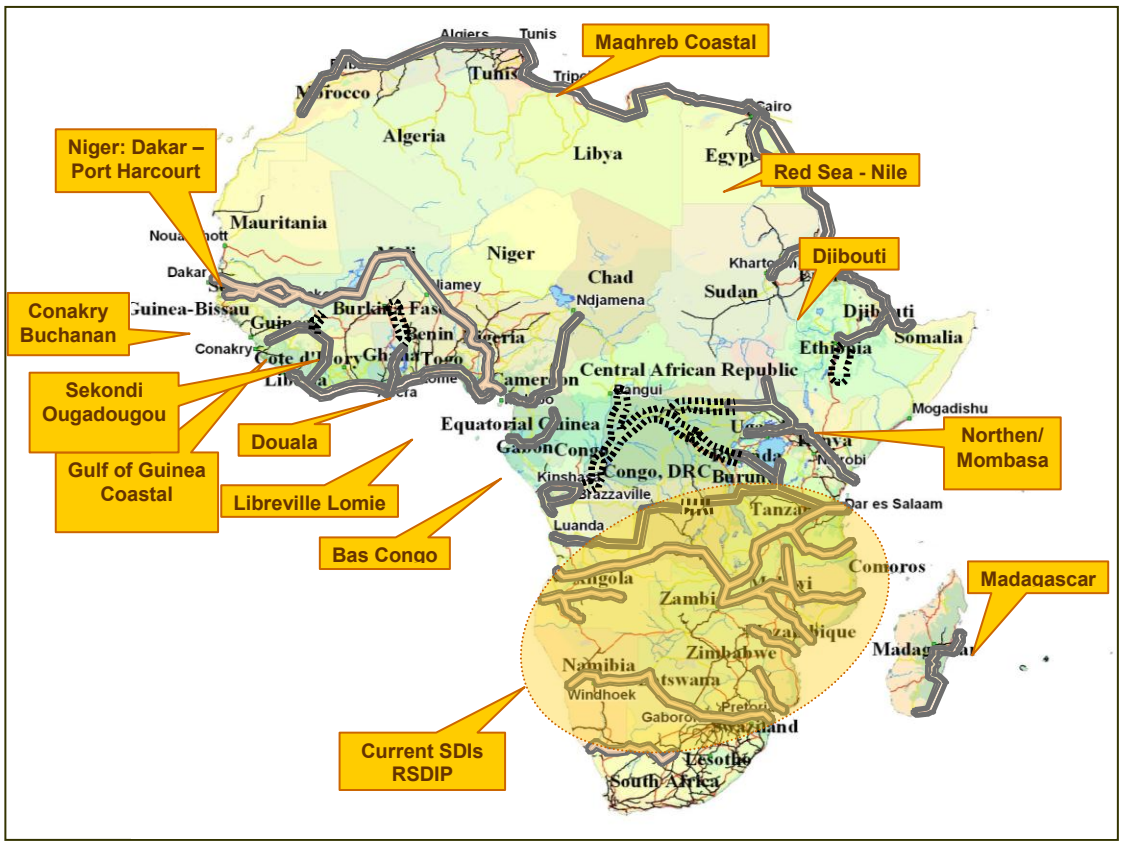


Figure 3: *Potential Resource-based African Sustainable Development Corridors*

[1] RSDIP: Regional SDI Programme of the SA Department of Trade & Industry

The Japan International Cooperation Agency (JICA) (2010:1-276) has prepared a comprehensive study titled: Preparatory Survey for Southern Africa Integrated Regional Transport Programme. This study was conducted to cover the region reportedly with the highest cross-border traffic in Africa, covering the 8 most southern countries. Significant growth has taken place in this region over the last decade, but was also negatively impacted on by the global financial crises of 2008. The study confirms a substantial growth in Direct Foreign Investment (DFI) in the region since 2005. However, to ensure sustained development, the report identifies corridors as a key requirement for growth. JICA (2010: ES-4) states: "The existing 18 corridors in the region connect local mineral and agricultural resources with global markets. The study proposed re-defining the role of regional economic and transport corridors according to growth scenarios (strategies), building on the growth belt concept, which encompasses the integration of resources, value creation, and global markets". Constraints that are identified to achieve these objectives relate strongly to border crossing delays, often for many days, maintenance of infrastructure, poor port performance and taxation regimes. Solutions are offered to address these negative findings. Figure 4 indicates the existing 18 corridors, for which in each case comprehensive trade movement data is available. Some of the corridor positions are (probably) not geographically 100% correct, but the overall presentation is acceptable for the purpose of this paper. From a socio-economic perspective, comprehensive data is available for each of the countries regarding demographics, scale of economic activity, governance and the business environment. From this a corridor development priority programme has been created for Southern Africa. Social conditions were further analysed per country in order to quantify population growth, governance standards, economic activity, trade, investment and regional co-operation and integration.

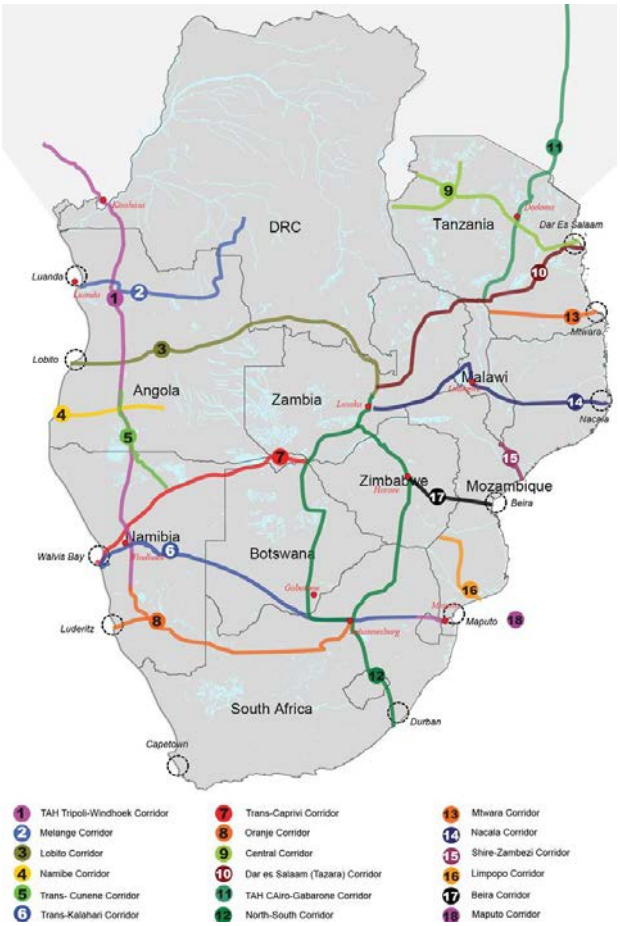


Figure 4: *Southern Africa Transport Corridors and Major Ports (JICA, 2010: 2-22)*

EXTENSION OF MDC: NODAL POINT ACKNOWLEDGEMENT

From The World Bank (Africa Region) Summary Report, the further extension of the MDC is anchored in a "growth poles strategy" that supports the position in this paper that development centres/nodal points/growth poles are key drivers of corridor development. Evidence indicates that "a road is a road" that connects poles. Development tends to take place mostly in the nodes/poles, with the axis benefitting socio-economic development, along the corridor in a catalytic fashion.

The World Bank Summary Report (2010: 4-21) reflects the above position, supporting the principle of a nodes/poles analysis when assessing corridor development. The following page referenced aspects of the report is indicative thereof. Noteworthy is the lack of specific "social upliftment" strategies, silently supporting the view that private economic development is the driver of development in general. "Social engineering" is not mooted in this report and it could therefore be assumed that "social development" is regarded as an automatic "trickle down" beneficiary of private sector-led economic growth initiatives.

P4: The objective of this study is to assist the Government of Mozambique in designing and implementing growth pole strategies in selected subregions, based on current and proposed programs and international experiences. The study focuses on subregions situated on the three main development corridors: Beira, Maputo, and Nacala. These subregions were chosen based on their concentration of private investments, opportunities for private sector-led growth, current development challenges, and ongoing interventions, as well as their potential to demonstrate the benefits of an integrated growth poles approach.

P4: The main goals of an integrated growth poles strategy for Mozambique are to promote private sector-led growth and employment while maximizing the development outcomes for sustainable and equitable growth, especially in underserved provinces. It consists of six pillars: (i) enhancing subnational economic competitiveness through business environment reforms; (ii) nurturing and developing local and indigenous enterprises by fostering linkages with large foreign investments; (iii) strengthening local institutional capacity; (iv) upgrading urban infrastructure; (v) strengthening economic governance; and (vi) improving management of the social and environmental impacts of large investments.

P4: In terms of national development objectives, the growth poles strategy supports the Government's program for shared and equitable growth throughout the country. It addresses critical development challenges at the subnational level and seeks to strengthen the competitiveness of regions within the corridors. It also accelerates the outcomes of ongoing spatial development initiatives (SDIs) through targeted interventions. The proposed growth poles strategy in Mozambique will complement existing initiatives by the Government and its development partners, including the World Bank, at the national and local levels. One of its main objectives is to support local authorities in planning, coordinating, and finding synergies among the government, donor, and private sector interventions in the context of decentralization. Where possible, the growth poles strategy will build on lessons learned from local initiatives, and complement or scale up those that support an overall local development strategy.

P4-5: Over the past decade, economic growth has been driven primarily by a number of large investment projects in agriculture, infrastructure and mining, as well as by large inflows of overseas development assistance (ODA). Megaprojects have helped stimulate economic

growth but account for less than 2 percent of urban private sector employment. The challenge is therefore to enhance job creation and technology transfers associated with large productive investments. In 2007-2009, the total value of investment projects authorized by Mozambique's Investment Promotion Agency (CPI) amounted to $14.9 billion. If a significant proportion of these projects are realized and well managed, they would have the potential to transform the socioeconomic environment in Mozambique and create many thousands of new jobs.

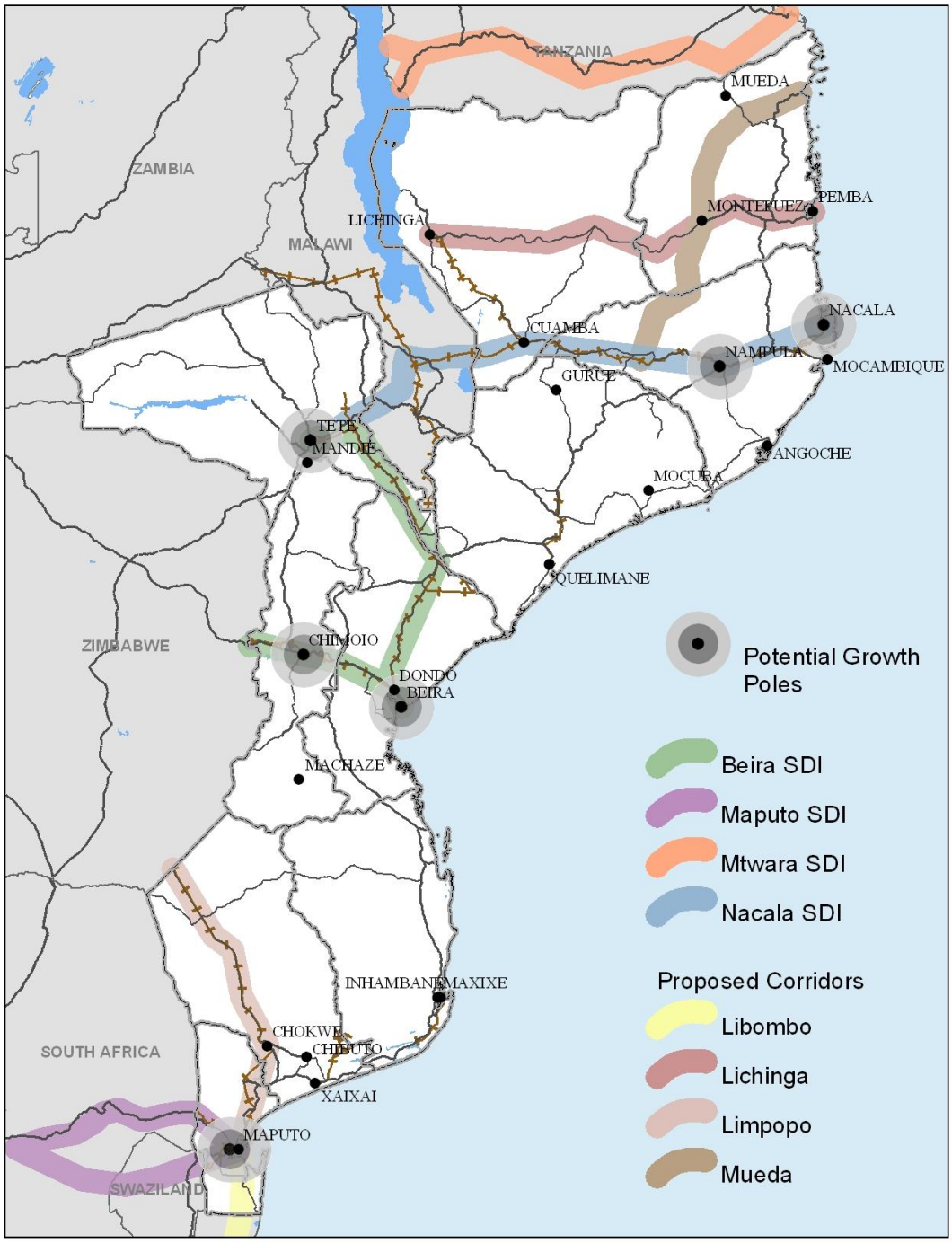


Figure 5: *Development corridors and potential growth poles*

The report emphasizes a variety of growth pole strategies, some specifically related to certain provinces. The following steps are however proposed in regional Mozambique context:
P21: ***Build awareness and stakeholder consensus on a growth poles approach.*** To chart a way forward, it is necessary to discuss the study's preliminary findings and proposals with key stakeholders in the national and provincial governments, the private sector, and the development community. Key issues are to ensure that: (i) the growth poles strategy is integrated into the spatial planning work being undertaken by COCEP; and that (ii) there is consensus among the key stakeholders, including the donor community, on the identification of potential growth poles and the implementation of the strategy.
Provide detailed identification of potential growth poles. A more detailed assessment of the potential for growth pole development is needed.
Ensure Government ownership and leadership. Adoption of a growth poles strategy by the Government of Mozambique will require high-level political commitment and support, possibly at the level of the prime minister or presidency.

OBSERVATIONS 2010

An interview took place with the Chief Executive Officer, Brenda Horne (2010) of the Maputo Corridor Logistics Initiative (MCLI) to obtain a perspective regarding the ensuing years since 2003, thus observing the resultant outcomes up to 2010. The MCLI, a non-profit company was registered to create a body where all stakeholders may contribute to develop the MDC in their collective best interest. MCLI subscribes to the following mission: "To support the development of the Maputo Corridor into a sustainable, highly efficient transportation route, creating an increasingly favourable climate for investment and new opportunities for communities along the length and breadth of the Corridor". Figure 6 indicates the MCLI membership structure.

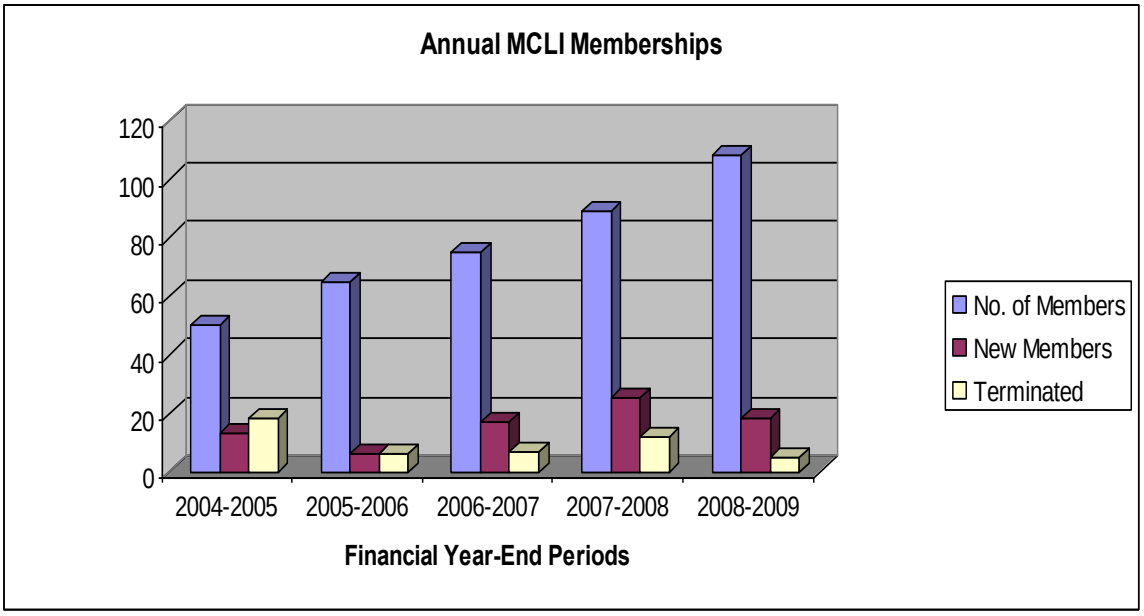


Figure 6: *MCLI International Membership*

In pursuance of the above the following provides an overview of the MDC as perceived by the MCLI presently, as was published as a MCLI Editorial in Export News, February 2009:

- The Port of Maputo is only 590 kms by road from Gauteng and 581 kms by rail and presents the shortest route to a port for South African exporters from the industrial heartland, Gauteng.
- To date, the private sector has committed an estimated figure of well beyond US$5 billion worth of investments in southern Mozambique and Mpumalanga.
- Some US$70m has been invested in the priority works programme at the Port of Maputo since April 2003, including dredging and marine operations, cargo handling, terminal and warehousing functions as well as port planning and development. Before the end of 2004, the port was working 24/7 in full compliance with the highest international security standards, the first African port that is International Ship and Port Facility Security compliant.
- Total tonnage handled through the port in 2008 was 7 591 000 tons; a 13.25% increase on the previous year. The port had been confident of achieving 8 000 000 tons prior to the dramatic slump in throughput in the last quarter of the year.
- Trans Africa Concessions, (TRAC) a founding member of MCLI, has spent US$400m on the rehabilitation and upgrading of the road from Gauteng to Maputo, with at least another US$400m to be spent on the road over the balance of the 30 year concession. The fact that this road has drastically reduced traveling time between the two countries has contributed significantly to the increase of traffic and consequently to trade. TRAC has indicated that traffic volumes have increased by between 5 and 7% per annum, with truck traffic increasing by 10% per annum on this road.
- By 2007 passenger transport between South Africa and Mozambique had increased by 80% since the lifting of visa requirements between the two countries in April 2005. This phenomenal increase has put pressure on the existing infrastructure at the Lebombo/Ressano Garcia border post, which is being addressed in the planning and implementation of a joint 24 hour one-stop border post scheduled for completion during early 2010.
- The World Bank's World Development report for 2007 listed Mozambique as the African country with the highest economic growth levels, with an average of 6% between 1995 and 2005. Real GDP growth was 7% and 6,5% in 2007 and 2008 respectively.

The MCLI has received one of three prestigious awards in 2009: The New Partnership for Africa's Development (NEPAD) Transport Infrastructure Projects of Excellence Awards. MCLI's Mozambican Chairman, Dr Antonio Matos, was delighted with the recognition given to MCLI's work, stating: "The Maputo Corridor has been a catalyst for economic growth in the region through the significant investment in infrastructure on the corridor and it is a great honour for MCLI. We are delighted that the efforts of this public-private sector organisation are being recognised by organisations such as NEPAD, and we believe that MCLI is a model for transport corridor development in Africa and we share this award with all MCLI's corridor partners." The Chief Executive Officer of MDC, Brenda Horne was also honoured for her contributions to develop the MDC, having been nominated as South African (Shoprite Checkers) Business Woman of the Year, 2010.

The impact of the MDC infrastructure improvements during the past twelve years could be summarized as follows:

- More than US$5billion invested in the Maputo Development Corridor
- 24 Hour Joint One Stop Border post (construction) in progress.
- Increased road safety, at 5% pa traffic growth rate. Freight increases at 10% per annum.

- Harbour concessions are in place and successfully managed by the private sector with a further developments and investments underway and increases planned for infrastructure investment during the next 20 years.
- Increased traffic in the Port of Maputo and its terminals (3 million tons in 1996, 8.3 million tons in 2009 and a 20-year port master plan anticipating 48 million tons.
- Increased shipping services and direct calls to the Far East introduced in 2009 have resulted in the container terminal, realizing the highest ever container movement at the terminal of 103 000 TEU's in 2009.
- Increase in tourism & trade (South Africa/Mozambique).
- Further investment in Port & terminals > US$750m.
- Continued investment and trade into Mozambique and substantial economic growth of Cities/Towns along the MDC.
- 2008 TRAC Gross Value Added desktop study declares that areas in close proximately of the transport corridor grew at higher rate than areas further removed.

REAL TIME VIEWS REGARDING PROPERTY DEVELOPMENT

A questionnaire was compiled to evaluate the views of MDC stakeholders in a **Likert 5-point scale** format, during 2010. The questions were designed to address issues dealt with in this paper. The resultant feedback was very disappointing as only six surveys were received by the time of publishing this document. However, what could be construed as indicative from this opinion survey are the following responses to selected questions (relevant to this paper), reflected in Table 1. The respondents were requested to rank their evaluations on the 1 to 5 scale: 1=little, 5=very much.

Question 1:
General economic growth over the last 10 years in your region attributable to the MDC/N4-corridor: 3.67

Question 5:
Will **future upgrading** of the MDC/N4-corridor stimulate new product development for industries? 4.00

Question 6:
Does the MDC/N4-corridor contribute to **wealth creation** in general in your region?
3.83

Question 7:
Does the MDC/N4-corridor contribute to **job creation** in your region?
3.67

Question 10:
To what extent has the MDC/N4-corridor specifically/directly caused **real estate development** (properties, buildings) to take place in the following economic sectors (in order of perceived importance):

1. Parastatals	2.00
2. Forestry	2.17
3. Agriculture	2.17
4. Mining	2.50

5. Education	2.67
6. Governmental	2.67
7. Manufacturing	2.83
8. Health care	3.00
9. Housing	3.17
10. Industrial	3.50
11. Commercial	3.67
12. Tourism	3.83
13. Maputo harbour	3.83

Question 12:
To what extent will the possible **further development of corridors** higher into Africa have on **real estate** development in **your region**?
3.83

Question 13:
To what extent will the possible **further development of corridors** higher into Africa have on **infrastructure development** in **your region**?
4.00

Table 1: *Maputo Development Corridor Stakeholder Survey*

From the data reflected in Table 1 it is clear hat the overall effect of corridor development strongly support socio-economic and property development.

CONCLUSIONS

From the data regarding Africa as continent, and more specifically Southern Africa, it is concluded that the success of corridors as transport routes, and importantly, creators of general socio-economic development, is undisputed. It could in fact be stated that without the successful development, maintenance, border crossing improvement and optimal functioning of ports, socio-economic development and regional trade growth and integration will be seriously compromised for the entire region, and indeed Africa as continent. The MDC results confirm the above.

A noteworthy shortcoming in literature in general is the lack of quantification of benefits per capita. Data tends to provide typical collective perspectives. Though the authors have attempted to collect quantified data per questionnaire, in the mode of an opinion survey, the response to that was marginal.

It is difficult to specifically adjudicate positive developments that emanate from the MDC into detailed socio-economic segments. It is, except for very pronounced projects, also difficult to ascribe property development to the MDC on a project basis, as most projects in the MDC axes are dictated by the general growth resulting from the MDC. Local municipalities (especially those on the N4 corridor) see the MDC as an important component in their planning and marketing. The positive effects of the corridor are clearly there, and in many instances measurable, but very difficult to quantify according to specific growth in specific sectors. It is rather in the style of a mass movement, than individual events. Data could not be found or generated to determine the exact contribution to, for instance, property development. Collectively the data supporting growth resulting from the MDC is undisputed, physical

development is there to observe, particularly pronounced around nodes on the axes, and at terminal nodes. The results from this research outline the positive outcomes emanating from corridor developments. It is clear that regional socio-economic development, particularly in Africa, will benefit extensively from corridor developments. It is difficult to foresee how such developments can take place in a sustainable fashion without it. Southern Africa already displays excellent results in this regard. It is also concluded that the "trickle down" effect of development corridors calls for further research, with particular focus on quantification of the effect thereof on the different economic sectors.

It is noteworthy that The World Bank is in line with the "nodal point" perspectives supported by this paper. It also appears as if they subscribe fully to private sector-led economic development, with employment creation regarded as an automatic beneficiary, rather than the prime focus.

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MICROGENERATION TECHNOLOGIES IN NEW BUILD HOUSING: TECHNOLOGICAL TRAJECTORIES AND USER EXPERIENCES

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Abstract
The UK has set a target for a reduction in CO_2 emissions by 80% by 2050 compared to 1990 levels. The domestic sector accounts for 25% of UK emissions from the generation of heat and electricity for homes. For this sector to move to a low-carbon path, it will need to transform the environmental performance of housing. The transformation will require system-wide innovation and change comprising new technologies, new markets and new institutional supporting systems. There is an urgent research needed to better understand, and therefore, steer this system innovation. The ongoing research project reported here contributes to this need by addressing the impact of the growing raft of environmental regulations on the UK housing development. The primary focus is on microgeneration technology (MGT) field within this sector. This research recognizes that the challenge of integrating MGTs is not merely a technical one for housing developers; rather, it has significant technical, social and economic implications for housing developers and their supply chains, as well as for home buyers.

Keywords: Innovation, diffusion, sustainability, housing, technology.

INTRODUCTION

The UK housing sector has a significant role to play in the UK Governments legally binding target to reduce CO_2 emissions by 50% by 2050 compared to 1990 levels (DECC, 2008). If the CO_2 emissions generated by new homes built between now and 2050 are not curbed then there is a significant possibility that this could offset any progress made in other sectors. In order to induce the UK house building sector to move onto a more sustainable trajectory the Government introduced the zero carbon homes agenda articulated through the Code for Sustainable Homes (CfSH or the Code). The CfSH is coupled to a series of planned changes to the Building Regulations (in particular, Part L) demanding increasingly higher levels of environmental performance, culminating in zero-carbon (yet to be defined) by 2016. CfSH is not mandatory in terms of it prescribes performance thresholds which new housing must achieve, but a rating for new homes against the six levels of the Code is mandatory. However, the changes contained within it are mirrored by the upcoming changes to Building Regulations which are mandatory. In this paper when we describe the changes required under the CfSH and the changes to the Building Regulation which will mandate that the targets and levels of performance specified in the Code are adopted for all new homes. Further, we discuss the early stages of an ongoing research project investigation microgeneration technology innovation systems in the new house building sector.

THE CODE FOR SUSTAINABLE HOMES

In 2005 the case for developing the CfSH was presented by the Government and, following a consultation period, policy was confirmed from 2008 onwards all new homes were to be rated against the CfSH was made (ODPM, 2005). The Code is based upon six levels of performance and assessed against nine different areas. These areas include improvements in building materials and energy/CO_2 emissions but also address waste production, water management and ecology among others. In order to achieve a CfSH home rating of 4* a 44% reduction in CO_2 emissions, based on 2006 Part L Building Regulations requirements, is needed (CLG, 2006). The precise definition of zero-carbon is still be determined (*** ZCH report reference ***). The expression of emissions target as a percentage reduction has been identified as potentially confusing (Zero Carbon Hub, 2010). In order to make requirements more explicit a carbon compliance measure has been adopted. The carbon compliance measure expresses emissions as a measurement of kilograms of carbon dioxide produced per metre squared of internal floor space per annum ($kgCO_2/m^2$/year). This means that the CfSH home ratings of 4*, 5*, and 6* dwelling described above can be expressed in absolute terms of 20, 14 and 0 $kgCO_2/m^2$/year emissions respectively. A dwelling complying with the 2006 Part L Building Regulations would be expected to emit typically 25 $kgCO_2/m^2$/year. Currently all new homes are required to be 4*. By 2013 this will be increased to 5* and by 2016 further increased to 6*.

The sources of CO_2 emissions from the home are not evenly distributed. Typically 55% of the emission emanate from space and water heating, 28 % from appliances and the remainder from cooking, lighting, pumps and fans (NHBC Foundation 2009a). The challenge of reducing emissions resulting from space and water heating are distinct from those of reducing emissions from the other sources and the strategies for tackling them are correspondingly different (Zero Carbon Hub, 2010). Emissions from heating water and space can be reduced through better specified materials, improved workmanship in the construction of the dwelling and more efficient boilers. They can be further reduced by the use of heat recovery systems and a range of technologies such as air and group source heat pumps, biomass and potentially combined heat and power units. Once emissions from heating have been reduced offsetting the emissions stemming from the other sources, and any remaining emissions from heating, relies on the active generation of energy on- or off-site. The potential for onsite generation at a dwelling level depends on dwelling type. For example, the use of photovoltaic cells to generate electricity, for example, depends significantly on, among other factors, the area of roof space available per unit. This area is much higher in detached houses that it is in high rise apartment blocks. Different solutions may be more appropriate for sites with greater dwelling densities compared to sites with lower densities. Solutions may also be targeted at a community level (for example a biomass fuelled CHP unit) or, alternatively, off-site renewable generation. The use of off-site renewable generation to offset the emission generated on-site is termed an allowable solution within the CfSH. The exact nature and extent of the use of allowable solutions when meeting the emission targets set in the Code have not yet been specified.

To reiterate, the exact specification of a ‘zero carbon’ home is still developing. The definition of the carbon compliance level has helped. However, the lack of clarity surrounding the meaning of zero carbon, coupled with the unknown nature and extent of allowable solutions, creates a very uncertain business environment for house builders at the very time they are being asked to invest significant resources into developing new design and

production approaches. Indeed, the scale and scope of the challenge is such that it will require system-wide innovation in terms of new institutional arrangements, technologies and markets. To further compound this situation a great number of different technologies are competing to penetrate into the housing sector and provide a solution to lowering carbon emissions. The NHBC Foundation review of microgeneration technologies has 11 separate groups of technologies, many with multiple formats within each (NHBC Foundation, 2009b). No single technology will be appropriate for all situations. In combination, the uncertainty generated by the number of new technologies available and the lack of clarity regarding the meaning of zero carbon presents a very real commercial risk to the house building industry. The next section draws upon the technological development literature to provide a theoretical basis for understanding the potential dynamics at work as the new house building sector selects, absorbs and uses new, in this case microgeneration, technologies.

TECHNOLOGICAL DEVELOPMENT – KEY ISSUES FROM THE LITERATURE

Technological development within firms and sectors can follow two principal paths; either, multiple small, incremental improvements in products and processes, or through rapid, disruptive changes. Tushman and Anderson (1986) present a model of technological change where long periods of incremental change are punctuated by technological discontinuities. These punctuations are followed by periods of great uncertainty termed the era of ferment. In this period there is no dominant technology and a greater amount of competitive uncertainty. The emergence of a dominant technology reduces the competitive uncertainty and concludes the era of ferment. We speculate that the UK housing sector has entered into such an era of ferment with regard to microgeneration technologies. House builders are unsure which of the technologies, or group of technologies, are likely to assert themselves as the dominant way of achieving the energy saving and onsite generation required in the CfSH.

Dominant technologies emerge through a combination of both disruptive and incremental changes. The opening of the market through disruptive changes allows the entry of radical new technologies which have the potential of significant performance and/or cost benefits over the existing technologies. These technologies are often not proven and learning has to occur to exploit them – in combination, they create business risks and uncertainty. From the growing number of alternatives one (or perhaps a group) of technologies begin to establish a dominant position within the industry. This technology is then refined over time through a series of smaller, more incremental improvements. Dominant technology evolution is often not based on pure rational choice. A wealth of factors, including political, economic, technical and individual, contribute to the emergence of a dominant technology and its supporting practices.

The construction industry in the UK, particularly the house building sector, is presented as having a low level of internally sourced innovation. A great deal of innovation within the industry is driven by compliance to regulation rather than competition on performance. Using Pavitt's (1984) typology of industries the construction industry would be classified as supplier-dominated. Supply-dominated industries source most of their innovations from outside of their sector and act as carriers for innovations from other sectors. The supply chain of the construction industry is the primary source of product innovations. This is the case with microgeneration technologies. The new technologies will be supplied by companies external to the house building sector. In this environment where supply chains are the primary mechanism of innovation, factors such as marketing, incentivisation and

relationship capital can become even more influential in determining which technology emerges as dominant. Particularly as often the industry is looking to its supply chain to provide a solution to meeting a regulatory requirement and not to differentiate its product through performance.

The challenge of meeting the targets presented in the CfSH has the potential to cause both component and architectural innovations in the standard designs used by the house builders (Henderson and Clark, 1990). Component innovations are changes in individual elements of a design with no changes in the relationships between the components. Architectural innovation is a change in the relationship between the components with no changes in the components themselves. This classification of technologies is useful when considering the affect that microgeneration technologies have on the standard design of a home. Some technologies, such as photovoltaic cells, are 'bolt on' component innovations that demand little change in the standard design. Others, such as ground source heat pumps, may require alternative heating systems within the home, such as under floor heating, which requires different designs and construction processes each with their associates skills, competencies and knowledge.

There is currently no empirical research within the housing sector to support the industry in dealing with the challenge of dominant technology selection. Although it is unlikely that dominant technology selection can be managed in the strictest sense of the word understanding how it can be encouraged and what factors could steer selection would be of immense value. To begin to address this stemming from this work should be a deeper understanding of how dominant technologies emerge with the construction industry, how they gain purchase and traction and breakthrough into the mainstream. The work will provide evidence for the effects of these technologies once they arrive within the industry and how the arrival of these technologies can be better steered and prepared for.

METHODOLOGY

The development and execution of this research has been underpinned and defined by industry and academe working together in an iterative process of coproduction. Throughout this work the research questions, aims and methods have been jointly guided by input from the research staff and from senior representatives with the UK house building sector. For each package of the work discussion papers have been produce and passed between the partners until a consensus has been reached. This method of communicating has been supplemented by regular meetings, phone call and e-mail discussions. The discussion papers have provided the main vehicle for capturing, refining and reaching agreement upon ideas.

The work has been split into two phases and the first phase will inform the development and execution of the second. Phase one focuses on the challenge of identifying and shaping the emergence of the dominant microgeneration technology while phase two seeks to understand more completely how people are accepting, or not, these new technologies into their homes and daily practices.

Phase one approach

Rogers (1995, p.14) developed five criteria which influence the rate at which innovation diffuse, if they do so at all. These criteria are:-

- *Relative advantage* – the degree to which a new innovation is perceived by the housing developer as being better than the previous.
- *Compatibility* – the degree to which an innovation is perceived as consistent with its existing capabilities and the needs of potential users.
- *Complexity* – the degree to which an innovation is perceived as relatively difficult to understand and use.
- *Trialability* – the degree to which an innovation may be experimented with on a limited basis.
- *Observability* – the degree to which the results or the benefits of an innovation are visible to others.

Although it is possible to contest if these criteria are appropriate for the diffusion of process based innovations they do provide a useful framework to analyse the uptake of product based technologies such as microgeneration technologies.

Rogers' criteria were used to inform the development of a web-based questionnaire. The questionnaire contains both open and closed questions to establish both the current use of microgeneration technologies and the trajectory of their use i.e. to establish if the current used technologies are becoming more entrenched within the sector or losing their position to other competing technology. The survey also explores the reasoning behind why one technology is selected in preference to another.

The most difficult aspect of deploying any web-based research tool is control over the sample set. While this remains a challenge several steps were introduced in order to minimise problems generated by inconsistencies in the sample set. Firstly, invitations to participate in the survey were sent by our industrial partners through their contact databases to increase the legitimacy of the work to the participants. Secondly, the first two questions in the survey were used to identify if the respondent was involved in the process of building new homes (from concept through to handover and sales) and if the respondent had previously answered the questionnaire. In the first case those not directly involved in the house building sector were thanked for their time but prevented from answering any further questions. In the second case respondents were directed to a different version of the survey to capture what had changed in their opinions and why since the first time they had completed the survey.

Invitation to participate in the questionnaire was sent to 3,000 individuals involved in the design, construction and sales of new housing. Individuals were selected so as to give an even distribution of participation geographically. Although other criteria could have been used to stratify the sample set this was the most practical and simplest to control across the partners' distribution lists.

In order to maximise response rate the invitation to participate in the survey was sent as part of a wider series of structured communications. One week prior to the survey being released an initial message was sent by the industrial partners through their distribution lists. This message emphasised the importance of a piece of research to raise the legitimacy of the research in the eyes of the respondents. The e-mail clearly indicated the nature of the research, a time line and reinforced the independence of the researchers and autonomy of responses. One week following this initial message the industrial partners sent an invitation to participate in the survey. This message contained the link to the survey and another statement to the importance of the research, an indication of the commitment (i.e. 20 minute web-based questionnaire), a statement relating to informed consent (covering data protection

and research ethics). Following the invitation to participate a reminder message was sent each each following Friday afternoon for 3 weeks. The survey then closed.

Phase two approach

Phase one of the project addresses technology uptake and trajectory. Phase two of the project follows on and engages the same challenge from a different perspective. Meeting the emissions reduction targets set out in the introduction will require individuals to accept and use the new technologies within their homes. This adds another complex dimension to the design of homes. Should designers and engineers design for the optimum technical performance or try to accommodate user's behaviour and practice? Designers and engineers often assume that people use buildings and the technologies in a rational, predictable way that optimises performance. The decision making process of the 'rational user' is driven by logic and reason often rooted in stark performance comparisons and economics. In truth, actual behaviour is often some distance from this 'ideal' decision making and can appear whimsical and difficult to predict. On a daily basis our behaviour is shaped by a plethora of factors including economic, cultural, social and behavioural.

Technologies can and do shape our behaviours and practices. Where we sleep, eat and socialise within the home is often directed by where the kitchen, bedrooms and living spaces are (Shove, 2007). This is not to say that the layout of our homes dictates these practises only that it has a part to play in them. Over time people often change their homes to better accommodate their practices or the practices which they aspire to (for example, put in an extension to accommodate a growing family, reorganise a kitchen to encourage family meals etc.).

This co-evolution of home and practice can be in stark contrast to the challenge laid down by very new, disruptive technologies. In particular, technologies which have specific user behaviour 'scripted' in. These are technologies in which the designers have particular user behaviour in mind and attempts to 'foolproof' against other patterns of use, forcing the user to comply with the technologies intended use. This often leads to the intended benefits of the technology not being realised and its use being 'subverted' or abandoned all together through 'workarounds.'

This phase of the project will deploy an ethnography like approach to study the everyday 'lived in' expereinces of people living in homes encorporating microgeneration technologies. Ethnographic approaches such as interviews, observations and shadowing will be used to build up a detailed understanding of the way in which home occupiers interact with the technologies incorporated within their homes. Detailed study of these interaction will reveal how our sample group affect, and are affected by, these technologies in the context of the environment where the interaction takes place. This approach will provide a narrow but deep, and hence qualitatively rich, understanding of the day to day interactions, both constructive and destructive, which take place with the new technologies entering the home.

The research team will then begin the ethnographic-like study using the following broad plan:-

•Meeting 1 (60 minutes) – establish family/participant background, previous experience of MGTs, dwelling history/background, establish participant's relationship to the 'green agenda' and motivations for living in a low carbon home, brief introduction to the home, capture of 'headline' issues.

•Meeting 2 (60 minutes) – further explorations of benefits and limitations of living in a low carbon home, demonstration of some of the technologies (if possible), identification of supporting or destructive practices (workarounds), identification of modification of behaviours and practices enabled, or not, by MGTs.

•Meeting 3 (60 minutes) – final meeting to expand upon any issues raised in the previous two meetings and to explain to the participants the next steps in the research.

A very important factor for the success of ethnography is access to, and willingness of, the participants to be involved in the project. Access to participants is being provided through the industrial partners on the project. A minimum of three visits to each home will be conducted to build up a relationship between the researcher and participant and to allow trust and confidence to develop. The researcher will aim to be as unobtrusive as possible while guiding the participant to demonstrate and talk about their interaction with the technologies within their home. During this time the researcher will be making observations of the layout, use and interactions with the technologies within the home. Where appropriate the researcher may take images or recordings of these interactions.

The sample set will include up to 20 homes spread across two different locations. The sample set will encompass different home user profiles (families, indivduals, couple etc.), different primary microgeneration technologies and different periods of time living with the new technolgoies.

PHASE ONE UPDATE

A total of six discussion papers, three for each phases, have been written and have been through a series of drafts to reach a consensus on each of the topics covered. The discussion papers have been through 3 to 6 iterations each. This approach had provided a common ground upon which to base conversations and the development of the research methods and strategy.

The broad structure of the survey questionnaire maps onto the theoretical framework set out in Rogers (1995) as detailed in the 'Phase 1 approach' section above. As would be expected, demographic information about the respondent is captured. This information includes details about the individual replying but also the company they work for. We then move on to interrogate which low- and zero-carbon technologies the respondent would consider using in a variety of dwelling and site types (greenfield vs brownfield vs conversion, terrace vs semi-detached vs detached vs apartment). Having established which technologies the respondent would consider using in which situations the respondent's opinions on various factors relating to the low- and zero-carbon technologies are established. These factors broadly map onto the Rogers' criteria and goal will be to investigate which factors are, or are not, important in shaping which technologies are deployed. Up until this point the data collected is set in the present. Having questioned which technologies are used in which sectors, and having looked at which factors appear to have shaped the inclusion of these technologies, the survey then asks about the respondents their opinion of future trajectories. In doing this we hope to identify which technologies are likely to become more entrenched and which less so.

At the time of writing the web-based survey is live and data is being collected. The iterative cycle of co-production deployed in this research has taken time but has led to a robust, industrially relevant research tool. Data collection will be complete by the end of May 2011 and we will report the results in future papers.

The results from this phase of the project should provide a comprehensive picture of the current low- and zero-carbon technology use. The data should illuminate the important factors shaping the selection of which technologies to use and give an indication of which technologies the sector feels are likely to become dominant. This will be of great interest to the house building sector as greater understanding of how dominant technologies emerge within the house building industry provides them with additional information with which to plan and to manage their risks.

CONCLUSION

Although the project it reports on is still very much a work in progress this paper lays out the challenges facing the UK new build housing sector in meeting the requirements of the CfSH. The various levels of the Code and the carbon compliance level are introduced in the context of meeting the Government's carbon reduction obligations. The challenges of both reducing the consumption of energy and of generating energy on-site are outlined framed by the different levels of the Code. Some of the uncertainties in the environment in which the house builders operate, stemming from the lack of absolute definition of zero carbon, the nature and extent of allowable solutions and the number of new to the sector technologies are identified.

The problem facing the industry in correctly identifying which of the different technologies is likely to become dominant is described. This problem represents a very real commercial risk in where to invest in supply chain and skill development, how to design and construct homes which perform reliably and how to market and sell homes which contain microgeneration technology. Phase one of the project, by addressing technological uptake and trajectory, will deepen our understanding of the factors shaping the uptake of technologies in the sector. Phase two of the project will provide a rich, qualitative insight into how microgeneration technologies are accepted into everyday routines and practices.

Phase one of the project will be complete and the data and analysis ready to present at the time of the conference.

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VALUE-BASED DESIGN AND MANAGEMENT OF HOSPITAL BUILDINGS

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Abstract

The purpose of this paper it to explore the concept of adding value by real estate and related performance indicators, and the way it is or could be applied in value-based design and management of buildings. The concept is being illustrated with research findings on hospital buildings, based on a literature review and ten interviews with CEOs and real estate project managers. The research findings show that different hospitals prioritize different added values, depending on their overall mission and vision, its position in the real estate life cycle, and the local context. On average, stimulating innovation, improving satisfaction of customers and employees, and supporting (change of) culture rank high, whereas risk management and opportunities to get the real estate costs financed are much less prioritized. A number of added values have been concretized in real estate interventions that are supposed to cause a positive effect on organizational performance, e.g. with regard to patient satisfaction, labor productivity, flexibility and cost reduction. The conceptual framework and research data can be used to support complex decision making in briefing, design and management of hospital buildings and other health facilities. The explorations of adding value by real estate might be applicable in other sectors as well.

Keywords: added value; stakeholders; strategy; performance; hospital real estate.

ADDING VALUE BY REAL ESTATE

Corporate or Public Real Estate Management is usually defined as the management of the real estate portfolio of a corporation or public authority by aligning the portfolio and services to the needs of the core business, in order to obtain maximum added value for the business and to contribute optimally to the overall performance of the organization (Dewulf et al. 2000). Several authors have tried to operationalize the concept of added value, starting with a definition. With reference to the well-know VAT-rate – focusing on the economic value added (EVA) – Van Wagenberg (2009) defines value added as: "*the difference between the value of the product/services delivered to a client during a period (value of output(s) in period Δ t1 – t2) and the value of the input(s) in the production function - or functions in the case of a supply chain - in the same period Δ t1 – t2.*"

Per Anker Jensen, Professor in Facility Management at the Technical University of Denmark in Copenhagen, defines added value as the ratio between added use value and costs (Jensen 2009). In a follow-up paper (Jensen et al 2010) this formula is extended to:

User value = Quality & Process / Price & Difficulties.

In the field of relationship marketing, Sarshar and Pitt (2009) present a similar definition for customer value or customer value ratio:

$$\textit{Customer value} = \frac{\textit{Results produced for the customer + service process quality}}{\textit{Price to the customer + cost and effort in acquiring the service}}$$

The definitions so far define added value as a ratio between output and input in connection to the difference between the output and input in a certain period of time Δ t1 – t2.

In the field of corporate and public real estate management the concept of added value is usually linked to the numerator and much less to the denominator. For the study presented here we have build on the work of Nourse and Roulac (1993) De Jonge (2002), Lindholm and Levainen (2006), Lindholm (2008), De Vries et al (2008) and Jensen (2010). All authors use different lists of possible added values. Based on similarities between these references, the added value of real estate can be defined as the contribution of real estate to organizational performance by its contribution to nine fields of performance (Table 1).

1. Reduction of real estate costs during the life cycle (investment costs, operational costs) by steering on efficient space use and smart design.
2. Improvement of (labour) productivity, e.g. by supporting logistics of primary processes and short walking distances between related functions.
3. Improvement of user satisfaction by steering on a functional, comfortable and pleasant working environment, taking into account user needs and preferences
4. Improvement of possibilities to get real estate financed by external parties, e.g. by regarding real estate as an asset to improve the overall finance position of the organization or an assessment of the (future) marketability of the building
5. Improvement of flexibility to enable future spatial, technical, organizational or juridical adaptability, e.g. by standardization, simple opportunities to extend the building or easy adaptability to other functions.
6. Support of a positive corporate image, e.g. by a nice overall building appearance and an appropriate building lay-out
7. Stimulation of innovations in order to improve business processes, e.g. by creating formal and informal meeting space to exchange ideas
8. Supporting (change of) corporate culture, e.g. by sharing work spaces to support social interaction
9. Risk management with regard to time, costs, health and safety, and coping with a changing context, e.g. technically by application of strict safety standards or juridical by short term rent contracts

Table 1: *Nine fields of adding value by real estate defined from literature*

Both from an academic point of view and to be applicable in decision making processes in practice, these nine fields of impact of real estate on organizational performance have to be elaborated in connection to available resources and limiting conditions. An ongoing PhD-research into healthcare real estate strategies in a changing context offered an opportunity to further exploring the concept of adding value by real estate in the health sector (Van der Zwart *et al*. 2009).

HOSPITAL REAL ESTATE IN A CHANGING CONTEXT

Due to the changing juridical and financial context of hospital real estate design and management, adding value management by hospital real estate is an interesting research area. In the last decade the government transformed the old budgetary system into a so-called regulated market system. In the former system the proposal for a new hospital building or renovation of an existing building had to be approved by the government to fit with the planning regulations (number of beds per 10,000 inhabitants), space criteria (maximum number of square meters per bed, functional performance requirements per function), and cost regulations (maximum budget for investment costs per square meter). After approval all building related capital costs and running costs were guaranteed by the government and paid by the insurance companies during the life-time of the building, independent of healthcare production. In the so-called February-letter of 8 March 2005, the Dutch Minister of Health, Welfare and Sports announced the replacement of this budget system by a regulated market system.In the new system not the government but the healthcare organizations themselves will be responsible for a sufficient return on real estate investment – by proceeds from health care delivery - and the consequences of real estate decisions on utility value, investment costs and running costs. “Deregulation” gives healthcare organizations more freedom in briefing, design and management of hospital buildings, but makes them more risk-bearing as well. The main objective of replacing the centrally directed real estate budget system - with governmental ex ante testing of building plans and investment proposals - by a performance driven finance system - with governance on the output - is to stimulating competition and reducing healthcare costs.

As a consequence of their new responsibilities, hospital organizations have to consider more carefully the costs and benefits of different real estate choices and how real estate can add value to organizational performance. Benefits such as creating a healing environment, improving employee satisfaction, or supporting labour productivity and image have to be weighted against the impact of real estate decisions on the costs of health care delivery and real estate life cycle costs. Political decisions, demographical and economical developments, innovations in medical technology and a continuously changing market of demand and supply are all part of a dynamic and unpredictable context, whereas healthcare real estate decisions have a long term impact. The constantly changing context with new opportunities and risks and the involvement of a growing number of stakeholders necessitates to changing traditional hospital real estate management into a more businesslike and integrated approach. Although most healthcare organizations are aware of the necessity to change, many of them lack sufficient knowledge and tools to steer on the added value of corporate real estate in connection to organizational performance.

For this reason a study has been conducted to explore answers on three questions: a) (How) do hospital managers e.g. the CEO or project managers take into account adding value by real estate in hospital real estate design and management; b) What are present priorities in value based real estate design and management? c) Which accommodation choices are guided by (perceived) adding value by real estate?

RESEARCH METHODS

Data have been collected by interviewing CEOs and real estate managers of ten hospitals in the Netherlands. In order to select appropriate respondents, first a list was made of hospitals that recently were or currently are building or designing a new hospital (period 2004 – 2012).

This list has been presented to experts in the field and has been updated when the respondents mentioned other hospitals that are initiating a new building process. This resulted in a list of approximately 20 hospitals. Then a selection of cases has been made in search for heterogeneity on three characteristics: 1) general, top clinical and academic hospitals; 2) size in number of beds and turn-over; 3) position in the building process i.e. initiation, briefing, design, construction, or use (Table 2). This makes it possible to explore if the type of hospital, size and phase in the real estate life cycle affects (priorities in) value added management.

	place	code	category	size	beds	m2	phase	respondent
Gelre Ziekenhuis	Zutphen	GZ	general	S	217	26.500	use	CEO
Gemini Ziekenhuis	Den Helder	GD	general	S	244	25.000	initiation	manager
Vlietland Ziekenhuis	Schiedam	VS	general	M	421	55.000	use	CEO
Deventer Ziekenhuis	Deventer	DD	top clinical	M	390	55.000	use	CEO
Reinier de Graaf Gasthuis	Delft	RD	top clinical	M	397	55.000	initiation	manager
Albert Schweitzer Ziekenhuis	Dordrecht	AD	top clinical	L	475	n.a.	construction	manager
Meander MC	Amersfoort	MA	top clinical	L	600	75.800	construction	manager
Maasstad Ziekenhuis	Rotterdam	MR	top clinical	L	620	84.000	construction	CEO
Erasmus UMC	Rotterdam	ER	UMC	XL	1320	n.a.	construction	manager
UMC Groningen	Groningen	UG	UMC	XL	1097	n.a.	use	CEO

S = small; M = medium; L = large; XL = extra large

Table 2: *Characteristics of the cases*

The selected cases represent approximately 10% of all Dutch hospitals and 50% of all Dutch hospitals that were/are planning or building a new hospital in 2004-2012. The selection includes three general hospitals, five top clinical hospitals and two academic hospitals. With regard to the number of beds, the case selection includes two small size hospitals, three medium size hospitals, three large hospitals, and two extra large academic hospitals due to the integration of research and education facilities in the real estate portfolio. Two hospitals were in the initiation phase and four hospitals were constructing the building at the moment of the interview. Four hospitals concern new buildings-in-use in the exploitation phase. Half of the interviews were conducted with CEOs, and half with the real estate project manager of the hospital. In advance, available information and documents on the internet were studied in order to get a first impression of the hospital, its mission and vision, and main real estate objectives.

The semi structured interviews consisted of two parts: an open interview where respondents were asked which values were or are taken into account in the real estate decision making process, and a structured interview where respondents were asked to prioritize nine added values found in the literature. The values spontaneously mentioned in the first part may be indicators of managers' awareness of possibilities to add value by real estate. In the second part the nine added values derived from literature were presented on little cards in a matrix with 3 rows and 3 columns (see Figure 1). The ranking of added values occurred in three steps. First respondents were asked to prioritize the three added values in each row. Second, respondents were asked to rank the three added values per column on least importance. In these two steps the respondents were made familiar with the added values used in literature in order to be able to prioritize all of them in the third step. After this ranking assignment, the respondents were asked how these added values are visible in the (design of the) hospital building. After the interviews transcripts have been made of the recorded interviews. These transcripts were summarized and sent back to the respondents for feedback.

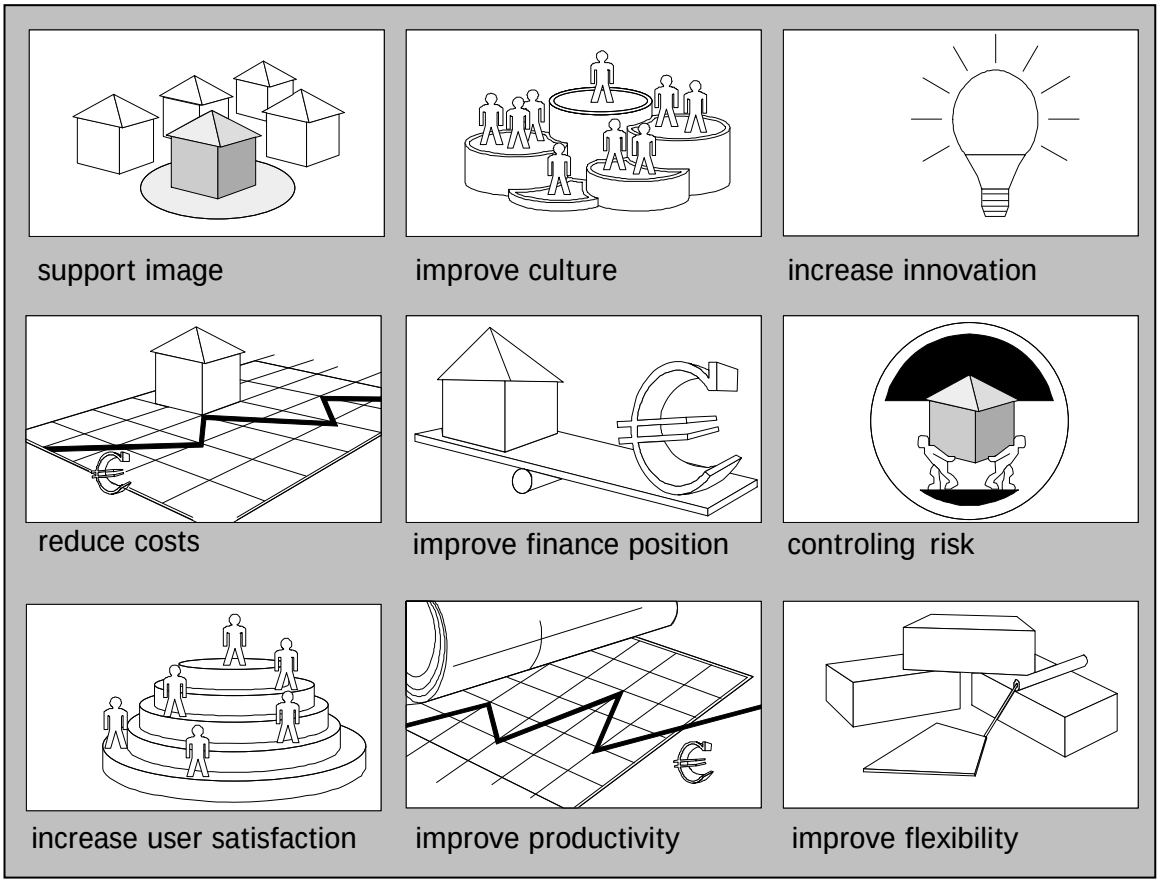


Figure 1: *Nine added values of real estate positioned in a matrix*

RESEARCH FINDINGS

The presentation of the research findings follows the three steps of the interview i.e. a) A summary of the responses to the open question for the main objectives of real estate investment decisions made in the past years, plus textboxes with brief characterizations of specific cases, based on the interviews; b) A cross-case analysis of prioritized values, from 1 (highest) to 9 (lowest); c) Accommodation choices supporting adding value are brought together by decoding the transcripts on the nine previous defined fields of adding value by real estate.

a) Value based hospital real estate management

The first priority of hospitals is to deliver good healthcare in a cost-efficient way. Real estate is secondary but at the same time an important resource to reach the organizational objectives and to optimally facilitate healthcare processes. Being a resource for production, real estate should always be judged upon its contribution to business processes and business economics. Supporting the primary process also means that the building should be comfortable. On the one hand the building should support patient's needs and wellbeing. On the other hand the building should be a pleasant and productive working environment for the healthcare professional.

In most cases, supporting efficient healthcare processes showed to be in the core of real estate design and management on building level. Much attention is being paid to efficient logistics of patients, health care processes and transport of people and goods. In spite of the widely

used motto “the patient is central”, most hospitals focus on efficient healthcare process, because it also benefits the patients if processes are well connected and as such supports both customer satisfaction, labour productivity and employee satisfaction.

Deventer Hospital, Deventer
The building should facilitate the healthcare processes in such a way that the building meets the organization’s objectives on the first day the hospital opens its doors. Besides, the building must be flexible in order to support business processes for a period of 40 years and to be able to cope with changing visions on healthcare delivery. The building concept is based on the vision that healthcare processes include four different patient flows: acute, urgent, elective, and chronicle. This resulted in a process based building with a focus on logical connections between medical healthcare processes.

Furthermore all cases show a connection between the organizational strategy and the real estate strategy. In most cases possibilities of the current real estate portfolio as well as the desired future supply is taken into account in the real estate strategy. Often organizational objectives such as transparency and appropriate healthcare are translated in the architecture of the building. But a strict translation of the organizational mission, vision and ambitions in architecture is also mentioned to be difficult because of the long planning and construction time – often 10 to 15 years - and 40 years of exploitation afterwards. In the mean time the organization will change several times its management structure and style, objectives, vision on optimal organization of healthcare processes etc. Therefore, flexibility is often mentioned as an important criterion of adding value by real estate. Flexibility should enable the hospital building to support the healthcare processes at least 40 years in changing circumstances.

Meander Medical Centre, Amersfoort
First a Long Period Accommodation Plan was made to formulate a real estate strategy. This strategy consisted of a renovation of the existing hospitals to support the use for another 10 to 12 years and in the mean time designing and constructing a new hospital on a central location. All complicated top clinical cure was centralized in the new hospital building. Besides, a regional hospital was renovated and converted into a day care hospital and four policlinics were initiated in the region. The central building is divided into three parts: 1) a hot floor with all high technical functions; 2) nurseries with standard one-person bedrooms, and; 3) multifunctional examination rooms, all with different technical installations and constructions and different access to patients. Flexibility is realized by expandability, adaptability and exchangeability of rooms.

Because of the new financing system that makes payment of investment and running costs dependent of the production in terms of diagnosis-treatment combinations, the usual starting point is very businesslike: no more square meters then necessary and life-cycle-costs as low as possible. The hospitals that initiated a new building after the introduction of the new regulation showed a shift of directing on maximum capacity and quality towards steering on less capital expenses and increasing productivity. These hospitals are designed and constructed on the basis of a business case and pay much attention to create a compact building with a little surplus square meters to enable future production growth, low capital costs and a high level of flexibility. Slim fit buildings are accompanied with extendibility in the future. These extensions are subject of a new business cases to be presented to financiers. The planning and construction period decreased from the usual 10-15 years to 4-5 years.

Gelre Hospital, Zutphen
From the moment of the first initiative, it was known that the building had to be financed on own risk, reimbursed by healthcare production. Therefore, a business plan was presented to financiers. Starting point of this business plan is to steer on as low as possible capital costs in order to gain competitive advantage with regard to the costs of healthcare products and services. This is accomplished with a cheap, functional and lean building with little surplus square meters and a focus on flexibility to anticipate on future alterations. Also typical for this project is the short period of totally 4 years from initiative to design and construction.

Since the introduction of the regulated market system, a growing awareness of the market position of the hospitals becomes visible. Most hospitals are part of a larger network with one central location with all complicated top clinical healthcare combined, and several day care hospitals and policlinics in the region. The peripheral locations demarcate the service area of the hospital and have to ensure that patients chose for this specific hospital and only go to the central hospital if top clinical cure is necessary.

b) Priorities in adding value management

The results of prioritizing nine added values by CEOs and project managers of ten hospitals are presented in figure 2. The horizontal axis is scaled from 1 = highest priority to 9 = lowest priority according to the respondents. The nine added values are presented on the vertical axis of the diagram. Horizontally next to these added values the priority ranks are plotted of all interviewed hospitals with their names abbreviated according to table 2. When two or more added values were given the same priority, these added values received the same average rank. The dashed-lined boxes cluster the most given answers, usually showing a maximum of three exceptional ranks per added value. The vertical lines show the average ranking per added value. The bold abbreviations show the hospitals with a median ranking for that particular added value. The added values on the vertical axis are ordered from the highest median rank (above) till the lowest median rank (below).If two added values share the same median, the average was used to choose the priority rank.

Figure 2 shows that on average supporting innovation, increasing user satisfaction and improving the organization's culture are given highest priority. Cost reduction is highly prioritized by four respondents, but ranked as not that important by five other hospitals. Because of this variety, the average rank is not very representative to express the different thoughts. Increasing productivity, optimizing flexibility and supporting corporate image are prioritized in the middle. Risk control and increasing financing possibilities are usually given low priority.

One hospital (GD) ranked the priorities of the nine added values almost opposite to (clusters of) most other answers. This hospital is currently planning a new hospital according to the so-called living building concept (LBC), a new form of Public Private Initiative.

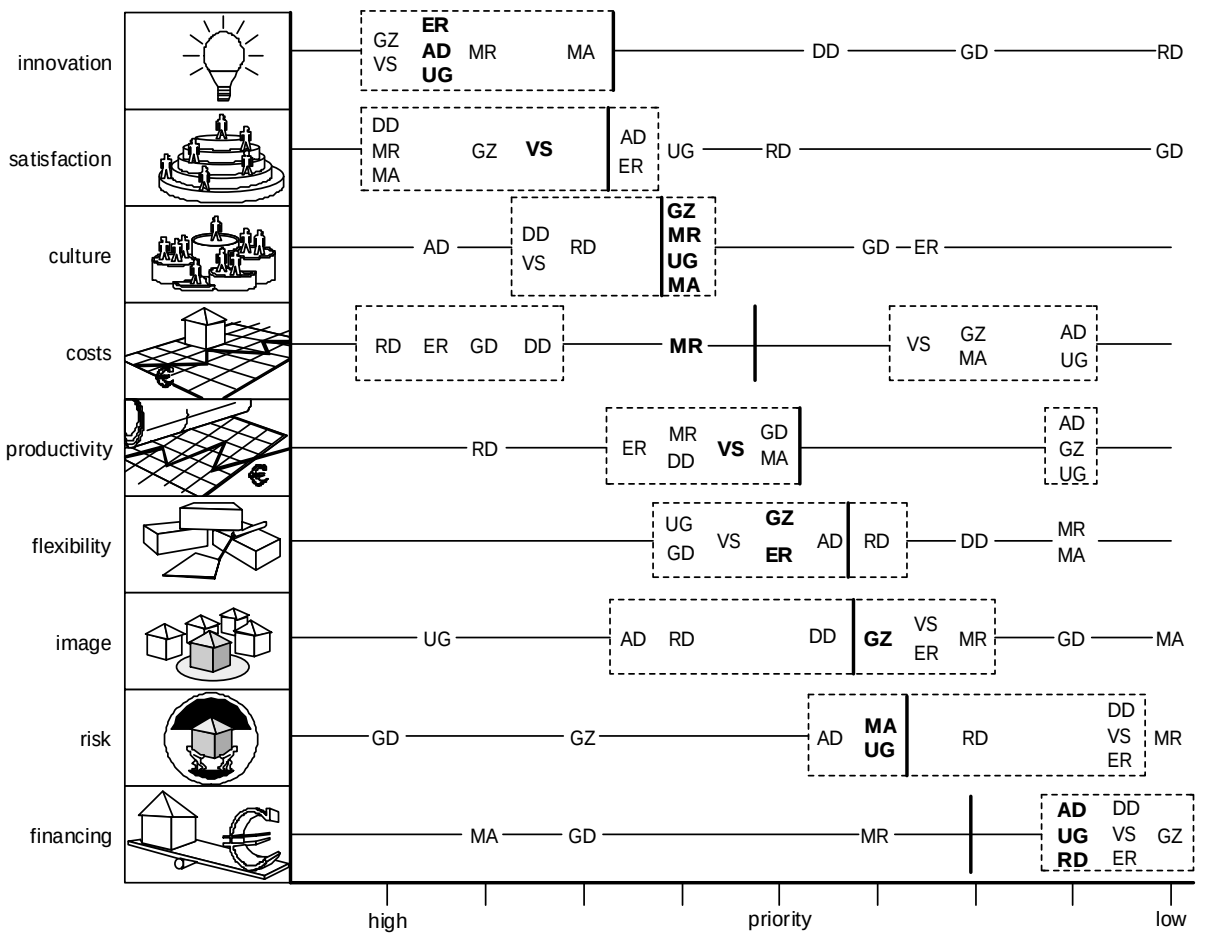


Figure 2: *Plot diagram of ranking prioritized real estate added values*

c) Accommodation choices supporting adding value by real estate

When hospital managers are asked to elaborate on the connections between real estate characteristics and organizational performance, different answers come up. But the responses have also much in common. The overall picture can be summarized as follows.

1. Cost reduction

Due to an ever growing demand for (expensive) health care and a shortage of financial resources, policy makers and hospital managers pay much attention to cost effectiveness and opportunities to reduce real estate costs. Since the introduction of the regulated market system directing on the reduction of life cycle costs and total costs of ownership has become more and more important. Elaborating a business case to make costs and benefits transparent both in the short and long run has become normal practice now. Real estate measures to stimulate cost reduction include co-operation in building, design and management of hospital real estate with other care organizations and commercial parties, new ways of contracting such as Design and Build, or DBFMO (Design-Build-Finance-Maintain-Operate), strict space budgeting, space reduction by shared workplaces and extension of opening hours, and sustainability measures in order to reduce energy consumption. Quite often extra investments are needed to reduce the life cycle costs of the building (e.g. investing in flexibility) or staff costs (e.g. extra lifts to reduce walking distances).

2. Increasing productivity
This added value is usually interpreted as production (output) and less as a ratio between output and input. Real estate choices to support production included:

- Optimally facilitating of medical care processes and supporting activities, e.g. by spatial clustering of top-clinical care processes, urgent care, patients with acute diseases and patients with chronic illnesses, or a thematic clustering of heart diseases and vascular diseases, oncology, mother and child.
- Well considered location of operation theatres.
- Location of units with a high flow rate near the entrance to avoid unnecessary patients flows within the building.
- Sound logistics of transport (beds, bedclothes, food, medical facilities) by a separation of transport of goods and patient flows, use of advanced transport systems, and well considered distribution points.
- Easy and place and time independent access to (digital) data.
- Extension of opening hours and operating time.
- An attractive indoor climate and indoor air quality in order to avoid absence by building related sickness ("sick building syndrome").

The impact of one bed rooms on labour productivity is a little ambivalent. On the one hand one bed rooms evoke fewer infections and speed up the healing process that might shorten the average stay in hospital. It also avoids problems of empty beds due to difficulties in mixing people with different cultural backgrounds or different gender. On the other hand a high percentage of one bed rooms can be counterproductive because of nurses have less overview and because of longer walking distances.

3. User satisfaction
This added value may be split up in satisfaction of consumers (potential customers of the hospital), customers (people that come to the hospital to visit a patient) and patients on one side and staff on the other side. Most respondents emphasize that good staff people with excellent medical skills and a customer-friendly attitude and behaviour are of utmost importance. But well considered real estate decisions can be supportive as well, e.g. by:

- Creating an attractive and functional "healing" environment where people feel at home: easily accessible, with a clear structure so that people can find their way easily, much daylight, a nice outside view, an attractive indoor climate, being able to make use of a one bed room (preferred by most patients but not all of them), and a high quality of semi-public spaces such as entrance halls, waiting areas and patios.
- Optimally facilitating medical care processes by steering on a lay-out that fits with the way cure and care are being organized and short walking distances between related functions.
- ICT-facilities (flat screens for watching TV/ information, internet) and catering services.
- Well organized communication and user participation in decision making processes.

4. Increasing opportunities to get the capital costs and operating costs financed
This added value is being stimulated by the involvement of external parties that rent space in the building or on a so-called health care boulevard or health park, leading to a sound business case. Other options are private public partnerships in owning the building, and steering on future value of the building by adaptability and marketability. Academic hospitals seem to have fewer problems in financing their real estate because they still get a separate budget for real estate investments and they can borrow money at a quite low interest rate.

5. Optimization of flexibility and adaptability
Flexibility is a key issue in hospital design for decades. All respondents include flexibility in their real estate policy and real estate management. Standardization, multifunctional use of space, a clear separation between the supporting structure and fill-in because of their different life cycles, extra power of load-bearing walls and floors in order to cope with future functions, easy-to-adapt bed rooms (from a two bed room in two one bed rooms and vice versa), facilities that make an enlargement of the building easily possible, all kind of measurements are more or less common sense nowadays. A more recent concept is the functional zoning plan. By spatial separation of the hot floor (high tech facilities such as the operation theatres), the fabric (labs), the hotel function (bedrooms) and office activities, hospitals aim to make part of their buildings more courant and as such easier marketable when the hospital want to shrink or to move to another place. One of the hospitals built the hot floor in a special zone and left the adjacent space vacant, so that in case of the hot floor becomes outdated a new one can be added easily while the present keeps going during construction. However, thinking in scenarios in search for spatial and financial implications of future developments is not very common yet.

6. Supporting a positive image
Marketing by real estate is merely managed by steering on a nice and easy to access location in a lively and safe environment, a nice overall appearance, an attractive "healing" environment with a high percentage of one bed rooms, nice colours and materials, light and transparent, and nice facilities, in order to improve patient satisfaction and as a consequence to improve competitive advantage. Attractive and professional staff facilities may help to attract and retain staff people. Quite often semi-public spaces are open for use by people from outside, to reduce the image of an inner directed medical environment. Some respondents emphasize that a hospital should primarily focus on its patients by creating an environment "where it is allowed to be a patient" and not feeling awkward when walking in pyjama wit a drip at hand.

7. Stimulation of innovation
This added value needs a similar real estate policy. Innovation requires individual creativity and team creativity. Creative thinking can be facilitated by opportunities to relax and to concentrate and places that support exchange of knowledge and stimulate new ideas. Most hospitals create meeting places such as a knowledge centre, study centre, or skills lab. Another real estate intervention to stimulate innovations is the spatial integration of different types of cure and care, but the present financing system could with separate money streams is mentioned to be an obstacle here. ICT is also used as a tool to innovating processes, e.g. by the use of information devices or application of a digital system to reduce waiting times. Medical-technical innovations may affect real estate as well, for instance by changing space requirements due to remote care, E-consults and new medical equipment.

8. Supporting (changing) organizational culture
Though culture is merely a matter of shared values and behavioural rules focusing on high quality care, reliability and customer-friendly behaviour, (changing) culture can also be supported by real estate. Most often hospital managers try to do so by creating more openness and informal meeting facilities, facility sharing and hot desking, in order to stimulate communication and to make different ways of behaviour or different attitudes a subject of open discussion. Another option is to create a front-back office with a different atmosphere.

9. *Risk control*
This added value is least discussed and also mainly managed by real estate choices improving flexibility and marketability, a well elaborated business case, outsourcing of maintenance for a long period, and reduction of risks of infections by smart hygiene measures and more one bed rooms.

DISCUSSION

The qualitative approach of this research – using semi-structured interviews with open questions – delivered much information on how real estate added values are perceived by hospital managers and how they are prioritized in hospital real estate decision making. The results contribute to a better understanding of adding value by real estate and the values mentioned in literature, in general and specifically for the healthcare sector. Although quantitative concepts have been used to summarize and interpret the research findings - modus, mean, average, a plot-box - these results should be regarded as qualitative data as well. As the priority diagram (figure 2) is a representation of only ten separate configurations, this diagram is not more then a first exploration of (clusters of) priorities. The validity of the results can be improved by conducting more interviews and organizing expert meetings to discuss and compare individual rankings. The same methods could be applied in other sectors like office organizations or higher education in order to explore similarities and dissimilarities in different fields.

Though hospital real estate is being regarded now more and more as a resource for production, a remarkable difference shows up between the answers on the open question and the prioritizing assignment of added values in the more structured part of the interview. In response to the open question to mention values that are steered on in design and management of hospital real estate, most respondents mentioned facilitating the primary processes and supporting productivity as the main objectives. Confronted with added values of real estate mentioned in the literature, the main real estate objective seems to shift from process oriented priorities towards the contribution of real estate to organizational strategic objectives such as stimulating innovation, improving culture and increasing user satisfaction. Whereas in the open interview flexibility is often mentioned as an important added value, in the ranking assignment this issue is never given a high priority, probably because it is already a common issue in real estate management for decades. Cost reduction shows to split the interviewees in two groups. Part of the respondents ranked cost reduction in the top of highly prioritized values, whereas others give this issue low priority. Although in the open interview most hospital managers call cost reduction a basic issue in most real estate decisions, in particular since the new healthcare real estate regulations, cost reduction gets median priority, just like productivity and flexibility.

The configuration of cards ranked by the CEO of hospital VS (figure 3) represents more or less the average ranking of all respondents. This hospital has been built under the former hospital real estate regulation and is now in the exploitation phase of the building process. This ranking shows stimulating innovation as top priority of adding value. Two other values - improving user satisfaction and improving organizational culture - are ranked second highest priority. Then two columns are recognizable (and also described as such by the CEO while sorting the cards). The three added values at the left were connected to the process: increasing productivity; decreasing real estate costs as a means to decrease the prize of healthcare products and services, and controlling real estate risks related to the production process. The three added values at the right side are more building related values: optimizing flexibility;

supporting corporate image, and increasing finance possibilities. According to this CEO these values were captured in the building design, and as a consequence adding value management with regard to these issues is less possible in the exploitation phase.

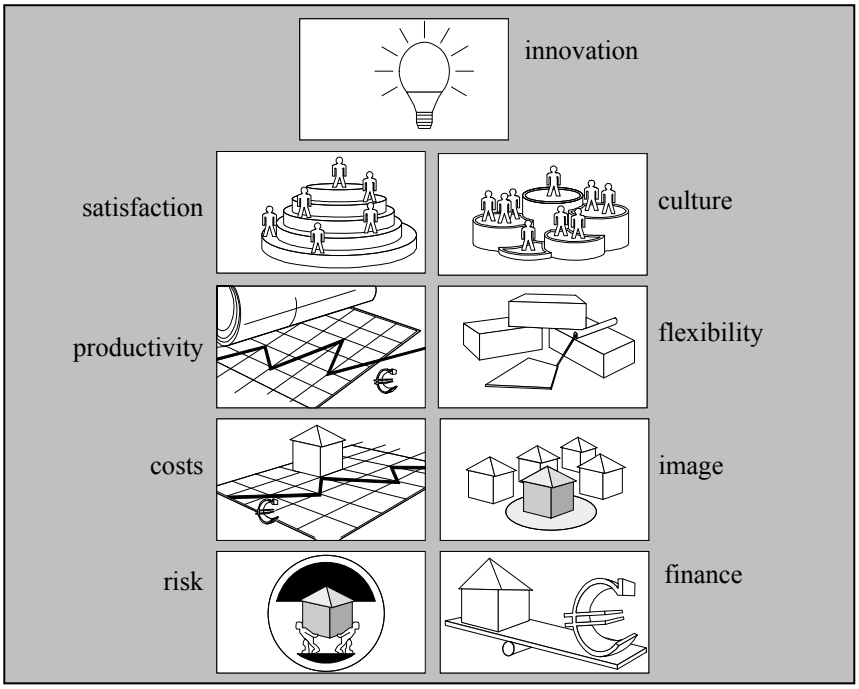


Figure 3: *The most 'representative' result of the ranking assignment*

Both the overall results of the priority ranking assignment (figure 2) and the "representative" configuration (figure 3) show some clusters of prioritized added values that seems to be connected to the widely used triplet of people-process-place (Duffy, 1992). The top three of prioritized added values by the respondents are stimulating innovation, increase user satisfaction and improving corporate culture. These three added values of real estate contribute to organizational performance with regard to '*people working together, in a smart way organizing things efficiently*' as one CEO mentioned in the interview. The second cluster of added values includes cost reduction, increasing productivity and optimizing flexibility. These three added values all contribute to the (production) process of healthcare services and the prizes of these products and services. A flexible hospital building makes it possible to adjust real estate to improve productivity and capital cost reduction reduces prizes of health care products and services. As one CEO mentioned: *'Maybe it is not that surprisingly that improving productivity is in the middle of this configuration, some added values are enablers and contribute to a higher productivity, others are more the result of an increasing productivity (ablers).'* The third cluster of added values - contributing to corporate image, controlling real estate related risks and improving finance possibilities - are more directly related to the real estate portfolio, as it appears in the concept of place. As one CEO mentioned in the interview: '*Contribute to corporate image or finance possibilities are strongly related to the location and appearance of the hospital building. I can imagine that it becomes important that a hospital is located in the city centre, but otherwise it is less important as a real estate objective.*'

In the interviews some other added values of real estate came up, in particular its contribution to a sustainable and healing environment. Usually sustainability is not perceived as a main objective of health care organizations, but as a necessity to cope with societal needs, now and in the future, and as a means to show corporate social responsibility. Most respondents admit that sustainability measures are applied only when the extra costs have a reimbursement period of less than 5-10 years. Of course steering on a healing environment is of utmost importance in health care and cure. Though not explicitly presented as one of the nine added values, it is implicitly included in improving satisfaction and supporting productivity. It seems to be more appropriate to add this value to the list as healthcare specific real estate added value. By adding sustainability as a particular value, as Den Heijer (2011) did in her dissertation on Managing the University campus, rankings in the health care sector may be better comparable with ranking in other fields.

CONCLUDING REMARKS

This research is a first exploration of adding value by real estate in the field of health care. Additional research is needed to improve our understanding of a) which real estate interventions will positively affect organizational performance; b) interrelationships between the performance indicators; c) synergy or conflicts between values; d) clearness and completeness of the list; and e) how does the concept of added value and its different aspects appeal to decision makers. It is well known that managing flexibility and standardization may conflict with other values such as low investment costs and efficient use of space. The need for much daylight may cause high cleaning costs and conflicts with the need for a reduction of CO2 emission. A review of current research in depth with a focus on only one possible added value of real estate - such as labour productivity, employee satisfaction or future marketability – will be one of the next steps. Furthermore the results of interviews will be linked to building assessments in a number of case studies, including floor plan analysis and analysis of documents such as the brief and corporate strategies.

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LEADERSHIP IN CONSTRUCTION ORGANIZATIONS AND THE PROMOTION OF SUSTAINABLE PRACTICES

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Abstract
The construction industry is a very important sector in achieving society's sustainable development goals; however the change towards sustainability is a process that presents a leadership challenge. Construction organizations need leadership that provide the collective vision, strategy and direction towards the common goal of a sustainable future. The aim of this paper is to critically examine the role, drivers and factors affecting leadership in the effective implementation of sustainable practices in construction organizations. A review of relevant literature and preliminary qualitative results from an in-depth interview with eight (8) leaders in United Kingdom construction consultant organizations, including sustainability directors, managers and consultants is presented. The analysis of the collected qualitative data revealed that, the leadership role in promoting sustainability in construction organizations include the development of strategies and the formulation of policies. A major driver for construction organizations to pursue sustainability is to win more business, while increased capital cost for sustainability is still a major challenge to many organizations. This study establishes the basis for further investigation in an on-going doctorial level research on the role of leadership in promoting sustainable construction practices.

Keywords: Construction organization, leadership, leadership style, sustainable practice

INTRODUCTION

Leadership is vital in the construction industry and a key success factor in the drive towards sustainability (Ofori and Toor, 2008). Construction organizations need leadership that provide the collective vision, strategy and direction towards the common goal of a sustainable future. Leaders should embed sustainability in their organizational activities and make sustainable development part of their overall business strategy. It is important that such leaders have both the ability as well as the sustainability knowledge to effectively guide their organizations strategically towards sustainability.

The role of leadership in improving the performance and innovation in the construction industry has been receiving increasing attention in recent times (Bonssink, 2007). However, less attention has been given to the capability of organizational leadership in promoting construction organizations towards the delivery of sustainable construction projects. There is extensive literature on the subject of sustainability and leadership as separate entities; however, little has been written about the link between leadership and sustainability in construction management research. The issue of sustainability is growing ever more importantly and construction has perhaps the greatest impact on it than any other sector. The

construction industry provides benefits to the society as well as causing negative impacts; this makes it a key sector in the fight for sustainable development (Sev, 2009).
The construction industry is a very important sector in achieving society's sustainable development goals; however the change towards sustainability is a process that presents a leadership challenge. Both Egan (1998) and Latham (1994) called on leaders to lead the quest for change in the construction industry. Leaders have an important role in guiding construction organizations toward sustainable practices and it is believed that such leaders require unique leadership styles. Leadership style is all about how people interact with those they seek to lead (Groetsch and Davis, 2006). However, Toor and Ofori (2008) believe that leadership is about authenticity and not style. The construction industry therefore needs authentic leaders (moral and ethical leaders) who can take advantage of the opportunities that sustainability brings, to secure a better future for the construction industry. It is suspected that the ability of organisations, irrespective of their level of maturity, to pursue the sustainable agenda is influenced by the commitment and conviction of their leadership towards sustainability.

This paper critically examines the role of leadership and the promotion of sustainable construction practices in construction organizations in United Kingdom (UK). The first part of the paper reviews literature on sustainable development and construction, leadership and leadership styles, drivers and challenges facing leaders in the effective implementation of sustainable construction practices. The final part of the paper concludes with the findings from preliminary interviews conducted with sustainability leaders in UK construction organizations. The interviews explored their role and identified factors affecting effective implementation of sustainable practices.

LITERATURE REVIEW

Sustainable Development and Construction

Sustainable development that balances social, environmental and economic objectives is now firmly on the agenda for the UK construction industry (Raynsford, 2000). Sustainable development balances environmental resource protection, social progress and economic growth and stability now and for the future. It focuses on improving the quality of life for all without increasing the use of natural resources further than the environment's ability to supply them for the foreseeable future. Sustainable development has been defined in many ways; Parkin (2000) pointed out that there are well over 200 rumoured definitions of sustainable development in circulation, however, the most widely accepted definition is:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"- From 'Our common future' (The Brundtland Report, 1987)

However, Brandon and Lombardi (2011) in their book "Evaluating sustainable development in the built environment" define sustainable development as:

"A process that aims to provide a physical, social and psychological environment in which the behaviour of human beings is harmoniously adjusted to address the integration with, and dependency on nature in order to improve, and not to impact adversely, on present or future generation".

Sustainable development means delivering built environment that sustains and improves the quality of life for human beings; removes the environmental and social damage from the past. Sustainable development also improves the sustainability of the wider environment, ecosystems and development of individuals and society's quality of life (Bennett and Crudgington, 2003). When setting out the UK's government role in sustainable construction, Raynsford (2000), the then UK Minister for Housing, Planning and Construction described sustainable construction as the set of processes though which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure and their immediate surroundings) that enhance quality of life, is flexible for future user changes, supports desirable natural and social environments to take full advantage of the efficient use of resources. Sustainable development is now understood as being a combination of three dimensions or 'Pillars' including economic, environmental and social dimensions; popularly referred to as the 'Triple bottom line' in business circles (Lehtonen, 2004; Hall and Purchase, 2006).
Sustainable development involves minimising the negative impacts of our activities to improve the environment and enhance a better quality of life for present and future generations. It is all about balancing economic growth and progress while protecting natural resources and promoting social equality (Leiper *et al*., 2003). The environmental dimension of sustainability is about reducing ecological impacts today in order to preserve the environment for future generations while the economic dimension involves providing for positive economic growth. Finally, the social dimension involves responsibility of corporations to conduct business ethically (Jones *et al*., 2010). However, Beheiry *et al*. (2006) believe that sustainability efforts in construction projects are biased towards the environment in comparison to the social and the economical dimensions.

The quest for sustainability has put enormous pressure on the construction industry from the government and the general public to improve on its currently unsustainable pattern of project delivery (Adetunji *et al*, 2003). There is now a wide recognition that the construction industry has a vital contribution to make towards sustainable development. However, Leiper *et al*, (2003) comment that, the construction industry is also slow in adopting sustainable approaches in its construction project practices. The construction industry has a significant social responsibility to minimise the damage its projects do to the social environment. Sev (2009) also add that both existing built environment and the process of adding to it have several environmental, social and economical impacts. The UK government in 2000 introduced a construction-specific strategy, "Building a Better Quality of Life" which highlighted key themes for action by the construction industry, namely;

- Design for minimum waste,
- Lean construction and minimise waste,
- Preserve and enhance biodiversity,
- Do not pollute,
- Conserve water resources,
- Respect people and local environment,
- Monitor and report (Department of the Environment, Transport and the Region(DETR), 2000)

Sustainable construction is the application of sustainable development principles in the construction industry. Parkin (2000), describes sustainable construction as a construction process that incorporates the basic themes of sustainable development. Sustainable construction aims at reducing the environmental impact of a building over its entire lifespan, providing safety and comfort to its occupants and at the same time enhancing its economic

viability (Addis and Talbot, 2001). Sustainable construction is conceptualized as having three broad dimensions; social equity, environmental protection, and economic growth as a reflection of those issues in relation to sustainable development. Social sustainability deals with legal, moral and ethical obligations of construction organizations to their stakeholders. Environmental sustainability on the other hand addresses the impact of construction activities on the environment by minimising waste, using natural resources and energy efficiently. Economic sustainability, however involves improved project delivery resulting in high productivity to maintain a high and stable level of economic growth (Parkin *et al.*, 2003).

Sustainability at the organizational level refers to meeting social and environmental needs in addition to the firm's profitability (Porter, 2008). Sustainability makes good business sense because it is of increasing importance to the efficient, effective and responsible operation of business. Some of the primary drivers towards the adoption of more sustainable business practices in construction organizations in UK is government policy or legislation, reputation and competitive advantage (Bennett and Crudgington, 2003; Woodall *et al.*, 2004; Holton *et al.*, 2008). In a qualitative study by Williams and Dair (2007) involving five (5) case studies of completed developments in England, they identified a number of barriers to sustainable construction practices, including; lack of consideration of sustainability measures by stakeholders, sustainability not being required by clients, real and perceived costs and inadequate expertise and powers. To add to the above Boston Consulting group(BCG) and MIT Sloan Management Review carried a mixed method research involving interview with fifty(50) leaders in sustainability and thousand five hundred and sixty (1,560)survey response from business leaders. This work identified the root cause of difficulties facing organizations pursuing sustainability as being a lack of the right information upon which to base decision, companies struggle to define business case for sustainability and flawed execution of sustainability by companies who deliver sustainable projects (Berns *et al*., 2009).

Leadership

Leadership is believed to be an important factor in achieving business success in any organization. Despite the extensive research carried out on leadership, Giritli and Oraz (2004), in their survey of leadership styles of construction professionals in Turkey, argued that, leadership is one of the least-understood concepts in business. Jing and Avery (2008) added that, despite the prevalent appreciation of the importance and value of leadership, the concept of leadership still lacks lucidity and agreement in leadership literature. In Odusami *et al.* (2003) quantitative research of sixty (60) questionnaire surveys to determine the relationship between project leadership and construction project performance, it was pointed out that not much work has been done on leadership in the construction industry.

Leadership has a very significant influence on organizational activities including sustainability yet leadership has not been a focus of research in the field of sustainability. The study and the understanding of leadership and its relationship to sustainability is still in its early stages (Egri and Herman, 2000; Quinn and Dalton, 2009). Little or no research has been done linking leadership and sustainability in the construction industry in particular. Even though, the field of leadership is well researched, Chan and Cooper (2007) conducted research through in-depth interviews with fifteen (15) leaders of the UK construction industry revealed that, the understanding of construction leadership is to some extent primitive, compared with the rather mature developments of mainstream leadership theories. The interest and the significance of organizational leadership is increasing rapidly as a result of the need for organisations to innovate continuously to meet the current changing business environment.

Despite the wealth of knowledge built around the concept of leadership, there is no single definition of leadership; however, a view of leadership according to Doh (2002) is that it is an executive position in an organization and a process of influence. Leadership is concerned with the ability to influence the behaviour of others to deal with the desires of the leader (Fellows *et al*., 2003). Ferdig (2007) describe leaders as those who inspire a shared vision, build consensus, provide direction, and foster changes in beliefs and actions among followers needed to achieve the goals of an organization. Northouse (2010) however define leadership as:

> *"A process whereby an individual influences a group of individuals to achieve a common goal"*

Leaders are essential at all levels (Munshi *et al.,* 2005) and can emerge at different levels of an organisation (Newton, 2009). Ferdig (2007 add that leadership is extended to any one who seeks sustainable change regardless of the role or position, and such leaders can connect with others using different assumptions about how people work together to create meaningful change. From the definition of leadership above, anyone in an organisation could potentially be a leader at some point in time if they are involved in a process of influence that involves encouraging sustainable practices (Taylor, 2008). The construction industry in general and the UK construction industry in particular, is in an era of a difficult socio-economic, cultural, political, and business environment. There is an urgent need to promote a positive culture in the construction industry and these require leaders with positive values and good levels of moral and ethical behaviour to change the conservative paradigm of management in the industry Toor and Ofori, 2008). Leadership theories identified by Munshi *et al*. (2005) include traits and styles; contingency; transformational/transactional; distributed and structuralist leadership theories.

Leadership Styles

Leaders have an important role in guiding construction organizations toward sustainable practices and it is believed that such leaders require unique leadership styles. Leadership style is all about how people interact with those they seek to lead (Groetsch and Davis, 2006). However, Toor and Ofori (2006) describe leadership style as a combined outcome of the leader's self-related cognitive information, personality traits, the primary motives, and thoughts on operating situational variables. Style is an important part of leadership but no single leadership style is best for all situations. There has not been any evidence to show that one particular leadership style is the best (Vecchio, 2002; Giritli and Oraz, 2004). There are different types of leadership styles, each proving effective depending on the given circumstances, attitude, beliefs, preferences and values of the people involved.

Many styles of leadership have been proposed for organizational leaders including; transactional, transformational, charismatic, democratic, servant, autocratic, consultative, laissez faire, joint decision making, authoritative, participative, tyrant, task oriented, relationship oriented, production-oriented, employee-oriented, delegating, authority-compliance, impoverished management, team management (Toor and Ofori, 2006). According to Bossink (2007), charismatic, instrumental, strategic, and interactive leadership styles influence an organization's innovativeness towards sustainability. The charismatic leadership style communicates vision, energizes others, and accelerates innovation processes such as sustainability. An instrumental leadership style structures and controls the sustainability improvement processes, while a strategic leadership style uses hierarchical power to innovate.

Finally, it is suspected that the interactive leadership style empowers employees to innovate sustainably and to become sustainable leaders themselves (Bossink, 2007). Transactional leadership helps organizations achieve their current objectives more efficiently while Visionary leaders (transformational, charismatic) create a strategic vision of some future to achieve high levels of cohesion, commitment, trust, motivation, and hence performance in the new organizational environments (Zhu *et al.*, 2005). Avery (2004) describe visionary leadership as leaders who employ a collaborative style for making decisions, share problems with their followers and seek consensus before the leaders make the final decision.

Leadership for Sustainable Construction

Sustainability requires organizational leadership to take bold steps to move beyond efficiency, compliance or just being green, to a higher level of performance. Sustainability is now viewed by organizations as being part of a strategy for long-term business survival and success (McCann and Holt, 2010). Leadership is vital in the construction industry and a key success factor in the drive towards sustainability. Leaders should embed sustainability in their organizational activities and make sustainable development part of their overall business strategy (Ofori and Toor, 2008). Parkin (2010) emphasises the link between leadership and sustainable practices when she asserts,

> *"Leadership is a vital ingredient for achieving sustainability. Without it sustainability will never make it in government, business or anywhere"* (Parkin, 2010).

Organizations are now required to fundamentally change the way they operate from focussing on the short-term maximization of shareholders value to now pay attention to the economic, social and environmental effects of their operations (Quinn and Baltes, 2007) The construction industry is therefore one of the key sectors required to lead the drive due to the significant negative impacts construction activities can cause. Both Egan (1998) and Latham (1994) called on industry leaders to lead the quest for change in the construction industry. It is believed that any effective change process requires committed leadership. Leaders have a significant role to play in the construction industry as the industry undertakes its critical role in the efforts to attain sustainable development (Ofori and Toor, 2008). It is suspected that the ability of organisations, irrespective of their level of maturity, to pursue the sustainable agenda is influenced by the commitment and conviction of their leadership approach towards sustainability. Leaders should communicate the importance of sustainability and establish a culture of integrating sustainability into day-to-day management decisions (Avery, 2005).

A qualitative study by Quinn and Dalton (2009) using structured interviews, sampled leaders from organizations that formally adopted sustainability practices and found that sustainability requires the integration of social, economic and environmental issues fully into the vision, values and operations of all organizations. This requires leaders to reform redesign and restructure their organizations to incorporate sustainability values into the fabric of the organization to minimize their negative impacts. In contrast, Ofori and Toor (2008) believe that leadership is the key factor of success in the drive towards sustainability. They argue that, the solution lies in leadership that is self-aware, committed and able to earn the support, and direct the actions, of all stakeholders towards the pursuit of a common project related goal of sustainability. This was the result from a study involving interviews with 32 prominent leaders in the Singapore construction industry.

A study by Szekely and Knirsch (2005) **identified** the best available methods and criteria that companies have been using to measure their sustainable performance as a result of implementing sustainable development initiatives. This work examined the way twenty major

German companies measured and reported their sustainability performance. They identified leadership as the most critical success factor that an organization needs to promote and achieve sustainability. Leaders have the opportunity to use the influence to help shift their organisations towards sustainability. This study acknowledges that it was important that such leaders have both leadership abilities as well as sustainability knowledge, to guide their organization effectively (Quinn and Dalton, 2009). In a survey to assess students' personal commitment to sustainability, sustainability knowledge, and interest in the topic of sustainability, it was found by Middlebrooks, *et al*. (2009) that as organizations and governments continue to underline a shift towards sustainable values and vision, then effective sustainability leadership will become increasingly important. Therefore the next generation of leaders must learn how to integrate their conceptualization of sustainability with the ability to facilitate others in pursuit of that vision.

However, Doppelt (2003) asserted that, organizations are not fully embracing sustainability because most organizational leaders do not fully understand the issues and do not know how to develop strategies required for the adoption of more sustainable practices. Even though Redekop (2007) comment that, the characteristics of a sustainability leader have not been systematically researched, Middlebrooks, *et al*. (2009) have identified the characteristics of sustainability leadership as; the ability to *see* organizational culture through the informed lens of the triple bottom line of sustainability, knowledge and understanding of the different balances and interconnections between bottom lines in the pursuit of sustainable ends, a desire to make a positive difference in the long-term, the ability to influence others in a socially just manner, and the ability to manage behavioural and systems change. Success with sustainability requires clear leadership at the organisational level, to identify, understand and manage efficiently ground-breaking solutions which address the critical social, environmental, and economic challenges faced by the world today as illustrated in figure 1 below.

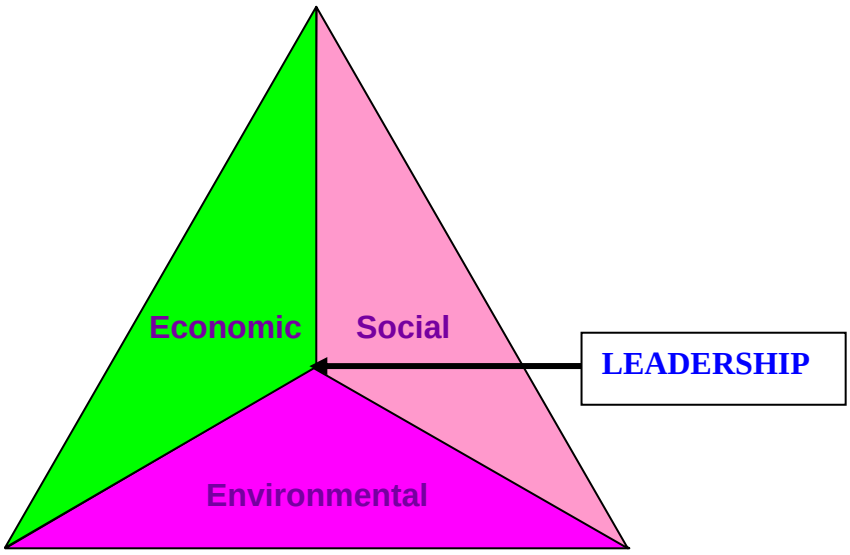


Fig.1 *Leadership at the centre of Sustainability*

When implementing a business strategy that commercially incorporates sustainability, leaders must be able to understand the motivation of different stakeholders, and engage and partner with mangers to weave sustainability into the fabric of the organizations. Leaders must also posses the ability to understand and overcome the challenges or barriers to adopting

sustainability (Lueneburger and Goleman, 2010). Sustainability leaders should not just give directions but should also develop and implement actions in collaboration with others, adapting to unforeseen changes in the environment overtime through modification as when needed (Ferdig, 2007). Sustainability leaders must display result delivery and commercial orientation competence as well as the ability to translate a vision of sustainability into a comprehensive programme of targeted initiatives (Lueneburger and Goleman, 2010).

RESEARCH METHODOLOGY

The primarily aim of this research is to critically examine the factors affecting the effective implementation of sustainable construction practices in UK construction organizations. It also investigates whether there is a difference in the leadership styles of sustainability leaders in construction. The research process commenced with a critical review of the literature, followed by a series of semi-structured interviews with sustainability leaders in construction organizations. A semi-structured interview involves the implementation of a number of predetermined questions. Interviewees are asked open-ended questions in a systematic and consistent order (Berg, 2001; Fellow and Liu, 2003). The interviewer prepares some questions or a frame for the interview and is also free to probe when necessary. Burns (2000) adds that, semi-structured interview allow greater flexibility than the closed-ended type and permit a more valid response from the participant's perception of reality.

To examine how leaders in UK construction organizations are promoting sustainable construction practices, in-depth semi- structured interviews were carried out with eight (8) sustainability leaders from construction consulting organizations in UK. Formal letters were sent to these leaders as an invitation to participate in the study. These were then followed with telephone calls and a total of 8 leaders agreed to take part and the profile of the interviewees is presented in Table 1 below. The interviews were conducted in a slightly loose manner lasting 30-40 minutes. It was also important to contact leaders from construction organizations currently pursuing sustainable construction practices. Despite the above, the data collected and the analysis presented here still yields some interesting preliminary findings related to the exploration of factors affecting the implementation of sustainable practices in construction organizations.

Interviewee	Job Title	Type of Construction organization
A	Sustainable Construction Manager	Consultant organization
B	Head of Sustainability	Consultant organization
C	Senior Sustainability Consultant	Consultant organization
D	Corporate Sustainability Manger	Consultant organization
E	Principal Sustainability Engineer	Consultant organization
F	Associate Head of sustainability	Consultant organization
G	Associate: Sustainability Manager	Consultant organization
H	Sustainability Consultant	Consultant organization

***Table 1**: Profile of Eight UK Sustainability Leaders Interviewed*

Naoum, (2002) indicates that this approach is best used when the research problem to be investigated is at its preliminary stage. Questions asked during the interviews addressed issues such as: what drives construction organizations to pursue sustainable practices; the role of leader in promoting sustainable construction practices; factors affecting leaders in the effective implementation of sustainable practices in construction and leadership style of sustainability leaders.

FINDINGS AND DISCUSSIONS

This section presents a discussion of the findings extracted from the analysis of the interviews. With most of the companies interviewed, the focus on sustainability started with a clear desire to introduce sustainability on the part of the leadership. Figure 2 provides a framework of the summary of each of the above issues considered in turn,

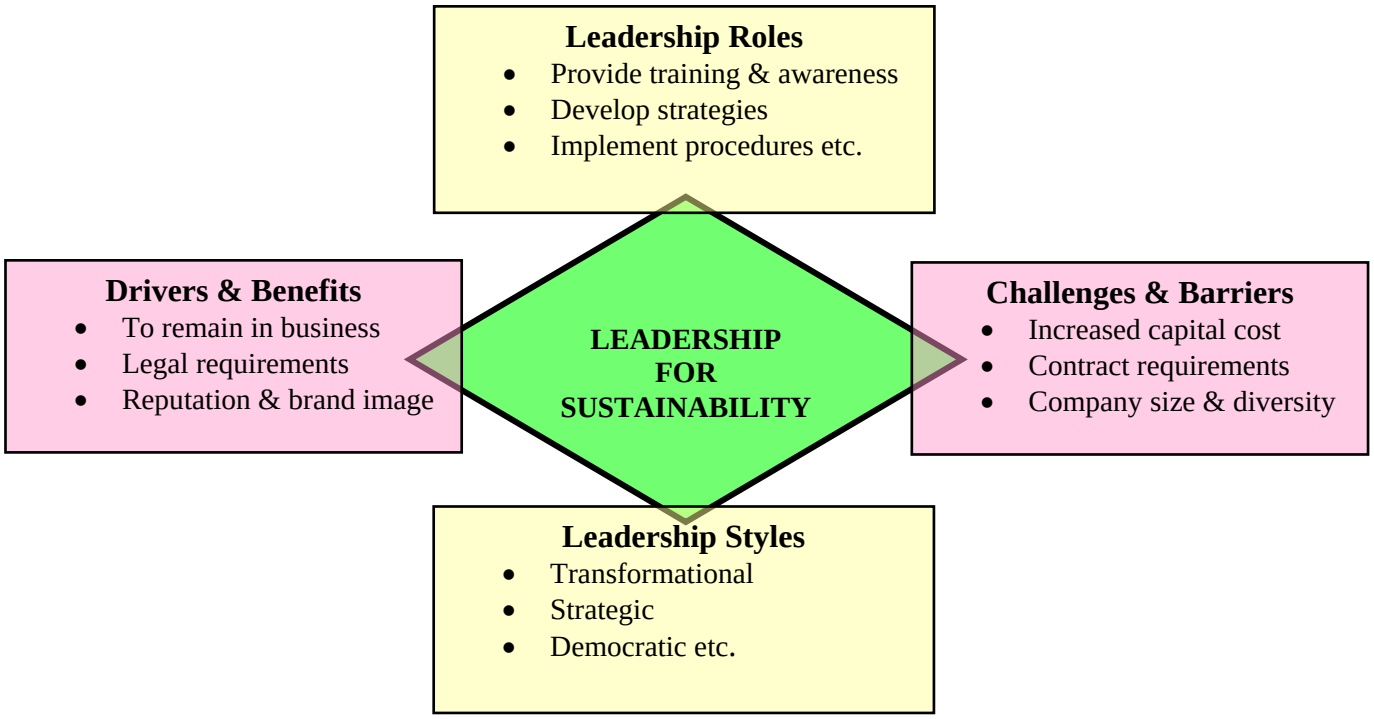


Fig.2 *Framework for analysis and discussion of findings*

Drivers

Sustainability leaders were asked about what drives their organizations to pursue sustainable practices and the results were very interesting. Some of the drivers include: company reputation or brand image; win more contracts to remain in business; position in the market place or competitive advantage; legislation or legal requirement; clients demand, improve economic performance; as a core value in corporate social responsibility. For example interviewee 'D' responded by saying:

"There are a plethora of business sustainability drivers that generate sustainable practices for us as a business and indeed for our clients, including: legislation and legal requirements, cost efficiencies, energy prices, water costs, waste issues, higher building profile, proximity to clients/competitors, proximity to public transport, social issues, ethics, stakeholder influence,

retention of key staff, competitiveness, green agenda, polluter pays, floods, environmental revenue, taxation, resource depletion, higher quality environment etc. These drivers are underpinned by a moral obligation to act with integrity and do the right thing".

Furthermore, many of the interviewees pointed out that, having a green reputation will help their organisations to win more business in periods of economic recession, interviewee 'B' noted:

"What drives this company to pursue sustainability is for corporate identity or brand to remain in business especially in this current economic climate"

Role

It was found that sustainability takes place in an organization better when there is an active leader within the company to champion the sustainability approach. Sustainability leaders have a role in helping to promote sustainable construction through: training staff on sustainability; produce guidance notes and policies; ensure that sustainability is embedded in the business; sustainability monitoring and appraisal etc. Interviewee 'F' highlighted that:

"I am the main author of our sustainability guide and responsible for the integration of our strategy internally within the company and the strategy promotion externally. I also sit on our group sustainability committee which drives the strategy throughout the company"

Several of the interviewees pointed out that the training of employees on sustainable issues was also a part of their roles. For instance interviewee 'E' said:

"I serve as catalyst in raising awareness on sustainability by training staff on sustainable construction practices".

Challenges

Sustainability leaders face many challenges in attempting to persuade their organisations to adopt sustainable construction practices. When leaders were asked about factors affecting them in the effective implementation of sustainable construction practices in their organization the following issues were raised, namely, one major challenge to organizational leaders is the lack of full understanding of what sustainability truly means to their company due to key fundamental information gaps. Following the analysis of the collected qualitative data, the following factors were identified as other challenges; lack of client awareness; lack of business case understanding; lack of client demand; large company size and diversity. In her view interviewee 'D' reflected that:

"Whilst sustainability involves achieving a balance of the social, economic and environmental factors, the current financial climate can influence perception that the economic considerations negate the social and environmental ones. The size and diversity of our company also proves a challenge in ensuring communications reach all stakeholders".

Furthermore, interviewee 'C' added that:

Managing competing and conflicting targets with other departments of the company to the understanding of a common sustainability goal is always difficult".

Senior management of company boards have other high priorities and sustainability is at the bottom of most company boards' priority list. A sustainability consultant; Interviewee 'H' explained that:

"Top management or company board lack the awareness and knowledge to make decision on sustainability"

Style

A significant part of the study was to identify leadership style of sustainability leaders. Leadership style was found to be an important part of leadership but no single leadership style was found to be best for all situations. Style of leadership was identified among the eight leaders interviewed as being; strategic, democratic, charismatic, transformational/ visionary and instrumental. Strategic leadership style was the most commonly identified style among the sustainability leaders. Most leaders described themselves as strategic and influential in the development of sustainability strategies. As interviewee 'A' observed:

"I am in a strategic role, active in the development of our sustainability strategy. I continue to influence the direction of the company in relation to sustainability and to help drive the ethos within the company through various mediums including engagement with stakeholders"

CONCLUSIONS

Sustainability is quickly becoming an essential market force ignited through customer, shareholder and stakeholder demands. Currently a business purely driven by profit without consideration for its environmental impact and no recognition of the social value of products and services will not prosper in a sustainable future. Construction organizations have critical roles to play in the efforts to attain sustainable development. Leadership is a vital factor for achieving sustainability. The role of the leader in guiding construction organizations toward sustainable practices is complex and vast, and it has been alleged that it requires an exceptional array of leadership skills, competencies and ethical commitment for it to be successful.

The desire of construction organizations to pursue sustainability is driven by a number of factors including: company reputation or brand image; the need to win more contracts to remain in business; positioning in the market place or competitive advantage; legislation or legal requirement; and the improvement of economic performance. However, there are number of factors affecting the effective implementation of sustainable construction practices such as: lack of the right information upon which to base decisions; companies struggle to define the business case for sustainability; a lack of consideration of sustainability measures by stakeholders; not required by clients; real and perceived costs. Leadership style is also an important part of leadership. It was found that a strategic leadership style is the most commonly identified style among the sustainability leaders involved in the study. Most sustainability leaders interviewed described themselves as strategic and influential in the development of sustainability strategies.

However, there were some differences in the opinion of leaders interviewed and that of reviewed literature. Sustainable leaders interviewed have a passion and fully understand the business case for sustainable construction, contrary to what was asserted in the literature. However the interviewees and the literature reviewed agreed that the importance of clients in

the pursuit of sustainability. The interviewees confirmed that the importance of client demand was a driver or a barrier to sustainable construction since the industry is client driven. The pursuit of sustainable construction practices is both a challenge and an opportunity. It is therefore important that organizational leaders turn such challenges into opportunities. Sustainable leaders have a role in helping to promote sustainable construction by training staff on sustainability; producing guidance notes and policies; ensuring that sustainability is embedded in the business, as well as the assessment and monitoring of sustainable practices. This therefore establishes the need to further investigate the role of leadership in promoting sustainable construction in the on-going PhD research study.

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CONTRACTOR ABILITIES TO DEVELOP COLLABORATIVE PRACTICES IN AUSTERITY TO MEET ENVIRONMENTAL SUSTAINABILITY AGENDAS

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Abstract *The boom era was characterised as continuous improvement in construction. Collaborative practices and a focus upon differentiation were primary features. The current market is austere with a primary focus upon cost. Survival is a dominant contractor strategy. Yet, certain contractors are retaining collaborative practices as a means to secure work, lever value and deliver effectively. Some have embedded collaborative practices as core competencies and dynamic capabilities that lever value in supply chains and networks. Environmental sustainability agendas are long-term and are likely to increasingly drive factors affecting construction in the future. Collaborative practices will be necessary to lever value to meet sustainability agendas early in the project lifecycle. Firms pursuing this path are likely to be the minority yet will be more successful by growing market share in the long run compared to the competition.*

Keywords: Collaboration, Competencies/Capabilities, Investment, Marketing, Survival

INTRODUCTION

How is the construction sector shaping and changing itself in the emergent economic era of austerity? To what extent will the resultant changes equip or constrain the construction sector to meet "sustainability" agendas over the coming years? The *aim* is to conceptually scope the ability to respond to future needs given recent and current responses during austerity. One *objective* is to evaluate the extent to which collaborative and partnership practices of the last 10-15 years provide a means to meet service and sustainability requirements in the future. A second *objective* is to evaluate the potential consequences for main contractors of low levels of investment motivated by survival during austerity.

Austerity is defined in terms of the consequences of economic downturn. It is evidenced as low levels of demand in the construction sector due cutbacks in investment from the public and private sectors. Most construction firms are primarily focused upon survival (El-Higzi, 2002; Skitmore et al, 2006; Skitmore and Smyth 2008). They keep their investment and overheads low; they keep capacity building and developing capabilities low. This is to maximise ability to respond to the "lumpiness" of demand at any time and the amplitude between the booms and slumps in the market (e.g. Smyth, 1985; Linder, 1994; Hillebrandt et al, 1995).

"Sustainability" is defined in environmental terms. Whilst definitions abound, this is conceived around current understanding as presented to industry, for example by the recent Morrell Report to the UK government (Morrell, 2010a). Collaboration is defined along two dimensions. The first dimension is the type of practices conceived in construction around so-called continuous improvement drivers, such as partnering the supply chain (Egan, 1998). In theoretical terms this is underpinned by relational contracting (Macneil, 1980; Williamson, 1985). The second dimension is the type of practices that emanate from investment within the

firms. The theoretical basis is core competencies (e.g. Hamel and Prahalad, 1996) and dynamic capabilities (Teece et al, 1997), which are embedded processes and abilities that go beyond the skills, expertise and professional disciplines that are essential to conduct a business. Examples of core competencies and dynamic capabilities might be organisational learning and knowledge management or the formal and informal routines established to conduct activities more efficiently and effectively. Collaboration can be a dynamic capability in itself to lever value from within mainstream operations, but can also act to lever value from another capability or core competency.

Main contractors tend to subcontract work. Leverage will typically be within a supply chain or industrial network (Håkansson, 1982; Håkansson and Snehota, 1995; Christopher et al, 1996; Skaates and Tikkanen 2003). Levering value is therefore largely a function of service provision rather than technology and production capability. This is why collaboration is important and requires capacity. There are two conceptual tensions. The first is between theoretically transitioning from relational contracting as a basis for collaboration, that is, responding to market and procurement drivers, to relationship management competencies and capabilities that are embedded in the firm. The lessons learnt from relational contracting may have become embedded as capabilities, but not automatically. This needs investment.

This paper explores the extent to which the demands ahead, especially around sustainability agendas, can be met in conditions austerity. Are collaborative capabilities being lost that may prove necessary in the future? The boom era was characterised by continuous improvement initiatives in construction, of which alliances, partnering, integrated teams were advocated as a major component of facilitating improvement (e.g. Egan, 1998). This type of collaboration was a move away from adversarial markets. There was a focus upon service differentiation (cf. Porter, 1985). In practice, initiatives largely fell short of original expectations. Improvements were generally project specific, but nonetheless improvements were made (Smyth, 2010a).

The current market is austere. It has shifted from being focused upon differentiation to one focused upon cost (cf. Porter, 1985). Cost savings and driving prices down are the primary client concerns (e.g. Morrell, 2010b; Smyth, 2010b). But that does not mean the capabilities for levering value across networks, especially through collaboration are lost? This needs exploration. At this point the conceptual case has to be explored in the light of limited available information beyond the anecdotal.

The paper undertakes this exploration by briefly reviewing the boom era of continuous improvement in construction. It considers the period of transition induced by the austerity of the slump market. It then considers the tension and balance between collaboration and low investment to conceptually gauge where the sector may be positioned for meeting sustainability agendas in the future.

THE ERA OF CONTINUOUS IMPROVEMENT

The era of continuous improvement was ushered into being within construction during boom times. It was conceived conceptually and in policy terms during the previous austerity period. Theories had been developed, such as lean production, and concepts were being applied in practice, such as supply chain management and partnering in other industries (e.g. Womack et al, 1990; Womack and Jones, 1996). Discontent, particularly amongst clients that had come to

expect added value when procuring other services and products, had been growing in construction during the early 1990s, as failure to meet minimal time-cost-scope/quality was common occurrence. Initiatives were emerging, for example through the Lean Construction Institute in the US, influenced by the work of Ballard and Howell (1988) in efforts to reduce waste and improve efficiency, and in the UK from the Latham (1994) and Egan (1998) Reports. Parallel influences in the UK were, for example, the work of Bennett and Jayes (1995; 1998).

A series of institutional arrangements were put in place in many countries, for example in the UK the Egan Report led to the Movement for Innovation (M4i) and Constructing Excellence as a successor to encourage and transfer „best practice". Collaborative practices were being advocated through client leadership, partnering the supply chain to improve innovation and performance.

There were early criticisms of collaborative approaches (e.g. Bresnen and Marshall, 2000; Green, 1999). Theoretical rigor was one; questioning how transferrable the measures were into asset specific supply was another; further criticism concerned the extent to which main contractors were committing investment or adopting the rhetoric to secure work and squeeze suppliers, and how penetrating successes were (e.g. Bresnen, 2007; Green 2006; Mason, 2008). A recent UK study considered 150 out of a total of 525 demonstration projects designed as exemplars of transferrable knowledge. Covering a 10-year period it was shown that more project benefits had accrued than strident critics suggested, yet have fallen a long way short of expectations, concluding:

> *…explicit knowledge has not been transferred beyond largely general descriptions of improvements. Although these descriptions may have stimulated other parties to try similar initiatives, there is insufficient description of what has been done and how it has been done in demonstration project write-ups to facilitate direct comprehensive knowledge transfer.* (Smyth, 2010a: 269)

Not only were lessons not being transferred between organisations, they largely remained project-specific in contracting organisations, that is, not being transferred through corporate investment to be embedded as core competencies and dynamic capabilities that go beyond the essential operational skills and expertise, nor embedded into contractor programme management. Furthermore, sustainability was a low priority in the early years of continuous improvement. Whilst it was coming to the fore in the mid-to-late-2000s, specialist consultants and subcontractors were the primary players rather than main contractors (Smyth, 2010a). Therefore, the role of main contractors was to lever value from the industrial network and supply chains. Value leverage is aided by collaboration (e.g. Beach et al, 2005; Kumaraswamy and Rahman, 2006; Anvuur and Kumaraswamy, 2008; Smyth, 2010a).

New tailored services could form the basis for developing core competencies and dynamic capabilities beyond the essential skills and expertise for operations. This could occur through teasing out generic skills and knowledge to be captured for widespread and repeated application. Some contractors took tentative steps, for example an increased strategic systems orientation in certain North American contractors (Zoiopoulos, 2011) and improved marketing capabilities to add service value (Chambers et al, 2009). The effectiveness of embedding such collaborative practices largely depends upon establishing new ways of doing things. This can be practically characterised as establishing formal and informal routines (cf. Nelson and Winter, 1982) that (a) improve the efficiency and effectiveness of mainstream

operations through collaboration by reducing transaction costs (cf. Williamson, 1985), and (b) lever added value through supply chains.

A PERIOD OF TRANSITION

The 2008 "credit crunch" changed a great deal. It ushered in austerity. The level of demand dropped and procurement drivers changed. Demand has shrunk. Where construction clients continue to buy, many have switched from demanding for service differentiation to a cost focus (cf. Porter, 1985). Some of the advocates of continuous improvement have made dramatic shifts, for example the UK supermarket chain Tesco has demanded a 30% price cut from all suppliers including consultants and contractors. The UK Government advisor on construction has also demonstrated how prices have risen (Morrell, 2010b), although an analysis of the extent to which the price rises have accrued as premium profits and/or added value is absent.

Cost drivers are likely to remain dominant short- and medium-term. However, there are two significant underlying trends. Some contractors are minded to retain collaborative practices. They have witnessed a shift in the culture, absorbed as informal and formal routines (e.g. Chambers et al, 2009; Smyth and Fitch, 2009). They perceive benefit in such capabilities for securing work from existing clients under conditions of intensified competition. This links to the second trend: sustainability. Its various dimensions are likely to increasingly drive factors affecting construction in and beyond the current era of austerity (e.g. Edkins et al, 2009; Morrell, 2010a).

Collaboration is an important part of main contractors meeting the sustainability agendas, yet UK projects where effective collaboration is sufficiently penetrating *"are still very much in the minority"* (Morrell, 2010a: 54). The UK case is not thought to be exceptional. What does vary between construction companies and national cultures is the degree to which strategic planning is applied. Madsen (1989) has shown that hands-on strategic planning and investment is necessary to be successful for business development and execution, especially in domestic and adjacent markets, for example the national and EU market for UK or Dutch contractors. UK contractors were less strategic than European counterparts and divested during the last recession, losing market share to European competitors (Stockerl, 1997; Stockerl and Smyth, 1998). Initial indications are towards a similar pattern emerging (Smyth, 2010b). The evidence overall points towards contactors that strategically plan and invest in capacity and capabilities are likely to be most successful in the long-term. This is in line with the resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984), and in line with the theoretical subsets of core competency and dynamic capability theory (e.g. Hamel and Prahalad, 1996; Teece et al, 1997). Collaboration is part of this theoretical line of thinking and builds capacity for the future. In contracting the necessary investment to embed collaborative practices requires investment, which needs to be sufficient whilst not taking risks that threaten survival (El-Higzi, 2002; Skitmore et al, 2006).

What sort of collaboration is in evidence and what is needed to meet sustainability agendas in the future? Collaboration during the boom era was characterised by contracting firms leaving it to individual responsibility (Smyth and Edkins, 2007). Those firms that have embedded collaborative practices have established formal routines through systems and procedures, which guide individuals towards collaboration, around which new norms and informal routines are established that have a reinforcing role (e.g. Pryke and Smyth, 2006; Smyth and

Fitch, 2009; Gustafsson et al, 2010; Zoiopoulos, 2011). However, most main contractors have not made the transition from relational contracting to investment in core competencies and dynamic capabilities.

TOWARDS COLLABORATION OR UNDERINVESTMENT DURING AUSTERITY

As main have not invested in new developing capabilities, collaborative practices are largely residual. They are in evidence through individual behaviour or through informal routines that emerged during the era of continuous improvement. The residual routines of collaborative practices have the capability to help secure work for firms and meet sustainability as it affects construction internally, through supply chains and across industrial networks, as well as in relationships with clients to secure and execute projects. These may prove fragile because of reliance upon individuals and their behaviour. Effective collaborative practices will be those that are most effective for leveraging value, for example to meet sustainability agendas. They will systematically involve project managers, directors and business development managers that can identify needs and lever the value to develop win-strategies prior to and during the bidding process. Collaborative practices during execution will maintain the integrity of the win-strategy and deliver added value benefits to clients and other stakeholders. This may challenge some pre-conceptions that value is primarily levered during execution.

This value leverage is part of marketing, specifically relationship marketing and management (e.g. Grönroos, 2000; Christopher et al, 2006). Relationship marketing has become established amongst some contractors (Smyth and Fitch, 2009). This is part of the strategic project front-end (Morris, 1994). The front-end strategy for projects therefore enables commitments to be made through relationship marketing that adds value to the client and yields improved strike rates, especially for repeat business clients, for the contractor. Commitments are not merely about getting close to a client or suppliers in a business sense but about relationships that lever value. They become part of social capital that is transferred to the client asset (cf. Gustafsson et al, 2010). Commitments of internal resources and with alliance partners in the industrial network are thus made to create capacity and resources necessary to configure the project content and service. This is also the basis for making commitments to the client, which are subsequently embedded into the project in contractual terms and service promises. In this way added value of technical and service content is levered. The result would constitute a shift towards a greater service orientation, in line with what Vargo and Lusch (2004) call the service-dominant logic.

Whilst there is a strong theoretical base to support the argument, mapping out what this looks like on the ground is difficult for two reasons. First, core competencies and dynamic capabilities, such as collaborative practices, are configured in many forms. The different forms are ideally aligned to market segments and individual clients in ways to position a contractor from its competition. Second, sustainability agendas differ as will the substantive content of requirements.

However, there are strong drivers of survival in construction that result in minimising investment as noted (Hillebrandt et al, 1995; El-Higzi, 2002; Skitmore et al, 2006). To develop the point, there are three main problems from underinvestment experienced at the level of the firm:

1. Threats in the market from rivals that do secure a competitive edge through

investment (e.g. Stockerl, 1998; Smyth, 2010b).

2. Low investment carries a series of consequences:
    i. Constrained ability to carry risks, such as in public-private partnerships (e.g. Stiglitz and Wallsten, 1999);
    ii. Clients remain dissatisfied as provision fails to meet expectations and requirements because intensified competition exacerbates low investment (e.g. Stiglitz 1981);
    iii. Opportunism can lead to underinvestment in relationship-specific activities, such as collaborative relationships, and other social or human capital (e.g. Edlin and Stiglitz, 1995).
3. Inability to respond to fast changing environments (Morden, 1997; cf. Micklethwait and Wooldridge, 1996).

Therefore, whilst survival may be secured in the short-run, long-term growth is secured by contractors that invest for growth, particularly in the downturn and on the upturn. Such growth is typically characterised by growth in market share rather than profitability (Smyth, 2010b). The implications of growth is that firms that invest expand at the expense of those that underinvest, so short-term survival may lead to long-term decline or takeover.

CONCLUSION AND RECOMMENDATIONS

It has been argued that long-term success is derived from investment, a type of investment being dynamic capabilities or core competencies shaped as collaborative practices to lever value.

It has further been argued that sustainability agendas are likely to require investment and project specific commitments by contractors to secure work and satisfy clients. Whilst there may be several ways to achieve this, an obvious path is to switch from reacting to procurement drivers to proactive investment, particularly in service provision around relationship building and value leverage. However, there are strong drivers for survival amongst contracting firms that militate against this. Yet, evidence from the last recession shows that those that both invest and survive tend to be more robust and grow market share in the long-term. Sustainability agendas are likely to create similar opportunities in the market on the upturn from austerity.

It is probable that few firms are likely to pursue the path of investment in capability development and collaborative practices. This is likely to be due partly to the perceived risk and partly due to habit and cultural norms. The majority of main contractors may continue to set the primary goal as survival. Whilst this may work in the short-term, it weakens firms in the long-term in the face of competition from firms that invest. Moreover, low levels of investment render it difficult to respond to competitors that do invest and survive. They will grow market share. The implications for clients and society is that construction firms developing capacity will be best placed to provide a high quality service and meet the range of sustainability agendas in the future.

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REVIEWING CONSTRUCTION STATISTICS IN NORTH CYPRUS

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Abstract
Construction is one of the industries of strategic economic importance. Governments using their national institutions are involved in the collection of economic statistics, which indicate the state of their economy in an annual time series. However the completeness and accuracy of these statistics are always questionable by the stakeholders within the sector. Therefore there is an increasing need of accurate, manageable and reliable statistics for the sound analysis of the construction sector. The main purpose of this research is to review construction statistics in North Cyprus. The objectives of the review are to 1) engage with users to ascertain their views on the statistics and to identify their needs, and 2) investigate whether the statistics in their present form continue to meet user needs, and identify options for change. As part of the review, a user consultation exercise aimed to identify whether there are needs that justify continuing the statistics, as well as to ascertain users' views on European Statistical System (ESS) key dimensions of the quality of the statistics. This review of construction statistics will provide a conceptual framework of statistical information to be presented in a more comprehensive content, sufficient portrait, highly reliable in terms of quality, and responsive to dynamic changes of the sector (inflation, structural adjustment policies etc.). Additionally, it is aimed to detect and minimize the uncollected information and thus make contribution for prevention of unregistered activities within the sector.

Keywords: Construction Statistics, construction industry, North Cyprus.

INTRODUCTION

Governments all over the world are involved in the collection of economic statistics, which among other things indicate the state of their economy in an annual time series. These indicators are commonly known as official statistics. Construction is one of the industries of strategic economic importance and governments are obliged to take the industry‟s statistics seriously (K'Akumu, 2007). Construction as a sector of society is characterized by the economic activity of building and civil engineering works (Wells, 1986; Bon and Crosthwaite, 2000; K'Akumu, 2007). It is a sector of strategic economic importance especially for developing economies. This is because of its macroeconomic contributions to gross domestic product (GDP), gross fixed capital formation, employment and inter-sector linkages (United Nations Centre for Human Settlements, 1984). The United Nations defines construction as comprising „economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature, and other such engineering constructions as roads, bridges, dams and so forth‟ (United Nations, 2001). Construction activity represents a significant share of the economies of most countries in terms of its contribution to GDP and total employment and it is also an important market for materials and products produced by other sectors of the economy. Pearce (2003) considered construction both in its narrow sense (on-site construction activity) with its contribution to GDP at around 5% and in a broader definition (including quarrying of construction raw materials, manufacture of building materials, sales of construction products and various associated professional services) making a contribution of about 10% of GDP (Ruddock, 2007a). In addition to the Pearce Report, the case for a new approach to the valuation of construction activity has come from two other areas. Firstly, the „International Council for Research and Innovation in Building and Construction‟ (CIB) Revaluing Construction agenda focuses on improving the value of the final construction output and requires that the totality of activities involved in the production of the built environment is reviewed (Ruddock, 2007b). Secondly, Carassus (2004) proposes a framework system approach for understanding the construction sector. The rationale for this approach is based on the view that the role of the construction sector should be viewed in a wider context than that of the narrowly-defined „International Standard Industrial Classification‟ (ISIC) definition of the industry.

There are some impressive reviews of construction statistics in certain developed and developing countries conducted with a view to improving them. The available literature confirms that the key concerns of construction statistics reviews are mainly with their adequacy (K'Akumu, 2007). The question of adequacy can be split into two: (i) scope; and (ii) quality that can engender reliability. Apart from these, construction economists readily single out the uniqueness of linkages between construction and the economy (Briscoe, 1988; Hillebrandt, 2000). The portrait of the role of construction in the economy is therefore a significant responsibility of construction statistics upon which they can be evaluated. The responsiveness of construction statistics in the light of transforming economic conditions is another important attribute of construction statistics that may be used to evaluate them. As time changes, construction statistics may change with time to maintain relevance (K'Akumu, 2007).

The Annan Plan has had a major impact on the construction industry and its sub-sectors with increasing production, import and sale volumes compared to previous records in North Cyprus. Between the years of 2003 and 2009, many building and civil engineering projects like hotels, residents, dormitories, and highways were constructed by the private sector

initiatives such as owners, investors, developers, and contracting firms. Additionally, many infrastructure projects were constructed under the Grant Program of United Nations Development Programme (UNDP) and the European Union. On the other hand, campus construction of some state universities of Turkey and local private universities are ongoing. Despite these economic developments, a national authority on statistics i.e State Statistics Institute has not been established yet. This creates a great lack of reaching and accessing updated statistic information needed within the construction sector as in other sectors. Department of Statistics and Research (DSR) under the State Planning Organization (SPO), Union of the Chambers of Cyprus Turkish Engineers and Architects (UCCTEA) and Association of Cyprus Turkish Building Contractors (ACTBC) are the current public and non-governmental organizations which provide statistical information to the sector. But the statistical reports prepared by these institutions are not timely and not equipped with sufficient information for the needs of the sector. Therefore all the stakeholders (investors, contractors, architects, engineers, consultants, material suppliers etc.) face difficulties in timely access to the information they need and therefore they cannot make sound decisions.

There is a widespread recognition by uses of statistics that managers in North Cyprus construction industry are poorly served by existing data in the formulation of policies and strategies. Considering DSR‟s current circumstances, lack of departmental investment in organizational structure, qualified staff and also in hard-and software has prevented the introduction of up-to-date systems to analyze relevant data. Although the construction industry has undergone considerably change over the past decade, this has not in any way been adequately reflected in available official data. The statistical requirements of the Government differ considerably from those which should and could make a positive contribution to decision-making within the construction industry. There are criticisms in the area of dissemination and feedback. Dissemination refers to both timeliness in the release of the data and in the detail in which the data are made available. The DSR was aware of the whole panoply of changes affecting the industry in the past decade, but failed to ensure that the statistical resources were available to monitor and track some of those changes.

The main purpose of this research is to review construction statistics in North Cyprus. The objectives of the review are to 1) engage with users to ascertain their views on the statistics and to identify their needs, and 2) investigate whether the statistics in their present form continue to meet user needs, and identify options for change. As part of the review, a user consultation exercise aimed to identify whether there are needs that justify continuing the statistics, as well as to ascertain users‟ views on European Statistical System (ESS) key dimensions of the quality of the statistics.

CONSTRUCTING CONSTRUCTION STATISTICS

Statistics are the cornerstone of most decisions business people take and, indeed, the cornerstone of most government policy. The gathering of data by the Government is seen purely from the point of providing evidence for the ultimate management of the economy rather than statistics which should be helpful to the industry itself. In an industry as large and complex as construction, statistics play a very crucial role, in terms of monitoring both the external and internal factors which influence its structure, its performance and its behavior. To have statistics in adequate detail is a problem both quality and quantity. The quantity and quality of the range of statistics available to the industry is therefore of concern to all those who operate within construction or whose roles call for a sound knowledge of the industry and the factors which affect it. Quality includes definitions, coverage, reliability, consistency

and integrity. These are essentially the concerns of the statisticians who gather and process data. Quality, however, goes beyond this set of factors. It also means accuracy, relevance and timeliness, to which users attach great importance. In terms of coverage, there is no general agreement about what the definition of the construction industry ought to be. Coverage of what is meant by the construction industry is therefore one of the issues which has to be considered in the wake of various endeavors under way to revise the current range of statistics produced by the Statistical Services (Cannon, 1994). Coverage of the industry in terms of obtaining sufficient correct information from firms is an issue with which official statisticians grapple as a matter of course. It is, however, an ongoing problem in an industry where entry and exit are extremely easy and where self-employment has become the major form of labor supply in the past decade or so. This is aggravated by the existence of a large black economy sector. The problem of unregistered labor in the construction industry is international, to the point that in some European countries the official measures of construction output include an estimate for "black economy work".

Construction statistics refer to a collection of selected numerical facts that seek to portray certain conditions or attributes of the construction industry (K'Akumu, 2007). The primary source of data for construction statistics is current and annual reporting. Reports are submitted to agencies of the Central Statistical Board of the countries by builders (including private builders) and by construction and designing and surveying organizations. In addition to reports, construction statistics carries out censuses and one-time inventories and surveys (for example, statistics of construction machinery, uncompleted construction work, stocks of materials and equipment at construction sites). Statistical agencies submit material to State Planning Committees and to ministries and departments for the preparation of future plans for capital construction. They also investigate specific problems, summarize statistical practices, and refine the methodology used for indexes.

To improve the quality of international (and national) data provision generally, Lievesley (2001) indicated that, although the term „quality", when applied to official statistics, is difficult to define, the following components should apply: (1) validity, (2) reliability, (3) currency, (4) clarity and transparency with respect to known limitations, and (5) comparability through adherence to internationally agreed standards. In the context of a truly global market for construction, an international strategy is required to ensure that national and international statistical systems are able to provide accurate and valid information. In many parts of the world the collection of reliable national information on construction activity is not an easy task, and the measurement of comparable, cross-national data can be problematic. Ruddock (2002) considered possible strategies for the improvement of data collection systems in the context of user needs.

Coverage of Construction Statistics in North Cyprus

Data required for producing the statistical outputs is collected from a variety of sources (Ministry of Public Works, municipalities, association of building contractors, etc.), and then is processed using different methods. The data sources used in the report are mainly annual sample surveys and censuses, monthly inquiries and administrative records. Data on public and semi-public construction activity are derived from government records such as the budget, departmental reports and financial statements. For the private sector, the data are obtained through special questionnaires that are filled in by enumerators of the Statistical Service. In the case of data on building permits, these are compiled through a copy of the actual permit issued by the appropriate authorities (municipalities and district administration offices) and forwarded to the Statistical Service.

DSR‟s Yearly Construction Statistics in North Cyprus comprises the following statistical outputs:

- Main indicators of the construction industry
- Output of new construction by category
- New construction by type of project
- Construction costs per square meter
- Dwellings completed by sector, district and type
- Indices of costs in the construction sector
- Cost Analysis by construction activity
- Price index of construction materials
- Building permits authorized
- Employment in construction

REVIEW OF CONSTRUCTION STATISTICS

Construction statistics would give vital insight into the contribution of construction to economic development. In spite of the importance of construction, its statistics are usually of questionable quality even in developed countries (K'Akumu, 2007). In the United States of America (USA), the review of construction statistics has been taking place for a long time. Gill (1933) carried out a review of the construction statistics of the USA. He felt that there was "lack of specific and accurate information available in USA on the subjects of construction and employment in construction" (Gill, 1933). Gill‟s argument about inadequate data and need for adequate data lays the foundation for any reviews of construction statistics. The USA President underscored the fact that statistical shortcomings had handicapped the development of effective policies to combat construction inflation and to meet future construction needs (Swerdloff, 1971), and therefore asked the Cabinet Committee on Construction for recommendations on improving the statistical information on construction. The US recognizes that the construction industry continually undergoes change and that it is important for the national statistical agency to provide users of construction statistics a forum to discuss statistical programmes vis-a`-vis their needs (K'Akumu, 2007). Fleming (1986) had pointed out the shortcomings of the UK‟s construction statistics. There has been a long debate on the inadequacy of construction statistics between UK government agencies in charge of statistics, i.e. the Department of Environment (DoE) and the National Economic Development Office (NEDO) on the one hand, and users of construction statistics on the other (Cannon, 1994). Bon (1990) and Cannon (1994) consider the usability aspects of existing public and private data and the failure of such data to meet the needs of its users. Cannon (1994) point out that many industry users may be unaware of the availability of some information because the originating institution may not recognize the usefulness of disseminating the data to a wider audience. Meikle and Grilli (1999), in their study of the measurement of construction output in European countries, point out that construction output data are not consistent in content and there is no generally accepted standard international definition. Lopes (1998) referred to the inadequacy and rudimentary nature of data on the construction industry in developing countries and pointed out the lack of input–output data in such construction sectors. The uncoordinated collection of data via several agencies leads to unnecessary processing problems, which could be eradicated by the setting-up of a central national agency. Ofori (2000) proposed the notion of a „central data bank for construction‟ and took this notion further, advocating the development of regional construction databases for groups of countries. Pearce (2003) considered measures of the construction industry in the UK and raised the problem of definition conceived in terms of „broad‟ and „narrow‟ classifications.

Briscoe (2006) examined the broader statistical issues in greater depth to identify shortcomings that could cause some of the findings presented by Pearce, and similar studies, to need qualification and possible revision. K'Akumu (2007) evaluated construction statistics of a developing country, Kenya, in order to ascertain their adequacy in terms of scope, portrait, reliability and responsiveness in their coverage of the construction industry.

SURVEY OF USERS AND CONSTRUCTION STATISTICS USED IN NORTH CYPRUS

The review of construction statistics includes data collection and compilation methodologies used to produce the statistics. User needs and requirements for the statistics were identified and their views on quality of the statistics were ascertained in line with the European Statistical System (ESS) dimensions of quality.

Sampling and Data collection

The study was focused on the public and private organizations actively taking part in the construction industry. The lists of all registered private organizations were obtained from the concerned chambers (i.e Union of Chambers of Cyprus Turkish Engineers and Architects; Turkish Cypriot Chamber of Commerce), and associations (i.e Association of Cyprus Turkish Building Contractors). Particular departments of some ministries (i.e Department of City Planning; Department of Planning and Construction; Water Works Department), academic institutions (i.e Universities), and municipalities are also included in the survey. For the study of wide range of organizations using the statistics, the following criteria were used in the selection of respondents taken randomly in the organizations. All respondents were

- either engineers or architects, and
- either from the top management or senior management in their respective departments.

The criteria for selection of sampling companies were homogeneously distributed throughout the country in order to ensure a complete view of the sector; and most of the companies were involved in construction work and design activities. With regard to the stages within the construction process in which the respondent companies were involved, most worked in at least two of them.

The profile of the respondents reflected the selection criteria used for the participant companies. Respondents were homogeneously distributed throughout the country. Selection of respondents for the interview was based on those who are involved in managing and working the day-to-day construction activities of North Cyprus. A collection of opinions from different organization members is assembled instead of a single respondent from each firm. Respondents were purposively selected to provide a representative sample in terms of the definition of the North Cyprus construction industry, i.e., consultancy, contractor, material suppliers and design offices.

The survey was distributed to construction professionals working in different organizations ranged from Material Suppliers, Design Offices and contracting firms in private sector and public organizations. Having considered that statistics were identified through continuous collaboration among members, respondents from different professional backgrounds, which include architects, engineers, project managers, and project coordinators were approached. As a result, 175 prospective respondents were enlisted and to whom the survey was sent. 134 completed questionnaires were returned. The overall response rate is 76 %.

Regarding the respondents‟ background, the results reported in Table 1 indicate that the respondents are playing different roles in firms ranged from engineers to project coordinators. Thus, it is considered that opinions of members working in different construction organizations have been obtained.

Table 1: Surveys received and the respondents‟ background matrix

Respondents‟ background	Material Suppliers	Trade Associations	Design Offices	Consultancy	Contractors	Government	Academic Institutions	Municipalities	Number of questionnaire received
Engineer	8	8	4	3	3	2	1	1	30
Architect	6	6	3	3	2	2	1	1	24
Project Managers	10	9	8	7	4	3	2	1	44
Project Coordinators	9	8	6	5	3	3	1	1	36
TOTAL	33	31	21	18	12	10	5	4	134

User Consultation Methodology

Understanding users of the statistics is fundamental to engaging with them effectively so as to improve the public value derived from the data. As part of the review, a consultation was conducted to ascertain users‟ views on the quality of the statistics, to understand how they make use of the data and to identify their needs. The user consultation was conducted through a user survey and carried out via e-mail and postal surveys using a questionnaire involve a wide range of users from various backgrounds.

The questionnaire was designed to elicit core user needs and their views on key dimensions of statistical quality. It was reviewed by key stakeholders (contractors, engineers, architects, consultants, material suppliers etc.) to ensure correct interpretation and a logical order of questions. Responses received from the e-mail and postal surveys produced both qualitative and quantitative data which were processed and analyzed using the SPSS software.

The questionnaire covers mainly types of respondent, purposes for using the construction statistics, frequency of uses of the construction statistics, and views on the quality of the statistics (timeliness, accuracy, relevance, accessibility and clarity, comparability with other data). The questionnaire also includes structured open questions covering the main use of the statistics, the usefulness of the statistics, user requirements in terms of details, coverage and types of statistics, problems encountered when using the statistics, and impact of discontinuation of the statistics.

Survey Results

A total of 134 responses were received, including postal responses.

Types of Respondent

Respondents to the survey came from a wide range of organizations, reflecting a diversity of users of the construction statistics. Figure 1. provides an overview of the organizations where respondents work or study. Respondents from Material suppliers (25%) and Trade Associations (23%) firms make up the two largest groups, accounting for nearly half of total respondents.

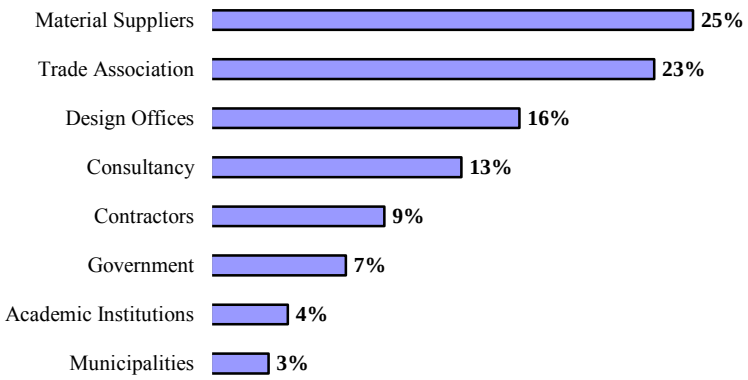


Figure 1: Breakdown of types of respondent

Uses of the Statistics

In terms of types of statistics used, both statistics of main indicators of the industry and statistics of output of new construction by category were used by the largest proportion of respondents (62%) followed by new construction by type of project (58%) and construction costs per square meter (57%). In comparison, only 10% respondents use the statistics of employment in construction, as indicated in Figure 2.

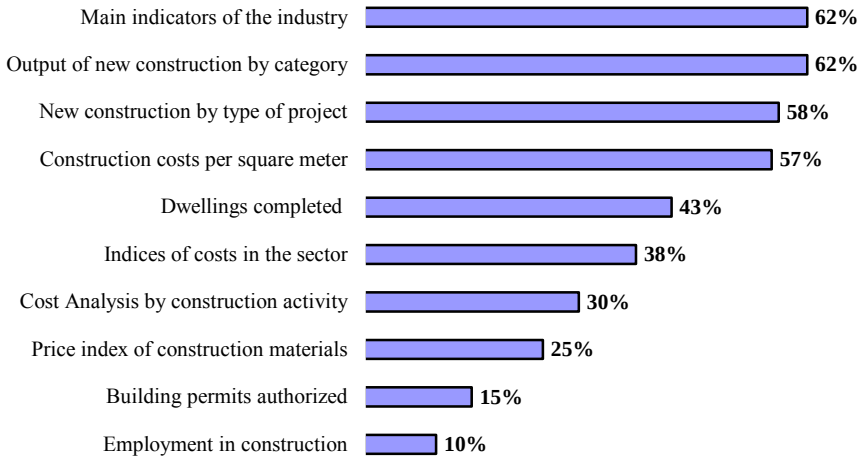


Figure 2: Type of statistics used

To discern respondents‟ principal interests in the various statistics, the uses of the statistics by types of respondent were analyzed as displayed in Table 2. The table indicates that Material Suppliers showed most interest in Main indicators of the construction industry and were least interested in employment in construction data, whereas users of employment in construction are mainly from Academic Institutions and Consultancy firms.

Table 2: Statistics used by types of respondent

	Contractors	Consultancy	Government	Material Supplier	Trade Association	Academic Institution	Design Offices	Total Use
Main indicators of the construction industry	3	7	3	11	6	5	4	39
Output of new construction by category	3	6	3	10	3	4	6	35
New construction by type of project	5	6	2	8	4	4	3	32
Construction costs per square meter	5	5	2	7	4	4	4	31
Dwellings completed by sector, district and type	6	6	3	2	4	5	4	30
Indices of costs in the construction sector	5	5	6	2	4	5	2	29
Cost Analysis by construction activity	6	4	2	6	3	3	4	28
Price index of construction materials	5	5	3	3	4	2	2	24
Building permits authorized	2	5	3	2	2	6	2	22
Employment in construction	2	4	3	2	2	5	2	20

Figure 3. displays the results concerning respondents‟ purposes for using the construction statistics. The largest proportion of respondents (67%) use the statistics for monitoring industry information, followed by assessing industry trends (55%). The statistics on construction are the only key source for assessing the economic environment for property market, for instance, monitoring the impact of the recession on residential real estates. Moreover, the price data of property market are useful for stakeholders to monitor and assess the variations in prices of particular real estates and the impact of recession and inflation on the prices.

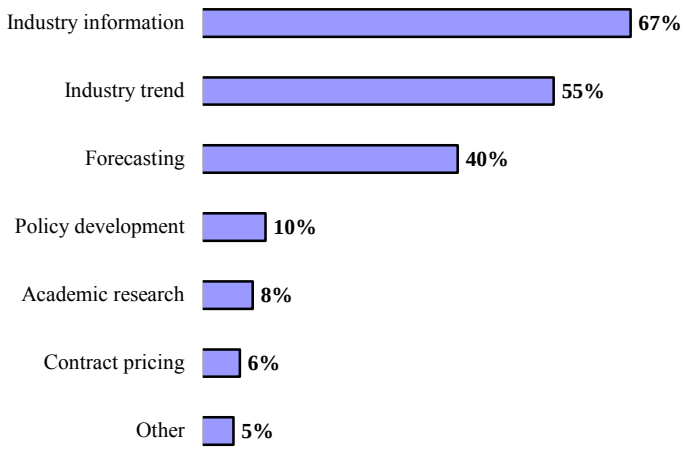


Figure 3: Purposes for using the construction statistics

Regarding the frequency of uses of the statistics, Figure 4. illustrates how often respondents use the construction statistics. It indicates that most respondents use the statistics yearly, which is also the frequency that the statistics are published.

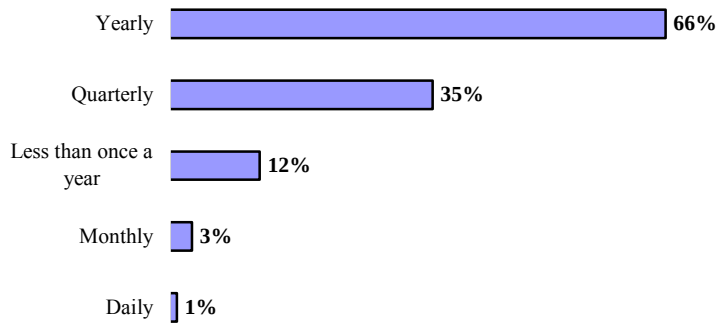


Figure 4: Frequency of uses of the construction statistics

Impact of Discontinuing the Statistics

Table 3. indicates how respondents‟ work would not be affected if the statistics were discontinued. The effect of discontinuing the statistics on respondents varies according to the types of statistics, but in the main, a majority of respondents felt that discontinuing the statistics would not cause major or significant disruptions on their work.

Table 3: Impact of discontinuing the statistics

	Major Disruption	Significant Disruption	Some Disruption	No effect
Main indicators of the construction industry	9%	15%	23%	53%
Output of new construction by category	8%	14%	21%	57%
New construction by type of project	8%	13%	20%	59%
Construction costs per square meter	8%	12%	20%	60%
Dwellings completed by sector, district and type	7%	12%	19%	62%
Indices of costs in the construction sector	7%	11%	19%	61%
Cost Analysis by construction activity	8%	12%	20%	60%
Price index of construction materials	6%	11%	19%	64%
Building permits authorized	5%	10%	18%	67%
Employment in construction	4%	9%	16%	71%

Respondent Views on the Quality of the Statistics

In the survey, the extent of respondents‟ satisfaction with the quality of the construction statistical outputs was ascertained in line with the following European Statistical System (ESS) dimensions of quality; *timeliness*, *accuracy*, *relevance*, *accessibility* and *clarity*, *coherence* (comparability with other data). In addition respondents‟ views were also asked on information available for how data is collected and level of details in the statistics.

The Likert scaling technique was adopted and applied to a majority of questions for ease and uniformity of response. Its application implied for the most part that analysis of data was based on a scoring system. Respondents were asked to state the extent to which they agreed with each statement by using a 5-point Likert type scale.

As illustrated in the Tables 4., 5., and 6. below, a large proportion of respondents were unsatisfied with the quality of each type of statistics in terms of relevance, accuracy and timeliness due to the lack of information on data collection methods and data quality.

Table 4: I am satisfied with the relevance of the statistics to my work.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Main indicators of the construction industry	10%	11%	3%	44%	32%
Output of new construction by category	10%	12%	2%	42%	34%
New construction by type of project	11%	13%	2%	41%	33%
Construction costs per square meter	11%	14%	3%	41%	31%
Dwellings completed by sector, district and type	12%	15%	2%	43%	28%
Indices of costs in the construction sector	12%	14%	2%	42%	30%
Cost Analysis by construction activity	11%	15%	3%	42%	29%
Price index of construction materials	12%	15%	3%	44%	26%
Building permits authorized	10%	11%	3%	43%	33%
Employment in construction	9%	11%	3%	44%	33%

Table 5: I am satisfied with the accuracy of the statistics

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Main indicators of the construction industry	18%	17%	3%	42%	20%
Output of new construction by category	17%	15%	2%	40%	26%
New construction by type of project	17%	16%	3%	39%	25%
Construction costs per square meter	18%	17%	3%	41%	21%
Dwellings completed by sector, district and type	16%	16%	3%	40%	25%
Indices of costs in the construction sector	15%	15%	2%	41%	27%
Cost Analysis by construction activity	14%	15%	3%	40%	28%
Price index of construction materials	14%	16%	3%	42%	25%
Building permits authorized	14%	15%	3%	40%	28%
Employment in construction	13%	13%	3%	43%	28%

Table 6: I am satisfied with how up-to-date the statistics are

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Main indicators of the construction industry	8%	10%	3%	44%	35%
Output of new construction by category	9%	12%	3%	42%	34%
New construction by type of project	10%	11%	2%	41%	36%
Construction costs per square meter	11%	14%	3%	38%	34%
Dwellings completed by sector, district and type	12%	15%	2%	37%	34%
Indices of costs in the construction sector	12%	14%	3%	39%	32%
Cost Analysis by construction activity	11%	14%	3%	38%	34%
Price index of construction materials	10%	13%	3%	40%	34%
Building permits authorized	10%	12%	3%	42%	35%
Employment in construction	9%	10%	3%	45%	33%

Table 7. indicates how unsatisfied respondents were with other key quality attributes of the statistics as a whole. More than 65% of respondents conveyed their dissatisfaction with all of the quality attributes. “Information available for how data is collected” gained a high disapproving rate, both with 70% of respondents feeling very dissatisfied or dissatisfied.

Table 7: Respondents satisfaction on the following aspects of the statistics

	Very satisfied	Satisfied	Undecided	Dissatisfied	Very dissatisfied
Clarity of presentation	12	18	2	41	27
Ease of access	14	19	2	36	29
Comparability with other data	13	17	2	40	28
Level of detail	14	18	2	40	26
Information available for how data is collected	11	16	3	42	28

CONCEPTUAL FRAMEWORK OF CONSTRUCTION STATISTICS PROGRAM FOR NORTH CYPRUS

Figure 5. shows the conceptual framework of construction statistics program. The flowchart illustrates how data in surveys are collected and employed in providing direct estimates or as input to construction statistics programs. Information on building permits issued for new private residential construction is collected from permit-issuing jurisdictions on number of housing unit permits issued and their permit valuation. These statistics are a leading economic indicator. Data are to be collected monthly from a sample of permit issuing places and annually from the remaining permit issuing places. Monthly, quarterly and annual estimates of housing units authorized by building permits can be available on the Internet. The survey of output for construction collects and publishes information on residential units started, sold, and completed each month. Information is collected directly from construction firms by field representatives. Firms should report business receipts, payroll, assets, and other economic information as well as types of construction they are engaged in during the year of the census. Included in the reports are values of work by type of construction, statistics by size classes, assets data, etc. The system achieves a more rapid collection of data, fewer late reports, and better quality of data since questionable responses are to be verified immediately. All data

collected in the field are to be transmitted directly to headquarters for review and tabulation. Monthly estimates of starts, sales, and completions are made at the national level and for regions, and starts and completions estimates are made for selected regions for type of buildings. The quarterly or annual estimates will include units started, units sold, units completed, and a wide range of characteristics of housing such as sales price, square footage of house, presence of garage, etc. Starts and completions estimates are to be published as preliminary, first, and second revisions. Since sales estimates are subject to greater numbers of late reports than starts and completions, they may have a third revision.

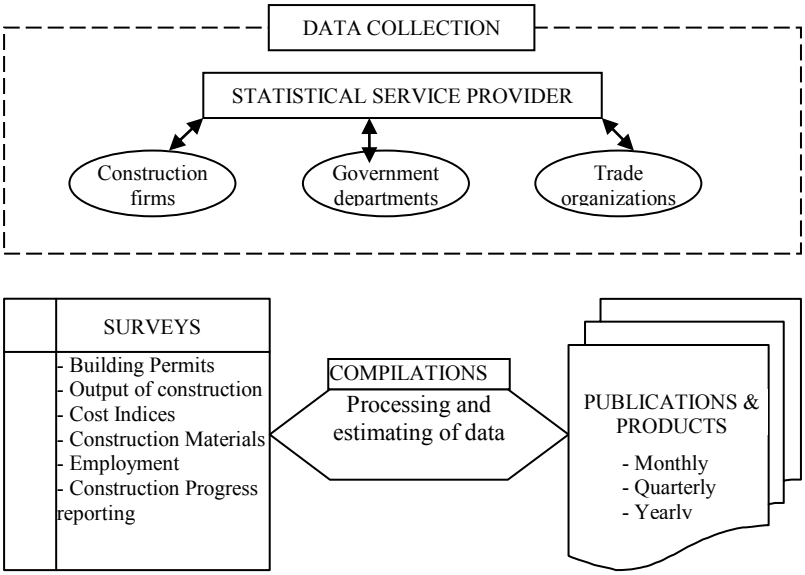


Figure 5: Conceptual Framework of Construction Statistics Program

CONCLUSIONS AND RECOMMENDATIONS

The review of construction statistics documented and examined data collection and compilation methodologies used to produce the statistics. It identified user needs and requirements for the statistics and ascertained their views on quality of the statistics through user consultation. The production of the statistics draws on a multitude of data sources and requires coordinated efforts from SPO-DSR, UCCTEA and ACTCC. The findings of the review indicate that the current data collection methodologies need improving to address various quality issues such as the coverage and accuracy of data inquiry panels.

The statistics have users from various backgrounds with a variety of purposes. Main uses include monitoring market information and assessing industry trends. Material supplier firms and trade associations account for more than half of respondents. The majority of respondents from the construction industry consider the statistics essential and helpful. Respondents‟ views on the quality of the statistics are mainly negative, because they are unsatisfied with the information available on how data is collected, indicating improvement needed in this area. Respondents from the industry have a stronger need for continuing the statistics than those from the government. The review also identified several user requirements for both existing statistics and new data.

This review of construction statistics also provides a conceptual framework of statistical information to be presented in a more comprehensive content, sufficient portrait, highly

reliable in terms of quality, and responsive to dynamic changes of the sector (inflation, structural adjustment policies etc.). Additionally, it is aimed to detect and minimize the uncollected information and thus make contribution for prevention of unregistered activities within the sector.

Recommendations

The main recommendations of the review are for improving the methodologies used to compile the statistics, for user consultation, for user requirements, and compliance with the statistical code:

- The coverage and accuracy of the sample panels used in the data inquiries should be regularly monitored and checked against other sampling frames and with relevant trade associations to ensure the representativeness of the data.
- DSR should consider options for improving response rates
- Methodologies used to process survey results should be improved.
- Sharing the responsibility of collecting and publishing the statistics with others should be considered.
- Wide and regular user consultation should be maintained continually through various ways such as meetings of Consultative Committee on Construction Industry Statistics and periodic on-line consultations.
- DSR should look into publishing more data alongside the existing statistics as requested.
- DSR should investigate how to modify the coverage of the statistics, maintaining their relevance to users and affordability.
- DSR should publish supporting commentary
- DSR should publish a revisions policy, and explain the nature and extent of revisions when revised statistics are released.
- DSR should set out a quality improvement plan to address quality issues identified during this review.
- DSR should ensure the staffs who deal with confidential data sign declarations covering their obligations

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THE ROLE OF RESPONSIBLE SOURCING IN CREATING A SUSTAINABLE CONSTRUCTION SUPPLY-CHAIN

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Abstract
Responsible sourcing (RS) provides a means to manage and ensure the attainment of sustainability objectives by procuring materials with a certified provenance. It is demonstrated typically through an organisation"s procurement policy, via its purchasing decisions and practices, and addresses a range of environmental, economic and social considerations. In the UK, the government requires that 25% of construction products shall be from RS schemes by 2012 and major contractors are considering raising this target even further for major commodities like aggregates, metals, steel, concrete, bricks and glass.Results from an industry survey and company case studies show that major materials industries are instrumental to provision of RS goods; architects, clients and major contractors will drive change in the supply-chain; scope for enhanced reputation and market differentiation are encouraging many companies to seek certification. RS has the potential to transform the construction supply-chain into a transparent and sustainable enterprise; market forces and the notion of „doing the right thing" may determine its more widespread adoption.

Keywords: Construction materials and products; Procurement; Projects; R&D; Sustainability.

INTRODUCTION

The construction industry is subject to growing stakeholder expectations about the accountability, transparency and legitimacy of its operations. This arises from concerns about:

- environmental impacts
- global supply chains
- labour and welfare conditions
- bribery and corruption

It is time to act on these concerns and ensure that the UK construction industry is responsibly sourcing its materials and products. Although there is no one single definition for responsible sourcing (RS) of construction products, it refers to the management of sustainability issues associated with materials in the construction supply-chain, often from an ethical perspective. Responsible sourcing of construction products offers a novel way to improve the implementation and traceability of sustainability objectives throughout the project supply-chain. The emergence of RS as a means to manage and ensure the attainment of sustainability objectives by procuring materials with a certified provenance, offers potential for improved sustainable procurement practices and higher scores in established sustainability assessment tools (Glass, 2011 forthcoming). Government initiatives for RS have changed the way that the construction materials supply chain is judged and a fast-increasing number of products are becoming certificated to new framework standards on responsible sourcing. This paper reports new results on the current state of RS practices in the UK construction industry. The key objectives of a survey and interview programme, with specifiers, contractors and manufacturers, were to understand:

1. the current scope and definitions of RS
2. drivers and benefits
3. who takes responsibility for RS on projects
4. the current state of RS assessment and certification

The outcomes from this work will help to define future directions for research on RS within the construction sector.

ABOUT RESPONSIBLE SOURCING

Use of the term „responsible sourcing" (RS) is relatively new due to the recent governmental sustainability strategy: Strategy for Sustainable Construction (HM Government, 2008), which encourages the construction industry to select responsibly sourced products. It stated that, by 2012, 25% of products used in construction shall be from schemes recognised for responsible sourcing and asked for framework standards to be developed, which it described as „*a documented set of criteria setting out the obligations of an organisation in managing the supply of construction products in accordance with a set of agreed principles of sustainability*" (HM Government, 2008). RS schemes therefore are expected to be more comprehensive than „chains of custody" such as Forest Stewardship Council (FSC) and managerial systems such as International Organization for Standards (ISO).

Responsible sourcing is demonstrated typically through an organisation"s procurement policy, via its purchasing decisions and practices, and addresses a range of environmental, economic and social considerations. It can be perceived as taking an ethical approach throughout the supply chain, but does not pertain only to social issues. Such attitudes are now enshrined in standards, for example, BS ISO 26000 (2010) urges equal consideration of ecological, economic and social development goals, together with broader scale adoption of principles of social responsibility.

Use of the term „responsible sourcing" has appeared only relatively recently in the context of the construction industry, namely in response to government strategy, which will be discussed late. Taylor (2008) suggests that responsible sourcing demonstrates that an organisation or industry „*accepts a broader responsibility for its licence to operate, beyond profit-maximising activities*", thereby seeking to „*avoid damage to bottom line economic performance by improving procurement policy, labour practices and management of environmental impacts*". His interpretation underpinned the development of the first framework standard for responsible sourcing, BES 6001 (2009), which is also discussed later, but importantly now defines the responsible sourcing of construction products as: *„a holistic approach to managing a product from the point at which a material is mined or harvested in its raw state through manufacture and processing, through use, re-use and recycling, until its final disposal as waste with no further value".*

This will affect procurement policy, supply chain management, product manufacture and specification practices, but will necessarily improve both accountability and traceability in the supply-chain. New (2004:271) asserts that „*...the notion of supply chain ethics cannot be swept away... buyers in particular will share some responsibility for the actions of suppliers".* Indeed, in other sectors like fashion, food and mining, companies and industry partnerships have already reacted to concerns about environmental degradation, child labour, unsafe practices, bribery and corruption by setting up ethical or voluntary codes of conduct. Specific examples include well-known voluntary, ethical trading initiatives such as Fair Trade and Rainforest Alliance for various consumer goods, plus certification schemes for materials such as the Forestry Stewardship Council (FSC). There are also supplier data exchange and auditing schemes, such as Sedex (www.sedex.org.uk) and StringTogether (https://stringtogether.com), used by companies in the clothing industry to handle detailed information on the provenance of materials, products and services, and new reporting mechanisms, such as FTSE4Good, the Global Reporting Initiative, and SA8000 from Social Accountability International, www.sa-intl.org), to report, audit and compare performance.

THE UK CONSTRUCTION INDUSTRY APPROACH

To encourage construction industry specifiers and clients to select responsibly-sourced products, the „*Strategy* for *Sustainable Construction"* (HM Government, 2008) sought to move away from the criteria set out in „chain of custody" schemes like FSC and management systems such as ISO 14001 (2004). It stated that, by 2012, 25% of products used in construction shall be from schemes recognised for responsible sourcing and asked for framework standards to be developed to evidence the management of: „*...the supply of construction products in accordance with a set of agreed principles of sustainability*". Two such documents now exist:

- BES 6001 *Framework standard for the responsible sourcing of construction products v2* (BRE Global) details a series of organisational management, supply chain

management and, environmental and social requirements; it covers legal compliance, management systems, traceability and more specific aspects such as waste management, transport impacts and life-cycle assessment. For each item, it sets out specific criteria against which achievement can be scored; there is a threshold level of achievement which acts as a barrier to entry and four levels of performance (see http://www.greenbooklive.com/page.jsp?id=169 for a list of certified products).

- BS 8902 *Responsible sourcing sector certification schemes for construction products – Specification* (BSI, 2009), sought to create a „standard for standards", defining responsible sourcing as „management of sustainable development in the provision or procurement of a material or product". This is a more straightforward document and contains a useful list of headings or issues that should be addressed in any responsible sourcing scheme. However, it was designed to be applied at sector-level, rather than specific products, so is not considered here in quite as much detail as BES 6001.

A responsible sourcing scheme enables individual manufacturers to gain accreditation for their products to a „standard framework" for a particular product/material group (i.e. concrete, timber etc). The manufacturer is then able to promote specific products as „responsibly sourced", based on its achievement on the rating system used (e.g. „Good", „Very Good" etc). This score can be used in established sustainability assessment tools, e.g. the Building Research Establishment Environmental Assessment Method (BREEAM, see www.breeam.org) and the Code for Sustainable Homes (see www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/). CEEQUAL, the civil engineering environmental quality scheme, also makes specific reference to materials from responsible sourcing schemes in version 4 (section 8.3) (see www.ceequal.co.uk).

Furthermore, RS offers a neat link between the „triple bottom line" aspects of sustainability and management of corporate responsibility. For this reason, a link is commonly made between responsible sourcing and sustainable procurement, a term which carries significant weight in the construction industry, particularly following publication of the „*Sustainable Procurement Action Plan*" (DEFRA, 2007) which called for change in how the government estate, roads and the supply-chain are procured to better address issues of low-carbon, water, waste and other sustainable development goals. Walker and Brammer (2009) define sustainable procurement as „*procurement that is consistent with the principles of sustainable development, such as ensuring a strong, healthy and just society, living within environmental limits, and promoting good governance*". Although the notion of abiding by a set of principles clearly connects this with responsible sourcing, the terms are not interchangeable; rather, the responsible sourcing of construction products nests within an overall ethos of sustainable procurement. This is evidenced in BS 8903 *Principles and framework for procuring sustainably – Guide* (BSI, 2010), which cites responsible sourcing as an example of good practice in leadership and governance.

However, there is a complete absence of a research agenda on RS and a lack of evidence about its current status in the construction industry. Although certification schemes exist, there is no indication of current levels of knowledge and uptake. The research reported in this paper has collected new data from industry respondents and identified some critical new research directions. The data and conclusions also form an important stepping off point for two related research projects:

- **APRES network on responsible sourcing:** Loughborough University is leading an Engineering and Physical Sciences Research Council funded academic-industry network (Action programme on responsible sourcing, APRES) to develop a coordinated response on responsible sourcing (see http://apres.lboro.ac.uk). The overarching aim is to react to the challenges of delivering responsible sourcing, by creating a community „centre" for knowledge-sharing of responsible sourcing practices, forging new research ideas and relationships. It provides an open and impartial discussion forum for industry and its customers, academics, government, professional bodies, trade associations and standard-setting bodies. A core group of companies and leading universities has already signed up to the APRES network (Bovis Lend Lease, Building Research Establishment, Responsible Solutions, URS Scott Wilson, University of Bath, University of Nottingham, University of Warwick), together with over 40 Associate Members.
- **Ready for responsible sourcing – SME training package:** The aim of this research project was to develop a new suite of training resources on the responsible sourcing of construction products; see www.responsible-sourcing.co.uk. It targetted both demand-side specifiers (i.e. architects, engineers and contractors) and supply-side manufacturing enterprises. It was funded by Sustainable Construction innovation Network (iNet), which is funded by East Midlands Development Agency (*emda*) and the European Regional Development Fund (ERDF); the project partners were Loughborough University, the University of Nottingham and Responsible Solutions.

RESEARCH APPROACH

This research study used qualitative and quantitative research methods. An online questionnaire survey was developed and circulated to a variety of stakeholders, including: materials manufacturers, contractors, specifiers – including architects and engineers, sustainable construction experts and advisory bodies, trade associations, regional bodies with a construction and/or sustainability remit; small and medium enterprise (SME) networks and peer/industry networks. A total of 51 organisations responded to the survey, which was then complemented by 15 interviews with key specifiers (contractors and designers) and manufacturers to discuss issues in more detail; their roles are shown in Table 1. The majority of informants were senior level staff; over 20 were from contracting companies, 15 were based in material/product manufacturers and 12 were from specifiers.

Table 1: *Respondents" roles within their organisations.*

Position	**Number of citations by respondents**	
	Survey	**Interviews**
Director/Manager/Responsible/Head	28	13
Supervisor/Leader/Trainer	3	-
Champion/Executive	3	-
Advisor	2	-
Designer/Engineer	5	-
Researcher/Scientist	2	1
Lecturer	1	-
Other	1	1
Unknown	6	-
Total	66	

Based on the objectives, the project team brainstormed a list of possible topics that the industry survey and interview instruments might include. These included: *"Company profile", "Corporate sustainability and RS", "Manufacturing and specifying for RS"*. From this list, draft questionnaires were developed and piloted with ten industry experts and experienced researchers. The answer formatting options to forms were further examined for fitness-for-purpose; clarity and variety.

The main benefits of using an online survey tool are its ability to present questions in a neat and uniform way, offer a gateway for data collection and perform basic analyses on the received data. This enabled the data analysis to be fairly straightforward and descriptive, although a cross-tab was used to examine and differentiate answers. An interview protocol for asking questions and recording information during the qualitative interviews was designed. This protocol comprised a heading, instructions to the interviewer, key research questions; probes to support key questions; space for recording the interviewer"s comments; and space for the researcher records reflective notes, in addition to audio recording of the interviews. The data were transcribed, prepared for analysis and organised categorically and chronologically, reviewed repeatedly and continually coded. The transcribed data were then sorted and categorised into a number of themes under headings, as per Miles and Huberman (1994). In all cases, a comparison was made between survey and interview responses; the results section which follows attempts to draw together some of the key descriptive statistics and major themes; it is followed by a discussion which relates our study to relevant literature.

RESULTS

Understanding the scope of RS

The survey and case study interviews showed a range of understanding and awareness levels of RS in the UK construction industry, despite the freshness of the subject. Respondents understood RS to be part of sustainability, ethics, standards, quality and supply chain management, as shown in Table 2.

Table 2: *Respondents"comments on the scope of RS.*

Theme		Respondents' statements
Sustainability	Environment	Renewable sources; Sustainable products; Low transportation CO_2; Depleting natural resources; Production/transportation; Manner that minimises impact on the environment; Least impact on the environment; Environmental dimensions; Respect the proper definition of sustainability ; Waste recycling; Use and re-use until final disposal; Responsibility for sourcing materials and products; Recycled and recyclable materials; Balanced societal/environmental impacts.
	Society	Local sources; Locally sourced; Provide work for local community; Maximise return for the people involved; Exploited individuals/resources; Enhance the social conditions of the supplying community; Ensure that people have not been exploited; Social dimension; Exploiting vulnerable people; Positive impact on life.
	Economics	Commercial dynamics; Price competitive; No limited categories of expenditure; Economical dimension; Economically and financially sound.
Ethics		Transparency; Fair trade; Responsible manner; Suppliers are treated ethically and with respect; Fair pay for workers; Ethical suppliers; Wages and working conditions; Ethos of supply chain management; Assurance;

	Principles; Guarantee; Being sustainable and ethical; Ethical, sustainable approach to procurement; Responsible manufacturer; Ethical and fair price; Ethically resourced; Products manufactured in an ethically sound way.
Standards	Sustainable policies and standards; Aspiration laid down in the Code for Sustainable Homes; Labour standards; Meeting legislation.
Quality	Standardisation and certification by 3rd party; Fully legally compliant, transparent fair and third party certified; Health and Safety.
Supply chain management	Approach an organisation takes to manage procurement activities; Ordering only what you need; Procuring materials and products; Process of supply chain management; Point of origin and method of production; Understanding whole supply chain; Product stewardship; Holistic approach to managing the social, environmental and economic impacts; Supply chain; Business requirements; Stage of the supply chain; Effective management; Appropriate environmental, legal, ethical quantity controls in place; Vetted and analysed products and services.

One interviewee stated that RS meant: "*the product and user business are performing at high ethical, quality and safety standards for both business and supply chain*", whereas others linked this with compliance, i.e.: "*sourcing the product and materials to meet with national and international standards... we look at environmental, social, ethical, health and safety issues related to manufacture and supply*". Of the 36 survey respondents who opted to provide a definition, 18 cited sustainability and 11 mentioned supply-chain management; several gave definitions which centred on procurement, for example: *"purchasing from a supplier that can demonstrate its products are manufactured ethically"*.

Examining the drivers and benefits

More than two-thirds of the interviewees stated that RS was highly important to their business. It was the manufacturers that used phrases such as "*extremely important*" and "*very important*", whereas specifiers (i.e. contractors and designers) described RS as "*important*" or "*customer-led*". More than half (54%) of the survey respondents believed that RS would be *"Of utmost importance"* in the next five years and 70% that RS was going to be beneficial to their core business activities. Manufacturers felt that "*having BES 6001 has made it easier to sell more even in a very difficult year*"; it had also enhanced their reputation and confidence. Of the 51 survey respondents, 29 described the benefits of RS; for example, being at the forefront of the market, gaining competitive advantage, showing evidence of duty/CSR and helping towards continuous improvement. One respondent captured the benefits by saying: *"(RS) can improve the rigour of procurement processes, prompt a fuller consideration of whole-life costs, provide a basis for joint improvement activity with suppliers and build reputational capital."* One of the interviewed manufacturers explained the background to this: "*If you take the main drivers of responsible sourcing, some of these came out from BRE documentation in terms of things like BREEAM, the Government"s Code for Sustainable Homes... (for which) you get credits for choosing products coming from RS schemes for the key elements of the building."* Hence, the manufacturer gains a better corporate reputation and more sales from having certified products and the client/building owner attains a higher score in BREEAM, CSH and CEEQUAL assessment schemes by selecting such products. For example, one manufacturer had sought accreditation specifically to gain recognition for products in the Code for Sustainable Homes and increase sales, he said: *"We are very focused on having green credentials. Knowing that we had such a high percentage of recycled material we decided to try for the next level. Also we have a management team that is ready... if you don"t have that it wouldn"t have worked; it has to come from the top*".

Taking responsibility for RS on a project

According to the survey respondents and interviewees, clients and specifiers shared responsibility for the selection of RS products on a project. Many felt that everyone had a role to play, e.g. one manufacturer said: "*everybody in the supply chain has a degree of responsibility... the client has responsibility in procurement because (and) the specifier's responsibility is in specifying the right material.*" 53% of the survey respondents thought clients should take the lead, followed by 12% citing architects and 6% selecting contractors. Indeed, by probing such answers, most interviewees tended to converge on specifiers and/or clients as particularly important. There was a clear sense that some clients were more likely to take a leading role (as „early adopters"), whereas others would latterly be driven by cost, legislation or market forces. Contractors believed that architects and clients were driving the process, but were not always convinced that these parties fully understood what RS meant and in any case, their specification was unlikely to go much further beyond a basic product specification; it would often fall to the contractor to actually select a particular manufacturer and product line. One contractor explained: "*the Client or specifier has the most power to drive RS. We, as a main contractor, do influence that products used are responsibly sourced if we think they (client/designer) are not using products as they should be – we try to influence our clients to source responsibly where we can*". This shows that some major contractors are very proactive on RS and are trying to create stretch goals for their clients.

The current state of assessment and certification for RS

The survey respondents were asked about their awareness of RS credits within the three assessment schemes mentioned previously; 67% were aware of RS credits in BREEAM, 50% CSH and 33% CEEQUAL (although the latter could be due to a bias towards building contractors rather than civil engineering contractors in the sample). This indicates an important gap in specifiers" knowledge of RS and points towards a key barrier to RS becoming more mainstreamed. Furthermore, the product certification standard (BES 6001) was launched in 2008, but less than half of the survey respondents (44%) had heard of it and only eight had actually specified materials with a BES 6001 certificate. That said, more than half of them were actually aware that aggregates, cement, concrete products and steel reinforcement were available through RS schemes; one even thought that there should be a responsibly sourced option for all product types. Seven manufacturers with certification to BES 6001 were included in the interview programme to ensure a balanced response. They considered certification to be an important addition to the construction industry, but raised concerns about the cost and process of attaining the certificate and the fact that RS accounts for only a small percentage of credits available in schemes like BREEAM, CSH and CEEQUAL. That said, the interviewed manufacturers perceived BES 6001 as vital in „setting the bar" at an appropriate level to ensure differentiation, saying that the standard has to remain meaningful. The interview findings also showed that, apart from „point scoring", there are a broader range of driving forces for manufacturers to seek RS accreditation, some of which are internal and the remaining are external (see Table 3); these include corporate reputation, competitors, stakeholder and customer pressure.

Table 3: *Drivers for seeking responsible sourcing accreditation.*

Driver themes		Respondents' statements
Internal	***Main drivers:*** Self confidence Ambition Improve Marketing Recognise strategies	To show what we can do; to be seen as leader in the market; ambition to be No. 1; to identify how to get better; framework for managing our procurement in certain aspects that is better for the business; our intention to increase sales; recognition of Code for Sustainable Homes; we are very focused on having green credentials; we have a management team that is ready to drive that... it has to come from the top.
External	***Main drivers:*** Commercial advantages Enhance strategies Market pressure Competitiveness	Marketing and commercial advantages; to meet with strategies and standards; UK Strategy for Sustainable Construction; we hold standard certifications we decided to go for another one that gathers them all to answer all questions; market place pressure; stakeholder pressure; drive to remain competitive.

There is clearly an increasing demand for RS-certified products in the marketplace: during the time of the research, the number of BES 6001 certificates issued rose from 10 to 43 by early 2011. Although many had been attained by large, multi-national materials companies, the most recent additions to the BES 6001 list (perhaps the start of the „early majority") include small businesses and specialist contractors, indicating a broadening of the adoption of the scheme. Several interviewees have also predicted that the shape of the construction materials supply-chain will be fundamentally changed by RS within the next few years, suggesting that product companies without certification will be at risk of losing market share.

DISCUSSION – CRITICAL RESEARCH DIRECTIONS

The results from the industry survey and interviews now enable us to identify a number of important areas that warrant further consideration and research effort, a few of which are outlined here.

There was concern that the construction sector is yet to alight on a precise definition of what it means by RS; descriptions oscillate around sustainability, supply-chain management and ethics, with some informants making a clear link to corporate social responsibility (CSR). For example, one interviewee suggested that: "*From my point of view about the responsible sourcing is a sort of moral issue. It is about doing the right thing, having the visibility of issues that you have in your supply chain and actually how you manage those*". This confirms Loosemore and Phua"s (2011) view that the construction industry commonly holds a duty-based (deontological) view towards its responsibilities. Indeed, one of the survey respondents said RS was all about: *"showing how responsible we are... it is our duty to give something back and be advocates for the correct procurement of materials".* The emerging literature on ethics and CR, such as Murray and Dainty (2009), Fewings (2009) and Loosemore and Phua (2011), demonstrates a real growth in this research area and it is clear that RS in the construction products supply chain can make an interesting contribution to the debate. For instance, our research confirms that a „compliance" approach towards business ethics is still prevalent in construction and that companies are a long way off from Loosemore and Phua"s (2011:99) integrity-based approach, with its „*long-term changes to espoused and enacted values".*

Certainly the „early adopters" of RS consisted in the main of large companies with integrated management systems and certification for quality, environmental and health and safety management already in place (e.g. ISO 14001, 2004); these features made the BES 6001 assessment process somewhat easier for them because they already had the right systems in place. The importance of management systems is echoed by Holton et al (2010) in their recent study of sustainability management in material manufacturing companies; these systems act as a vital stepping stone towards better engagement with the subject, improved capabilities and market reputation. It is pertinent that Jones et al"s (2010) concern about a lack of focus on the social aspects of sustainability in construction companies (in the US) could be allayed, at least in part, by a greater recognition that RS includes a robust examination of social and moral issues.

Some of our respondents believed that transparency on performance was the common requirement for a product to be described as responsibly sourced. Interestingly, the notion that business should be more transparent and accountable is now firmly embedded in international practice. Commentators like GRI (2010:43) and Lueneberger and Goleman (2010:7) go further, respectively foreseeing „integrated storytelling" and „radical transparency" in years to come, which only serve to reinforce the potential future role for RS as an important mechanism for construction product businesses. We can envisage greater and greater pressure on companies and projects to disclose information on environmental and social indicators in a live and interactive way; this opens up opportunities for IT support tools to help companies communicate their RS performance with stakeholders.

Finally, McKinsey"s (2010) recent survey of 1,946 global business leaders (from a range of countries and sectors including construction and engineering) confirms that companies for which sustainability is a top-three priority are much more likely to actively seek opportunities and embed sustainability into business practices. While this is a truism, some of our interviewees demonstrated a lack of knowledge and understanding in some key areas of sustainable construction, which indicates an important gap between corporate values and operational expertise on the ground. In Accenture"s CEO study and strategy to „create the conditions for a new era of sustainability", Lacy et al (2010:48) call for new concepts of value and performance to be embedded at organisation and individual levels, which suggests that any disparity in understanding could prove to be a major pitfall for RS.

CONCLUSIONS AND RECOMMENDATIONS

Responsible sourcing is an effective means of ensuring that all three aspects of sustainability are managed in the construction supply chain, with particular respect to the procurement of materials. It is already embedded in commonly used sustainability assessment tools and the list of responsibly sourced materials is growing steadily:
(see http://www.greenbooklive.com for a list of certified products) . RS is part of sustainable procurement and helps supply chains to audit and improve transparency and traceability. This is an important development for the construction industry, because it rewards those who take their roles in the ethical supply-chain seriously and represents a major step towards better inclusion of sustainability parameters in decision-making on materials.

RS is a complex issue composed of social, ethical and moral, and economical factors which requires the involvement of manufacturers, clients, contractors and designers. However, there is an imbalance in the supply-chain at present with larger manufacturers being well-informed

and pro-active, but very few small companies participating in RS certification. While our findings suggest that many people have heard of „responsible sourcing" of construction products, there was a lack of awareness of certified products and inconsistent awareness of credits for responsible sourcing in BREEAM, the Code for Sustainable Homes and CEEQUAL. It was clear that people did not fully appreciate which materials are available through certified schemes. Findings demonstrated that currently there is no one party that should be solely responsible for implementing RS, as everyone is involved in the process. However, it is the clients and specifiers (i.e. contractors and designers) who are thought to have the most influence, due to their critical involvement in selecting construction products. It is ironic then that these groups do appear, at least on the face of it, to have a lesser understanding of RS schemes than manufacturers do at present.

These findings form an important early part of the evidence base on RS in construction; the study certainly sits within the realm of sustainability, CSR and ethics research, but specific concerns around definitions, scope, roles, SME participation, procurement, management systems and transparency are specific and need to be addressed if responsible sourcing is to make an important contribution to reducing the impacts of the construction supply-chain.

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INTERNATIONAL STRATEGIC ALLIANCES IN CONSTRUCTION: PERFORMANCES OF TURKISH CONTRACTING FIRMS

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Abstract
Firms need various resources and capabilities in order to compete with each other effectively. These resources and capabilities can be acquired, developed internally, or obtained via an ongoing cooperative relationship with another firm through the use of a strategic alliance. The use of strategic alliances in construction industry has increased sharply over the last decade and they are particularly effective in helping a firm maintain a superior competitive position in dynamic environments. Alliances reportedly improve the competitiveness of the construction firms by providing access to external resources, by providing synergies and by fostering rapid learning and change. The purpose of this research is to identify the success factors and key components of the development process of strategic alliances, and propose a process model of strategic alliances performances based on alliance conditions in international construction industry. The research involves a questionnaire survey conducted to the Turkish contracting firms operating internationally. Different types of projects constructed by Turkish contractors in Commonwealth of Independent States, Middle East Countries, African Countries, and other regions of the world between 2002 and 2009, were analyzed and used in the developments made in this study. The results indicate that shared risk, trust between parties, and equity are found to be the most important determinants of strategic alliance success. The research findings support the contracting firms enhancing their productive capacities and acquiring competitive advantages that enable them to increase alliance performances. The study also commences on how the identified factors enhance the effectiveness of the participating firms' competitive strategies by providing for mutual resource exchanges (technologies, skills, or products).

Keywords: Strategic alliances, international construction, success factors, Turkish contracting firms

INTRODUCTION

The globalization of the construction industry is rendering the familiar model of a single firm doing all things in-house outdated. The technological, sharing sources (workmanship, machinery, equipment, etc.), political, financial and competitive capabilities that are required to operate in the global construction market means that firms need to establish alliances with other participants in order to survive. Alliances are defined as voluntary arrangements between firms involving exchange, sharing or co-development of products, technologies or services (Gulati, 1998; Ngowi, 2007). In the construction industry, alliance organizations are

employed when parties that are involved in similar activities, such as contractors joining forces to leverage their complimentary capabilities to carry out work. This occurs in situations where risks are too high for subcontracting to be viable. The cooperative aspect arises from the fact that each firm needs access to the other firm's know-how and that the firms can collectively use their knowledge to produce something that is beneficial to them all (common benefits). The competitive aspect is a consequence of each firm's attempt to also use its partner's know-how for private gains, and of the possibility that significantly greater benefits might accrue to the firm that finishes learning from its partner before the latter can do the same (Khanna et al., 1998). Interfirm collaborations, such as strategic alliances, have become important business management instruments to improve the competitiveness of firms, especially in complex and turbulent environments. Alliances help to bridge the gap between the firm's present resources and its expected future requirements (Eisenhardt and Schoonhoven, 1996). In this time of globalization and radical technological change, alliances have become important strategic manoeuvres in construction industry.

As is the case for many other export-oriented economic activities in Turkey, the unique geographical location of Turkey at the crossroads of three continents -Europe-Asia-Africa- contributes a great deal to the global competitiveness of Turkish construction products and services abroad. However, Turkeys location is only one contributing factor to this competitiveness of the sector, as the country can also boast cost effective service at international standards, high client satisfaction, credibility in partnerships, extensive knowledge and experience gained in a wide variety of projects, familiarity with the business environments in the nearby regions, qualified manpower and a calculated risk-based approach to business. The Turkish construction sector comprises a group of businessmen at the crossroads of three continents that are active in each country in the Eurasian market of 580 million people, covering an area of 26 million km^2. Turkish contracting firms are open to international partnerships, not only in the field of contracting but also in construction industry investments, ranging from the manufacturing of construction materials to infrastructure, housing, industry and tourism. Extensive know-how and experience gained through working abroad for nearly four decades in all kinds of challenging engineering projects and in all forms of business environment are among their distinctive strengths.

There is a significant change in the pattern of Turkish overseas contracting firms portfolios. Turkish contracting firms are now exploring the significant needs of the products and services of the countries in which they are operating or intending to operate. They are catering to those needs with whole package offers consisting of basic or process engineering, feasibility studies, equipment selection and extension of credit. So far, the total value of projects undertaken by the Turkish contractors has reached $33 billion US (the projects still under progress amount to $15 billion US). The present share of the Turkish construction sector in the international market is about 10% and today, Turkish contractors play a major role in the international arena and are active in more than 25 countries. The experience gained in the Middle East and Common-Wealth Independent States (CIS) carried the Turkish Contractors to an outstanding position in comparison with their competitors some additional advantages such as geographical proximity, low labor cost and high quality technical personnel make Turkish contractors noteworthy. Within the six year period between 2002 and 2009, the annual volume of business undertaken abroad increased from 1.7 billion USD in 2002; to 23.6 billion USD in 2008. In 2009, because of the affects of the global crisis, this figure decreased to 18.8 billion USD. The internal and external forces and factors that have contributed to this rapid development can be grouped under the following three categories: the attractiveness of business opportunities abroad; reduced business opportunities in Turkey;

and the increasing competitiveness of Turkish contracting firms. Further market diversification and specialization in certain types of projects were the major trends in this period. The number of countries in which Turkish contracting firms was working increased considerably, causing the percentage of work in each country to decrease relatively. Nevertheless, the Russian Federation maintained the first rank (18.90%), followed by Libya (10.73%) and Kazakhstan (8.07%). In this period, the United Arab Emirates (7.05%), Qatar (6.57%), S. Arabia (6.06%), Azerbaijan (4.12%), Romania (3.86%), Turkmenistan (3.84%), Iraq (3.33%), Oman (2.93%), Afghanistan (2.79%), Algeria (2.69%), Jordan (2.47%), Bulgaria (1.99%), Ukraine (1.85%), Morocco (1.83%) and Ireland (1.46%) emerged as new markets. In the aftermath of the interventions in Afghanistan and Iraq, the rebuilding activities in these countries were closely followed by Turkish contracting firms. The types of work undertaken during this period and their relative shares in the total business volume were as follows: road/bridge/tunnel works (15.28%), commercial centers (12.80%), housing (9.41%), industrial plants (7.56%), pipelines (7.47%), social and cultural facilities (7.39%), airports (6.98%), power plants (5.38%) and petrochemical plants (4.13%). In this period, significant progress was made in terms of the scope and size of projects being undertaken. Market, product and business diversification continued further, while several companies started to specialize in certain project types, such as international airports, railways and urban subway systems.

Firms need various resources and capabilities in order to compete with each other effectively. These resources and capabilities can be acquired, developed internally, or obtained via an ongoing cooperative relationship with another firm through the use of a strategic alliance. The use of strategic alliances in construction industry has increased sharply over the last decade and they are particularly effective in helping a firm maintain a superior competitive position in dynamic environments. Alliances reportedly improve the competitiveness of the construction firms by providing access to external resources, by providing synergies and by fostering rapid learning and change. The research focus is to 1) explore the key elements of the strategic alliance process 2) identify the potential success factors in strategic alliances, and 3) develop a conceptual framework of strategic alliance that would reflect more about the real practices of alliancing in international construction industry..

STRATEGIC ALLIANCES IN CONSTRUCTION INDUSTRY

The ensuing globalization of the construction industry as well as the highly fragmented and divisive nature of the industry are among the forces that are influencing it to seek management approaches such as strategic alliances that could leverage the capabilities of the various participants (Ngowi, 2007). Strategically, organisations may enter into alliances (a form of partnership) in order to innovate, access new markets, overcome local market restrictions, raise entry barriers and share risk for mutual benefit (Stanek, 2004).

A strategic alliance is a cooperation with a duration longer than a project, which has the intention to change the product market competence combinations of the participating partners. These partners share the rewards and risks. They conscientiously create a level of mutual dependence and exclusivity, without losing their independency. Implicit rules of trust and equality apply to the mutual interaction and attitude (Snijders and Geraedts, 2007). Alliancing is generally assumed to be a long-term business strategy linking together client, contractor and supply chain (Rowlinson and Cheung, 2004). Alliance partners are brought together for a specific outcome or project, where risks and rewards are jointly shared and there is goal alignment between parties. Alliance between firms that are engaged in similar

activities has both cooperative and competitive aspects. While the former enables the firms to leverage their complementary capabilities for common benefits, the latter tend to push the allied firms to engage in competitive racing in learning the capability of the partner(s) for private benefits (Ngowi, 2007; Khanna et al., 1998)

Research has documented numerous benefits that strategic alliances hold out for small firms, including the ability to tap into new markets, access scale economies, obtain complementary resources in under-developed value chain activities, respond to environmental uncertainties, and receive endorsements from reputable incumbents, among others (Arino et al., 2008; Deeds and Hill, 1996; Dickson and Weaver, 1997; D'Souza and McDougall, 1989; Eisenhardt and Schoonhoven, 1996; Gomes-Casseres, 1997; Hara and Kanai, 1994; Larson, 1991; Shan, 1990; Stuart et al., 1999).

Process of Strategic Alliancing

Strategic alliancing is typically characterised by a number of phases ranging from the selection of contract participants through to the completion of the correction period. There is a common premise in the management perspective of strategic alliance that the process should be composed of three stages (i.e., formation, implementation, and evaluation) (Buono 1997; Das and Teng, 1999).

In this study, the process of strategic alliance is composed of four stages unlike the past studies. These stages are Alliance Planning, Alliance Formation, Alliance Implementation, and Alliance Completion. Alliance Planning refers to strategy development and partner assessment. Strategy development involves studying the alliance's feasibility, objectives and rationale, focusing on the major issues and challenges and development of resource strategies for production, technology, and people. Partner assessment involves analyzing a potential partner's strengths and weaknesses, creating strategies for accommodating all partners' management styles, preparing appropriate partner selection criteria, understanding a partner's motives for joining the alliance and addressing resource capability gaps that may exist for a partner. Alliance Formation refers to an agreement, implicitly or explicitly, made by all key construction parties to establish an informal relationship for the purpose of accomplishing mutually agreed upon goals and objectives. During this stage, involved parties should prepare to diagnose their current practices and to address their concerns about what partnering can help them to fill the performance gap. They may be required to unfreeze their mind to accept the needs for change when they accept the concept of partnering. Alliance Implementation refers to the execution of the informal relationship to accomplish the mutually agreed goals and objectives in line with the construction project. At this stage, alliancing is operating to exert its influence on the construction projects. It is a process to learn and experience the newly adopted concepts and practices derived from alliancing. Alliance Completion refers to the intention of the construction parties to rerun an informal relationship with the same group of firms for a new project after the completion of the current project. Most often, if construction parties aim at implementing alliancing for a single project, the alliancing team will be resolved after the project is completed.

Determinants of Strategic Alliance Performance

Multiple factors determine the performance outcome of strategic alliances, ranging from the nature of the industry and institutional environment, within which the alliance operates, to the quality and commitment of the alliance management. Successful alliancing requires creativity, trust, commitment, interdependence, cooperation, open communication, goal alignment and joint problem solving (Peters et al., 2001; Howarth et al., 1995; Hampson and

Kwok 1997; Rowlinson and Cheung, 2004). Alliance structure is also a highly relevant factor in alliance performance. Parkhe (1993) reports that appropriate alliance structure curbs opportunistic behavior and leads to better alliance performance. Alliance structure serves the purpose of control in alliances, which is critical because of the shared nature of alliance governance (Das and Teng, 1999).

Collaboration between alliance partners is essential for a successful alliance project. During collaborations, alliance partners are able to share resources including professional expertise; this initiates a higher frequency of ideas flow – after all, two heads are better than one. Alliancing will not succeed without continuous flow of information and communication. Through open and honest communication, foreseeable risks are exposed and parties have a better understanding of each other's needs. Trust, continuous open communication and knowledge sharing are the keys to successful alliancing (Rowlinson and Cheung, 2004). During the life of alliances, the internal and external circumstances may change, often in unexpected ways (in the construction industry circumstances continuously change). How partners adapt to these changing circumstances determines whether an alliance prospers or flounders (Kraar, 1989; Ngowi, 2007). Successful adaptation of these changes calls for a delicate balance between the twin virtues of reliability and flexibility. Flexibility is necessary for partners to have a viable relationship in the face of changing circumstances, yet unlimited flexibility affords companies the opportunity and incentive to cheat, reducing the reliance partners can place on each other (Heide and Milner, 1992; Ngowi, 2007). Black et al. (2000) indicated that partnering experience is a critical factor toward partnering success. Firms learn and experience the newly adopted concepts and practices derived from partnering application. Wu et al. (2009) report that previous alliance experiences is a significant criteria of strategic partner selection process. Firms with experience in international strategic alliance activities may place more value on a partner with potential for development of new technology/knowledge and learning (Nielsen, 2003).

A number of researchers gathered lists of factors that are considered to be influential upon the success of strategic alliances. Table 1. summarises the literature of key success factors for strategic alliances.

Table 1. List of Alliance Success Factors and Sources

No	Factors	Source
1	Mutual goals & objectives	Green and Lenard (1999); Haque et al. (2004); Jefferies et al. (2006)
2	Tight alliance outline	Elliot (1998); Abrahams and Cullen (1998)
3	Alliance structure	Abrahams and Cullen (1998); Haque et al. (2004)
4	Commercial incentives	Abrahams and Cullen (1998); Haque et al. (2004); Jefferies et al. (2006)
5	Stretch targets	Green and Lenard (1999); Haque et al. (2004); Jefferies et al. (2006)
6	Partnering experience	Cheng and Li (2002), Black et al. (2000); Wu et al. (2009); Nielsen (2003)
7	Open communication	Haque, Green and Keogh (2004); Cheng and Li (2002)
8	Trust Between Parties	Elliot (1998); Green and Lenard (1999); Haque et al. (2004)
9	Flexibility & adaptability	Elliot (1998); Jefferies et al. (2006)
10	Shared risk	Bennett and Jayes (1995)
11	Adequate resources	Cheng and Li (2002)
12	Equity	Green and Lenard (1999); Haque et al. (2004)
13	Cooperative spirit	Elliot (1998); Abrahams and Cullen (1998); Haque et al. (2004)
14	Facilitation	Abrahams and Cullen (1998); Haque et al. (2004); Jefferies et al. (2006)
15	Sound relationship	Elliot (1998); Abrahams and Cullen (1998)
16	Best people for project	Abrahams and Cullen (1998); Haque et al. (2004)
17	Strong Commitment by senior management	Elliot (1998); Green and Lenard (1999); Abrahams and Cullen (1998); Haque et al. (2004); Jefferies et al. (2006)

18	Good cultural fit	Black, Akintoye, and Fitzgerald (2000)
19	Joint process evaluation	Green and Lenard (1999); Abrahams and Cullen (1998)
20	Shared knowledge	Abrahams and Cullen (1998); Haque et al. (2004)
21	Dispute resolution process	Green and Lenard (1999)
22	Continuous improvement	Larson (1991)

RESEARCH METHOD

Sampling

A list of contracting firms within the construction sector operating internationally was obtained from the Turkish Contractors Association (TCA). The list consisted of 185 member organizations. The sample includes relatively medium to large companies. Company size is determined by the number of professional staff, number of construction projects per year, and the size of a typical project in US dollars. A company with more than 750-1000 employees is defined as large – 75 percent were large size companies. The numbers of international projects per year ranged from 5 to 20 projects, 60 percent were involved 5 to 10 projects. Project size ranged $1.5 million to $50 million (80 percent) and to over $100 million (20 percent). Distribution of international projects by type of work is shared by building construction (32%), transportation (36%), energy (12%), hydraulic works (7%), infrastructure (6%), industrial plant (5%) and other (2%). Major regions for projects undertaken by Turkish contractors abroad were Commonwealth of Independent States, Middle East Countries and African Countries. In this study, small size companies were not taken into consideration and kept out of the survey as they are not included in the TCA main list.

Data Collection

The empirical data was collected through a questionnaire survey, which was administered to the firms registered to the TCA. During the survey, all these firms operating internationally (185 member organizations) were contacted and asked to participate in the study. They were then fully informed of the research objectives, that the research was a strictly scientific and confidential and that their anonymity was assured. A total of 135 completed questionnaires were received, giving a high response rate of 73 per cent indicating that the sampling procedure was effective and that the respondents perceived the research to be relevant and worthwhile. The respondents were asked to rate the extent to of agreement with each statement based on a five point Likert scale of 0 (No effect) to 4 (Maximum effect). Contact personnel in the companies for the questionnaire survey were either the top management or senior management in their respective departments, therefore their level of knowledge expected to provide responses was acceptable for the purpose of validity of the survey results.

The questionnaire survey consisted of 22 statements. The questionnaire covers general information about the initiatives (owners, developers, contracting firms), alliance conditions and alliance development, partnering criterion and key success factors, partnering experiences, and the nature of the benefits accrued.

FINDINGS

The participating contracting firms provided numerical scoring expressing their opinions on the significance of each factor. The weighted average for each factor was calculated and then it was divided by the upper scale of the measurements in what is referred to as “importance index” therefore the level of important of the factors categorized into four processes of strategic alliance development were calculated using the formula (Kish, 1965):

Level of Importance (Index) = [Σ(aX). 100] / 4
a= the score given to the factor by each organization (varying from 0-4)
X= n/N
n= Frequency of organizations
N= Total number of participant organizations

Table 2. shows a matrix of variations in level of important indices of the factors for determining the success factors and key components of the development process of strategic alliances. The X-axis of the matrix indicates the processes of strategic alliance classified into four categories as *Planning, Formation, Implementation*, and *Completion*. The Alliance Success factors were listed in the Y-axis of the matrix with their index values. The matrix also includes the calculated mean of importance indices and the rank orders of all the processes of strategic alliance listed at the bottom of X-axis with their index values. Studying the matrix the factors carrying the highest level of importance are mostly from the process *Planning*. These factors are "Shared Risk", "Trust between parties", and "Equity". In observing the highest ranked process, *Planning* carries the highest level of importance.

Table 2. Matrix showing the Variations in the level of Importance Indices of the factors

			Processes			
Rank	MIP	Factors	Planning	Formation	Implementation	Completion
6	3,07	Adequate resources	57,00	57,00	42,75	57,00
11	1,75	Tight alliance outline	28,50	28,50	28,50	28,50
4	3,73	Alliance structure	71,25	57,00	57,00	57,00
7	2,85	Commercial incentives	57,00	42,75	42,75	42,75
15	0,88	Stretch targets	14,25	14,25	14,25	14,25
4	3,73	Partnering experience	71,25	57,00	57,00	57,00
10	1,97	Open communication	42,75	28,50	28,50	28,50
2	4,17	Trust Between Parties	71,25	71,25	71,25	57,00
13	1,32	Flexibility & adaptability	28,50	28,50	14,25	14,25
1	4,38	Shared risk	71,25	71,25	71,25	71,25
8	2,63	Mutual goals & objectives	42,75	42,75	42,75	42,75
3	3,95	Equity	71,25	71,25	57,00	57,00
13	1,32	Cooperative spirit	28,50	28,50	14,25	14,25
14	1,1	Facilitation	28,50	14,25	14,25	14,25
9	2,41	Sound relationship	42,75	42,75	42,75	28,50
15	0,88	Best people for project	14,25	14,25	14,25	14,25
16	0,66	Strong Commitment by senior management	14,25	14,25	14,25	0
5	3,51	Good cultural fit	57,00	57,00	57,00	57,00
12	1,53	Joint process evaluation	28,50	28,50	28,50	14,25
8	2,63	Shared knowledge	42,75	42,75	42,75	42,75
17	0,44	Dispute resolution process	0	0	14,25	14,25
18	0,22	Continuous improvement	0	0	0	14,25
Mean Importance Index (MIP)			13,59	12,5	11,84	11,4
Rank			1	2	3	4

Discussion of the Survey

The factor "Shared risk" is ranked #1 and is perceived by respondents to have influence on all the alliance processes with a value of importance index 71,25. The interviews and observations highlighted that alliance partners are brought together for a specific outcome or project, where risks and rewards are jointly shared. The findings are in congruence with the literature (Walker and Hampson, 2003, Peters et al., 2001). Through open and honest communication, foreseeable risks are exposed and parties have a better understanding of each other's needs. Under the alliance, all parties should take collective ownership of all risks associated with delivery of the project, with equitable sharing of risks using a risk/reward mechanism (Rowlinson and Cheung, 2005). The risk/reward mechanism are to be adopted in the alliance project which will create financial incentives and equitable risk sharing between the alliance parties. By adopting a risk/reward mechanism, there are motivation incentives for all parties which encourage them to work towards "best for project" solutions.

The factor "Trust between parties" is ranked #2 and is perceived by respondents to have influence on the alliance processes *Planning, Formation, Implementation* with a value of importance index 71,25, and on the alliance process *Completion* with a value of importance index 57,00. The interviews and observations highlighted that trust between alliance partners creates an opportunity and willingness for further alignment (such as future job opportunities), reduces the need for continuous cross monitoring of one's behavior, reduces the need for formal controls and reduces the tensions created by short-term inequities. It allows the partners to focus on their long-term business development as well as cutting down cost and time outlays. The findings are consistent with the literature (Rowlinson and Cheung, 2005). Without trust, there would not be sharing of resources and knowledge; without trust, there would be hidden agendas and closed communication.

The factor "Equity" is ranked #3 and is perceived by respondents to have influence on the alliance processes *Planning*, and *Formation*, with a value of importance index 71,25, and on the alliance processses *Implementation*, and *Completion*, with a value of importance index 57,00. The interviews and observations highlighted that firms try to design alliances that are efficient and equitable at the time of the alliance's establishment. Alliances enhance the value of equity ownership ties between firms. Equity is an important ingredient in developing win-win thinking among parties. The findings reinforce the literature (Allen and Phillips, 2000; Chan et al., 2004; CII, 1991; Husted and Folger, 2004). The development of an equitable relationship between the stakeholders has been found to be necessary as equity promotes mutual motivation when "win–win" solutions were sought rather than the "win–lose" solutions of traditional relationships.

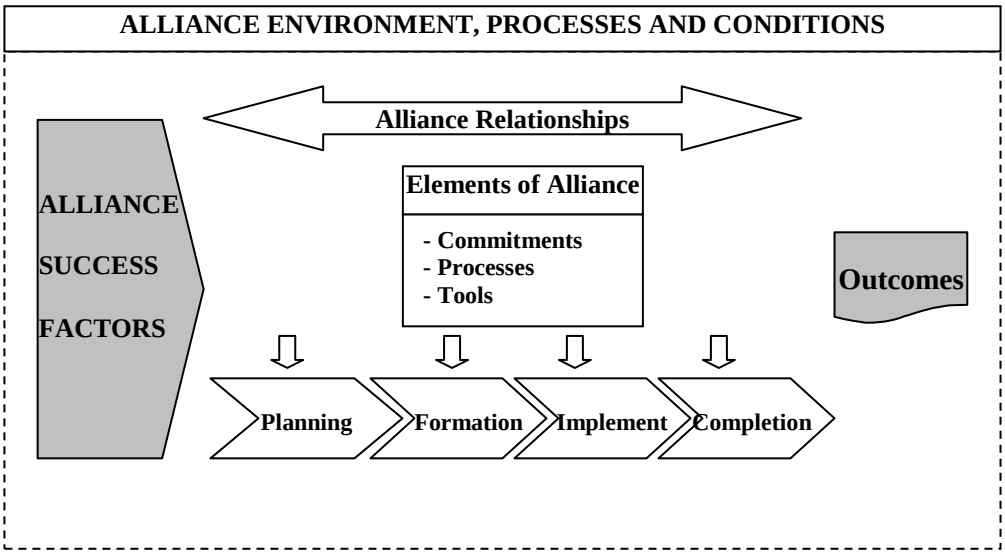


Figure 1. Model Framework of Strategic Alliance

As it is shown in Figure 1., the conceptual framework uses a four-stage process—planning, formation, application, and completion—which forms the basis for considering what factors lead to the success of each stage. In the proposed conceptual framework, it can be seen that the commitment, processes and tools criteria are considered to have the greatest bearing on the establishment and development of the alliance relationship. Successful outcomes of individual projects involving the use of strategic alliance are likely to generate shared rewards and benefits and create an opportunity for the organizations to share risk, develop and build trust and equity between parties, maintain alliance structure, good cultural fit, and achieve joint learning from the experiences. These outcomes act as feedback to the process further strengthening the role of each element and benefit the relationship development process overall. The research findings support the contracting firms enhancing their productive capacities and acquiring competitive advantages that enable them to increase alliance performances. Shared resource exchanges (technologies, skills, or products) between the parties enhance the effectiveness of the participating firms' competitive strategies. In strategic alliances, having a common strategic direction helps firms to have a better understanding of their mutual goals and expectations. Alliance structures should include a learning framework enabling open reflection of partners' knowledge whilst retaining visions and individualism. This allows all parties to benefit from shared knowledge.

CONCLUSION AND RECOMMENDATIONS

This paper presents a survey study for determining the strategic alliances' performances of Turkish contracting firms operating internationally. The success factors and key components of the development process of strategic alliances were identified and a process model of strategic alliances performances based on alliance conditions in international construction industry was proposed. It was found that "Shared risk", "Trust between parties", and "Equity" are found to be the most important determinants of strategic alliance success and *Planning* and *Formation* are the two processes which the interviewees believed would highly be influenced by the success factors mentioned above.

Managers of contracting firms can reduce the risk of alliance failure and can generate more value from their alliances by studying the detailed critical success factors. Process and content issues are equally important for alliance success. Alliance competence, i.e. knowledge of how to forge and manage alliances, could provide contracting firms with the capability to protect their independence while surviving in a tide of globalisation and rapid technological change.

Successful alliance operations require enormous inputs of physical and intangible resources: management skills, production technologies, employee motivation, adaptiveness, innovativeness, and the partners' capacities to set aside direct pursuit of their individual business interests while sharing both the benefits and risks of collaboration. The shared interests of the partners in the alliance create goal alignment which minimizes opportunism, and there is a mutual hostage situation as both partners have made substantial investments and are dependent on each other's performance. These features assist in managing relational risk. As cooperation and competition coexist between alliance partners, cooperative relationship evolves over time as partners learn more about each other's motives, capabilities and attitudes toward control, conflict, cooperation and competition. During this period, and the entire life of the alliance the partners are vulnerable in the various ways. Thus, in successful alliances, trust is often touted as a prerequisite, a necessity, an absolute must.

The challenge for the strategic alliances is minimizing the polarization of construction industry in a global environment. Furthermore, this kind of organizations provide a trigger effect for the contribution of mutual strategy between the developed and developing construction industries through the world.

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EMBEDDING ENERGY SAVING POLICIES IN THE DUTCH NON-PROFIT HOUSING SECTOR

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Abstract
Many studies on policy implementation have emphasized the difficulties of putting policies into practice. The paper presents several ways in which Dutch non-profit housing providers incorporate their energy saving policies in their 'regular' housing management regarding the existing stock, such as planned preventive maintenance, renovations and other physical improvements. Several housing associations were selected that have formulated an energy saving policy and that have at least some experience in implementing these policies. Interviews were held with managers of asset and maintenance management and with policy staff of housing associations. It is investigated to which extent the policy ambitions, both at the portfolio level and at the project level, are carried out, and in which way these ambitions are embedded in the organisations' regular working processes. In addition, the main stimuli and barriers for the implementation of the energy saving policies are identified. Special attention has been paid to the feasibility of combinations of energy saving measures with other physical improvements in the housing stock. Results show that the implementation of energy saving policies in annual improvement and maintenance plans is in most cases not problematic, and that the most significant problems arise during the preparation of individual investment projects.

Keywords: energy saving, implementation, social housing, the Netherlands

INTRODUCTION

As in many other countries, energy efficiency has gained priority on the agendas of governments, housing providers and the building sector in the Netherlands. This paper deals with the implementation of energy efficiency policies of non-profit housing providers (in the Netherlands almost always housing associations), in particular with the way in which these housing associations materialise their own energy policies in their housing management practices.

Dutch energy policy has three major goals: security of supply, environmental quality and economic efficiency. Over the longer term the government aims to achieve a sustainable energy system. Current energy and climate policy focuses on cost-effective measures to carbon-reductions, on energy conservation and sustainable electricity (Kern and Smith, 2008). The official Dutch goals set in reaction to global climate change are ambitious. The Dutch goal states that in 2020 CO_2 emission must be reduced by 30 per cent compared to 1990. In line with EU policy, the Dutch government also aims that 20 per cent of the energy used will be produced sustainably in 2020.
In line with these governmental ambitions, *Aedes*, the umbrella organisation of Dutch housing associations, declared in 2008 that the sector will reduce the natural gas consumption level with 20 per cent in ten years. It also agreed with the Ministry of Housing and *Woonbond*, the national body of tenant organisations, a reduction of energy consumption in new building with 25 per cent in 2011 and with 50 per cent in 2015.

There is a lot of literature on energy saving and other forms of energy efficiency in housing. Among them, many publications deal with energy saving measures and techniques and their application, in individual dwellings (e.g. the use of solar panels, types of insulation, high efficiency boilers), a building block (e.g. heat and cold storage) or at the neighbourhood level (e.g. district heating). A lot of attention is also paid to governmental energy regulations, including taxes and subsidies, subjects on which several internationally comparative studies have appeared (e.g. Beerepoot, 2007; Itard and Meijer, 2008; Sunikka, 2006; Horne, 2008; Engelund Thomsen, Wittchen *et al*., 2008; Schüle *et al.*, 2009; Hamilton *et al*., 2010). In addition, there is growing literature on tools for assessing the sustainability or, reversely, the environmental impact of buildings, for example Life Cycle Assessment (e.g. Fay, Treloar and Iyer-Raniga, 2000; Forsberg and Von Malmborg, 2004; Meijer, 2006). However, the embedding of energy efficiency in the management of individual housing organisations is not often explored, although this subject is important for two reasons.
First, numerous studies show that there can be a wide gap between the policy ambitions and the implementation of these objectives in concrete measures. Many planning studies show a poor implementation of policies due to conflicting interests, miscommunication, misinterpretation and lack of anticipation on possible side effects. In most cases, these implementation studies concern large governmental institutions or large companies, but recent research (Nieboer, 2009) has found similar outcomes for Dutch housing associations, which organisations are considerably smaller (think of a few hundreds of employees). In addition, his research dealt with policies trying to influence *internal* decisions, which are different from most government policies in the sense that these are usually directed towards *external* parties. In his research in the Dutch building sector, Hoppe (2009) found similar results.
Regarding energy efficiency more specifically, there are also many indications for wide gaps between policy ambitions and implementation (e.g. Jaffe and Stavins, 1994; Brown, 2001; Zilahy, 2004; Sorrell *et al.*, 2004; Hoppe, 2009). What is more, many studies regarding the implementation of energy efficiency programmes indicate that progress is often less than what could be expected on the basis of rational models, which assume a smooth translation of

policy into action. Already some decades ago, for instance De Man (1983) and Coltrane, Archer and Aronson (1986) pointed out the importance of social-psychological factors such as personal attitudes in adopting energy conservation programmes. As for housing portfolio management in non-profit housing sectors, recent studies (e.g. Gruis and Nieboer, 2004; Gruis, Tsenkova and Nieboer, 2009) indicate that housing portfolio management is in an early stage of development, despite initial expectations of rapid policy development as a consequence of neoliberal policies and, related to that, reduced government support. Although (particularly in the Netherlands, Australia and the United Kingdom), some studies have focused on transferring approaches from business planning to housing portfolio management (e.g. Van den Broeke, 1998; Larkin, 2000), these planning approaches are not often applied in practice (e.g. Gruis and Nieboer, 2004; Nieboer, 2009a and b).
Second, the implementation of energy efficiency policies at housing management organisations takes place in a political context that was, in the last two decades, dominated by policies that entailed a shift of responsibilities from government to market (Clarke and Newman, 1997; Peck and Tickell, 2002). This has led to a different relationship between government on the one hand and non-profit and other private institutions on the other hand, with government taking a more enabling and a less providing role. This development was particularly visible in the non-profit housing sector (see e.g. Whitehead and Scanlon, 2007; Boelhouwer, 1997 and 1999; Priemus, Dieleman and Clapham, 1999; Priemus and Dieleman, 2002), where government influence is, almost by definition, larger than in the commercial housing sector. The shift away from government control and towards market forces was often coupled with reduced levels of government support, a growth of the owner-occupied sector, and greater independence of housing associations from the government. The shift from government to market has entailed a more dominant role and responsibility for non-profit housing providers to achieve social objectives, for instance in the field of energy saving.
In this paper we focus on the non-profit or social housing sector. The focus on the non-profit sector is particularly important in this context, as evidence from advance performers indicate that it is this that is taking the lead in terms of implementation of energy efficiency policies, not just in individual buildings where the types of measures are selective, but also on a neighbourhood basis.

As has been stated earlier, literature is generally rather sceptic about what to expect as regards the reflection of policies in individual actions. In this light, it is plausible to expect a gap between energy efficiency policies of Dutch housing associations and the realisation of these policies. It is, however, not well known, how wide this gap is and, if there is such a gap, where in the implementation process the main problems occur. As for this process, we distinguish two stages. The first stage is about the embedding of these policies in general steering mechanisms such as the annual investment planning and budgeting. Also the embedding in related policies, such as maintenance policies and rent policies, are addressed. The main focus here is on corporate wide working procedures and related policies. The second stage is about the materialisation of these corporate wide forms of steering in concrete investment projects. The main focus in this stage is at the project level.

The research questions are as follows.
- In which way do Dutch housing associations materialize their policies in their measures regarding maintenance and other investments in their existing housing stock?
- To which extent are planned energy saving measures in investment projects of Dutch housing associations carried out?
- Which stimuli and which barriers do Dutch housing associations encounter when embedding their energy saving policies in maintenance and other investment activities?

The following section goes into the approach of the research. Then, the findings are presented. On the basis of these findings, we draw conclusions and present some recommendations.

RESEARCH APPROACH

The research has been done in two stages. The first stage is about the embedding of the energy saving policies in general steering mechanisms such as the annual investment planning and budgeting. Also the embedding in related policies, such as maintenance policies and rent policies is addressed. The main focus here is on corporate wide working procedures and related policies. The second stage is about the materialization of these corporate wide forms of steering in concrete investment projects.

First stage: energy saving policies

For the first stage, nine housing associations were selected that have formulated an energy saving policy and that have at least some experience in implementing these policies.
The housing associations presented in this paper are anonymously addressed as A, B and so on. Except one housing association with around 4,000 dwellings, all selected housing associations are, to Dutch standards, large organisations. Most of them have approximately 20,000 homes; some of them have more than 50,000 homes.

Interviews were held with managers of asset and maintenance management and with members of the policy staff. In principle interviews were held with people responsible for:

- the asset management and the energy saving policy;
- the maintenance planning and budgeting;
- maintenance projects;
- renovation projects.

Depending on the division of tasks per housing association and knowledge about the subjects, the interviews were held with 2 to 4 persons per housing association. For the interviews a structured checklist was set up. This checklist was tested beforehand by one of the selected housing associations.

Second stage: energy saving projects

The second stage is about the materialisation of these corporate wide forms of steering in concrete investment projects. The main focus in this stage is at the project level. For this research a distinction has been made between 4 types of investment projects:

- void repairs;
- planned preventive maintenance;
- minor improvements;
- major improvements.

For this research void repairs and planned preventive maintenance are considered investment projects. Energy saving measures can be realized simultaneously with void repairs and planned preventive maintenance interventions. Table 1 shows the main characteristics of the investment projects.

	Void repairs	Planned preventive maintenance	Minor improvements	Major improvements
Occasion	Change of tenant	Maintenance planning	Need for quality	Need for quality
Cyclical process	No	Yes	No	No
Realisation per dwelling or housing estate	Dwelling	Housing estate	Housing estate (or dwelling)	Housing estate
Realisation occupied or unoccupied	Unoccupied	Occupied	Occupied	Unoccupied
Service Life extension housing estate	No	No	Possible	Yes

Table 1: *Characteristics of investment projects*

From the nine selected housing associations of the first stage of the research, four were selected for this second stage. The outcome of the interviews at one of the four housing associations gave too little solid information to be included in this paper, so we have included the findings of three housing associations, presented here by the letters A, B, and C. Per housing association projects were selected representing each type of the investment projects. Selection criteria for the projects were:

- significant energy saving measures have been realised that result from the energy saving policy
- the project is typical for the housing association
- the project is (nearly) completed

If possible, per housing association projects were selected with single and multi-family dwellings. Unfortunately, projects representing void repairs were not found at any of the selected housing associations. An additional study is carried out to 'repair' this omission, but the results of this study are not available yet.
The research was done through a document survey and interviews with people of the housing association involved with the projects. For the interviews a structured checklist was used comprising questions about the project management, the results and the process.

FINDINGS

The findings, based on interviews and document study, are divided into the two stages mentioned in the previous section: first the findings about the embedding of the energy saving policies in general steering mechanisms such as the annual investment planning and budgeting are presented. Secondly, the materialization of these corporate wide forms of steering in concrete investment projects is presented.

Policies and goals for energy saving

To make energy saving policies more concrete, ambitions or goals are established. Examples are an ambition for decreasing energy use in terms of percentage, to be reached in a particular year, the number of energy label steps per year, or the removal of the worst energy labels (E, F, or G) within a set period of time.
Mostly, there is a relationship between policies of individual housing associations and the national, local or umbrella organization covenants these individual housing associations follow. A lot of the interviewed housing associations follow the covenant of the Dutch umbrella

organization for social housing associations, which aims to save 2% per year on natural gas, starting in 2008 until 2018.
Table 2 gives an overview of some of the goals per housing association.

Housing association	Goals		
	Total CO_2 reduction	Other	
A	20% in 2018	-	-
B	20% in 2018	Improving/optimizing all dwellings under label D	Striving for label B in renovations
C	20% in 2015	-	-
D	20% in 2018	-	At least a B label when exploitation period exceeds 15 years
E	25% in 2018	-	-
F	2% per year	-	-
G	30% in 2014	No more E/F/G labels in 2014	All renovated homes have at least a B label
H	Unknown	Two label steps if measures are repaid within 20 years	At least a B label when exploitation period exceeds 15 years
I	3% per year	1000 label steps per year	17.000 E/F/G labels improved to B label

Table 2: *Overview of goals per housing association*

Next, the links between energy saving policies and general steering mechanisms such as the annual investment planning, budgeting and the forms maintenance and investments are presented.

Link with budget for maintenance and investments
There are three ways housing associations deal with the embedding of energy saving policies in their (regular) budget. First, there is no special budget for energy saving measures; costs are part of the regular maintenance budget. Secondly, there is a special budget, but this is not necessarily meant for energy saving measures, but can be used for sustainability or environmental measures. Thirdly, a special budget is available only for energy saving measures. Each housing association that was researched is presented in one of these three categories. A special budget meant only for energy saving measures seems to be an advantage but the size of the budget, whether or not earmarked, is much more important.
Some housing association also mentioned another hindrance to incorporate energy saving measures in the regular long-ranged investments plans, because the capacity to invest is under pressure and the future is uncertain. Alterations in tax regulations and the decrease in house sales increase the financial uncertainty. Furthermore, some housing associations did not provide all their stock with an energy label, making it difficult to assess the need for energy saving measures and therefore estimate a budget. Other housing associations are depending partially on the willingness of tenants to agree on an increase in the rent for the financing of energy saving measures.

Link with planned preventive maintenance
For many housing associations in the research, planned preventive maintenance is the most important moment to carry out the energy saving measures, mainly because of scale advantages. In general, a large group of dwellings is grasped and a cluster of measures can be placed per dwelling. Six out of the nine housing associations have standard energy saving measures in its planned preventive maintenance, mostly double glazing and improving or adding insulation of façades, roofs and floors.

The use of the word 'standard' suggests that these six housing associations are executing these measures in all circumstances but some exceptions on this are made. If the particular dwellings have a short life span, measures will not be carried out and investments are restrained. Furthermore, there is some freedom for the department or project managers directly involved in the projects. Sometimes this means parts of the list of requirements are not always followed.
An important condition in general is that the benefits (costs savings and energy saving capacity) are greater than the general costs. Some housing associations use tools such as Gross Initial Return for energy investments or Internal Rate of Return for calculating the return. The table below gives an overview of the standard energy saving measures of the nine housing associations.

Housing association	Standard energy saving measures				Special budget? **
	Double glazing	Façade insulation	Roof insulation	Floor insulation	
A	X	-	-	-	yes
B	X	-	-	-	yes
C	X	X	X	X	yes
D	-	-	-	-	no
E	-	-	-	-	yes
F	X	-	X*	X	no
G	X	-	X	-	nee
H	X	X	X*	-	yes
I	X	X	X	X	yes

*When the roof needs replacement **including special budgets for sustainability or environmental measures

Table 3: *Overview of goals and standard energy saving measures*

Link with void repairs

The housing associations interviewed for this research rarely perform energy saving measures during void repairs. The costs are higher, because of the lack of scale advantages. Sometimes a tenant objects to the planned preventive maintenance or renovations but when this unwilling tenant has moved, void repairs are used to make the dwelling in accordance with the dwellings renovated earlier.
Investments during void repairs can also happen if waiting for planned preventive maintenance is considered irresponsible. An example is the replacement of single glazing by double glazing, when the window frame is ready to be replaced.

Link with renovations and improvements

Most of the researched housing associations have the same requirements on energy saving and use the same conditions for renovations as they use for planned preventive maintenance. This means in general that the same energy saving measures are considered for renovation as for planned preventive maintenance. Higher requirements for renovations do occur, but only if they are required by the Building Code.

As already stated, for the second stage of this research staff members of three housing associations were interviewed. These three housing associations have at least some recent experience in implementing its energy saving policies in maintenance and renovation projects. Below, summaries are presented of the interviews with the staff members of the three housing associations. Subjects covered by the questions were energy saving ambitions, project organisation, project features, the energy saving measures and cooperation of tenants.

Housing association A

To give a practical result to the ambition housing association A has formulated four spearheads: energy saving and CO_2 reduction, health and liveability, sustainable solutions for maintenance and new developments and finally internal environmental care. The energy saving ambition is 20% reduction in 2018 compared to 2008.

A list of requirements housing association A uses has four ambition levels for planned preventive maintenance and renovations. Every ambition level corresponds with the new exploitation period and the strategic label. Once the exploitation period and strategic label for a particular project have been established, a list of energy saving measures is more or less automatically generated. This procedure ensures unambiguous further development by architects and other consultants. The design of projects can also be assessed this way. In its Environmental Policy Plan, housing association A states that they will guarantee tenants that the energy bill will decrease (based on the project as a whole) more than the increase of monthly rent after the renovation.

Three projects of A were selected for this research. The first project was a four storey doorway apartment building, built in 1974. This project can be considered a planned preventive maintenance project. Tendering for this project was done by a private contract, based on a so called 'building team' contract. This means the contractor was already involved from the initial phase of the project. Energy saving measures for this project are replacement of window frames with hard wood window frames with the FSC quality mark, the fitting of highly efficient double glazing, adding of insulation of façades, led-lights in central stairways, removal of geysers, placement of collective hot water supply with heat recovery and adding mechanical ventilation. With these measures, the energy label went from G to B. The placing of solar panels would have made label A possible, but proved to be too expensive.

The second project consisted of four buildings, each with 12 storeys, built in 1960. In total 288 galleried dwellings were refurbished. This project can be considered a planned preventive maintenance project. Energy saving measures carried out in this project were highly efficient double glazing in all window frames, roof insulation, new ventilation registers and closing of cracks, placement of mechanical ventilation, placement of new closed geysers, improvement of collective heating system, placement of thermostatic radiator valves and individual cost indicators, placement of wind turbines on the roof. This last measure was eventually rejected by the municipality, because of objections by dwellers in the neighbourhood. The energy label went from G to B.

The third project, a minor improvement project, consisted of a three-storied doorway housing estate, with a total amount of 226 dwellings, built in 1928. The project was a pilot for 'performance based collaboration', which means the housing association describes the approach through quality and performance requirements. From the design phase, the contractor is involved to consider the measures that ensure technical and financial efficiency on the short and long term. Measures in this project included the placement of highly efficient double glazing, roof insulation, the removal of geysers, the placement of highly efficient boilers and the fitting of mechanical ventilation. Some measures were considered, but not executed. Heat recovery proofed to be technically complicated and not cost-effective and the replacement of inside insulation meant the tenants needed to be temporarily moved from their homes. Furthermore, floor insulation also proofed to be too costly and sound insulation of the floors was not necessary, because the placement of fire resistant ceiling solved this issue. Because of the measures installed, the energy label improved from G/F to C/D.

It seems tenant cooperation was not an issue in executing the measures in the mentioned three projects. The housing association chose not to increase the rents after completion of the projects, only voluntarily when a tenant asked for a specific improvement of their home. A side

effect of not increasing the rent is that tenants could be less aware of energy use and costs, because it is not visible in their living costs.

Housing association B

In September 2009, housing association B specified their Environmental Policy Plan, in which they state to aim for 20 % CO_2 reduction compared to 2008, to be reached in 2018. All dwellings with an EPC lower than D will be optimized, starting with the ones that have the worst performance. Maintenance activities that are part of the planned preventive maintenance program are taken into consideration and adopted for these specific projects. At far-reaching refurbishments, it is policy that at least energy label B is reached. Some measures are considered standard in the Environmental Plan, i.e. placing of double glazing simultaneously with painting of the windows, which is combined with the adding of mechanical ventilation when the tenant alters. Old boilers are always replaced with new highly efficient boilers. Collective boilers are always replaced by environment friendly collective systems, if the system has the capability to individually bill the tenants. This housing association strives to cover 75% of the costs by raising the rent.

Only one project of B was selected for this research, because this was the only recent renovation project that has the Environmental Policy Plan as a framework. The project is a six storied gallery flat, built in 1963, and can be regarded as a minor improvement project. The exploitation period of the building is extended by 25 years.

The project acted as a pilot for 'performance based collaboration'. The contractor involved came up with recommendations for the set of energy saving technologies including installations. The standard set included the fitting of high efficiency double glazing, insulated panels in the façades, placing of mechanical ventilation and the replacement of kitchen geyser for electrical boilers. Additional and more expensive measures the contractor suggested were floor insulation, hollow wall insulation, roof insulation, heat recovery trough mechanical ventilation and solar panels. In the end, the following energy saving measures were considered economically feasible: high efficiency double glazing, insulated façade panels, mechanical ventilation, hollow wall insulation of the brick facades, floor insulation under the first floor, the replacement of geysers by a collective heating and hot water system and finally roof insulation. The increase in rent after the work is finished is calculated based on the expected decrease of the energy bill at the level of the individual home. This will not be guaranteed to tenants, but it might be considered in the future.

The project is going to be evaluated with special attention to investigating if the right measures were applied to the building. The housing association guaranteeing occupants a decreased energy bill is also studied, because this helps to get 70% of tenants to agree on the renovation, which is a legal impediment. Generally, the implementations of far-reaching energy saving measurements are studied per individual project. In this specific project, more energy saving measures were implemented than could be expected from the policies in the Environmental Policy Plan. In conclusion, the success factors in this project are that the building apparently was technically suited for quite a number of measures, and the willingness of tenants to agree with the increase of the rent.

Housing association C

Housing association C laid down its ambitions regarding energy savings for its stock in the document 'Energy project 2009-2015'. The 20% CO_2 emission reduction was to be reached in six years, a period based on the painting cycle. In this period the whole stock was to be updated for a budget of € 90 million. Half of this budget had to be earned back by rent increase. The policy is that every dwelling needs to be equipped with high efficient double glazing, façade insulation and roof insulation, unless the dwelling was already sufficiently equipped.

Ground floor insulation would only be considered if economically feasible. The Energy Project started with a pilot phase, in which homes ready for planned preventive maintenance, were fitted with energy saving measures. The pilot was executed by a project group consisting of a project manager, a communications manager, an engineering project coordinator and a financial consultant.
The initial plan was to start the pilot with six projects, dispersed by type and building year. Four projects were finally included: 40 single family homes built in 1920, a flat built in 1973, 15 dwellings for the elderly built in 1960, and 10 small apartments in a villa, built in 1920 and renovated in 1982. Following the principles of the Energy Project, all homes would be fitted with double glazing, façade insulation, roof insulation (even if the roof doesn't need replacement) and sometimes floor insulation. The actual pilot projects of the Energy Project, however, showed a greater variety in energy saving measures than the policy plan prescribed. This can be explained by technical issues or by the fact that some of the measures had already been taken.
The 40 single family homes built in 1920 were to be fitted with floor insulation, insulated glazing, façade insulation and roof insulation in the extension. Roof insulation in the rest of the dwellings was placed in the 1990s and is still functional. The fitting of double glazing sometimes means replacing the moving parts of the window frame. Tenants only pay for the glazing, not the replacement of the moving parts. Furthermore, the dormers are replaced and these are equipped with double glazing, but tenants don't have to pay an increase in the rent.
The flat built in 1973 is to be fitted with floor insulation for the bottom apartments, insulated glazing in new window frames and the insulation of facades. More specifically, the end wall is insulated on the outside, resulting in a higher insulating value than insulating the hollow walls on the long facades. The roof was already insulated in the 1990s.
The 15 dwellings for seniors, built in 1960 are fitted with floor insulation, roof insulation, the replacement and adding of double glazing and facade insulation of three dwellings. The replacement of the roof was part of planned preventive maintenance for this year. For this reason, the costs of the replacement and insulation are not recalculated in the rent.
The 10 apartments in a villa, built in 1920 and renovated in 1982 are to be fitted with ground floor insulation, insulation of the flat part of the roof and double glazing. 'Wrapping' the building with façade insulation is complicated, due to municipal regulations on altering the appearance of a building. Ground floor insulation is limited to the parts directly under a dwelling, because of the vaulting of the floor. As with the aforementioned project, the replacement of the roof was part of the planned preventive maintenance for this year. For this reason, the costs of the replacement and insulation are not recalculated in the rent. The increased insulation has consequences for the ventilation, but the proposed solution is not popular with tenants.
In the light of the ambitions of the Energy Project, the results of the pilot were rather disappointing. First, the combination with planned preventive maintenance, did not work out well. The preparation of the projects took more time than is actually desired for these type of projects. So, the principle of combining energy investments with planned preventive maintenance projects has been abandoned. Second, the principle to get a 50% payback in the rent for the measures was difficult to realise, for which reason housing association C has abandoned this principle. The most important bottleneck in the progress of the Energy Project was the willingness of tenants to contribute financially to the measures. Further, there were frequent internal discussions about which activities or materials had to be charged in the rent and which not. Ultimately, in most projects of the Energy Project, the costs were not recalculated in the rents. As a consequence, housing association C decided to carry out the energy saving measures with half of the initial budget, which means that it must be much more selective in its selection of investment projects.

An example of a project outside the scope of the Energy Project was a project consisting of 147 particularly small single family dwellings. These dwellings were improved significantly by altering the plans, adding a dormer window and combining 20 small dwellings to make 10 big new dwellings. The roof and floor were insulated and double glazing was put into place. In general, it can be stated that the role of energy saving in the project was limited. First the decision was made to replace parts of the dwellings, then it was decided how to do this as sustainable as possible. Energy saving measures were joined in with other ambitions and options. Because the costs of these measures were only a small part of the total expenses, they were a problem for neither the tenants nor the housing association itself.

DISCUSSION AND CONCLUSION

The interviews from the first stage of implementation (from policy to general steering) seems to suggest that the embedding of energy policies in regular investment activities can take place fairly easy, simply by including energy saving measures into planned preventive maintenance and/or renovations. An important condition is that budget is available for the extra costs of these specific measures, that the financing is independent from third parties and that tenants are willing to accept the resulting rent increase. Especially the financing of energy saving measures is a problem, for several reasons. First, the liquid assets of housing associations have worsened recently, due to decreased sale of dwellings, an increased tax burden and also tight national rent regulations. Second, uncertainty about the future rent regulations and energy prices, which influence payback possibilities, increase the financial risks involved. The embedding of energy policies into the regular work processes seems to be hampered especially by financial constraints and not, as expected beforehand, by internal and organizational factors, such as the lack of coordination between departments.
However, the results about the second stage of implementation (from general steering to projects) give reason to doubt these conclusions. Some interviewees indicated that the official project requirements are not always followed in the preparation of a project, and that energy saving measures agreed upon in the preparation phase of a project is actually not carried out in the execution phase. This research, however, does not give evidence about how often this takes place. Some interviewees have indicated that for those who lead investment projects time and budget are more important than energy saving. In line with Hoppe (2009), interviewees have also stated that the implementation of measures in this area is partly dependent on the motivation of these project leaders.
Another factor in the implementation of energy saving measures is related to the type of investment projects. There is merit in the argument that energy investments must be combined with other investments, because this combination of efforts reduces capital loss and saves money on the long term. The study indicates that energy saving measures can be relatively easily included in renovation projects, because renovation as such entails a range of physical measures and a relatively long preparation period. If combined with planned preventive maintenance projects, however, the story is different. There is a risk that these projects 'explode' in both time and budget, especially if considerable energy measures have to be carried out and if extra communication with the tenants is needed, for instance about a rent increase. This would suggest that improvement projects such as renovations are more suitable moments to carry out energy saving measures, but the problem with these projects is that they do not frequently occur: if we would wait for all such project to be carried out, the energy policy ambitions (as given, for instance, in Table 2) would not be met. So, both planned preventive maintenance projects and (larger) improvement projects are not entirely appropriate to include energy saving measures. A solution to this problem could be a combination with a

long-term investment program to increase the physical quality of the housing stock, a kind of investment scheme that many Dutch housing associations have developed and mostly has duration of 10 to 15 years. Further, it is conceivable to make use of several types of investment projects, for instance to carry out relatively simple measures (e.g. double glazing) in planned preventive maintenance projects and to carry out more complex measures in renovation projects.

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SUCCESS AND FAIL FACTORS IN SUSTAINABLE REAL ESTATE RENOVATION PROJECTS

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Abstract
Sustainability remains an important issue for the construction industry. Yet, sustainable real estate developments are still considered as highly ambitious projects. To find out how and why sustainable renovation projects actually became sustainable we systematically evaluated 21 leading Dutch real estate renovation projects. In each project we interviewed the client, consultant, architect and contractor. Based on the results it was concluded that it is not necessary to have a pre-defined (sustainability) ambition in order to realize a project that can be considered sustainable in practice. Most of the respondents indicated that the ambition developed throughout the project, mainly because of the potential sustainable reputation or the parties involved in the project. Ambitions were not set as highly as expected: about half of the respondents consider preservation of the building and recycling as sustainable solutions already. The composition, management and collaboration of the construction team were found to be very important during the process. In this sense sustainable projects do not appear to be any different than regular projects, so then the only question is: Why not sustainable?

Keywords: ambition; sustainability; real estate renovation, project management, process management

INTRODUCTION

What we build, maintain and renovate today, has much influence on the achievement of our sustainability objectives for tomorrow. According to the Brundtlandt report (1987) a sustainable development is a development that meets the needs of the present generation without compromising future generations with the potential to jeopardize in their needs. Resulting from the agreements reached in 1997 in Kyoto, the Netherlands needs to reduce the emission of greenhouse gases by 6% in the period 2008-2012. The built environment is responsible for more than 25% of the total use of energy (Jeeninga et al, 2006). In addition, 35% of the national amount of waste is caused by the construction (Hails, 2008). The built environment therefore has a significant impact on the achievement of a sustainable society. Reports of the Ministry of VROM (2002), Atriensis/Vabi (2009) and van Oel et al (2010) show that the biggest potential for CO2-reduction is to be obtained of the attached row houses from before 1975. 3.6 million homes in Netherlands is built before 1976 (of a total of 7 million houses). Of this stock 40% (approximately 1.5 million homes) is weak from architectural and energetic point of view. Offices are of course also important energy users. The total office stock in the Netherlands consists of 46 million m2 usable floor area, of which 27 million m2 (= 61%) in the rental market. 7 million m2 (= 13%) of this stock is permanently vacant, including hidden vacancy this is currently even approximately 25% (DTZ Zadelhoff, 2010). About 20% of all office buildings is in use by national government

and local authorities. The majority of buildings do not currently meet the sustainable purchase agreements of the Government, which is based on a minimum energy label C.
In 2007 the Government (Ministry of VROM, 2007) stated in its working programme "Schoon en Zuinig – nieuwe energie voor het klimaat" (Clean and economical - new energy for climate) three ambitions: 1) to reduce the emission of greenhouse gases, particularly CO2 for 30% by 2020; 2) to double the pace of energy saving in the coming years; and 3) to increase the share of renewable energy of total energy use from around three percent to 20 percent by 2020. From this perspective the Netherlands should therefore strive for 'net zero ' buildings and planning districts which are at the same time as healthy, comfortable and productive as possible and have positive impact on the environment. Energy neutral means in this sense that the total balance of energy consumption for a dwelling or for a district is equal to the energy supply. The three-step strategy of Trias Energetica (reducing consumption, commitment to renewable energy and efficient use of fossil sources) can help to realize this ambition.
For the Dutch construction industry the theme of sustainable is almost inevitable. Yet the Dutch construction sector is unfortunately still mostly project-oriented. Integrated approaches are often lacking, both in thinking and in the process, and knowledge is often not retained and sufficiently deployed in future projects. There is a growing social pressure on the construction sector regarding a contribution to innovation, sustainability and the environment. This means that will also be in the construction industry more and more knowledge sharing needed in order to achieve those goals. At the same time construction projects are a perfect means to achieve objectives in the area of sustainability because they are set up to achieve common goals (Emmitt, 2010; Tryggestad et al., 2010). More and more research is available about sustainable building processes (e.g. Häkkinen & Belloni, 2011; Horman, Lapinski, & Riley, 2005; Pitt, Tucker, Riley, & Longden, 2009; Stenberg, 2006). However, practice still seems to make the same mistakes. Next to that most of the research focused on new building projects instead of renovation. In the Netherlands several buildings and districts have been realized which can be set as exemplary projects in Netherlands, but these examples are (still) not commonplace. The 'Building Brains - Smart Building and District: Energy Neutral' initiative provided an excellent opportunity to make the knowledge about sustainable renovation projects explicit. Building Brains' is a Dutch research programme that has arisen from a series of crisis measures of the Dutch Ministry of Economic Affairs in 2009 to ensure that critical knowledge about construction is maintained for the industry. For the period of one year a diversity of companies from the total supply chain got together under the supervision of a few knowledge institutions to do research on the theme of sustainability in construction. One of the projects from Building Brains research program consisted of an analysis of the construction process of a 21 sustainable renovation projects. The main objective of this analysis was to close of the construction cycle of initiation, design, construction and transfer lessons learnt to future projects. The author of this paper participated as one of the team members in this evaluative research project.

RESEARCH METHODS

Through desk research a long list was generated of sustainable projects that were realized in the Netherlands in the last 2 decades. The list consisted of 80 newly constructed projects and 40 renovation projects in the housing industry, 10 new and 10 renovation projects from the private construction industry and 20 projects from urban developments. In the end 21 projects were chosen to be included in the analysis for this project: 12 housing renovation projects, 5 sustainable commercial buildings and 4 urban area developments. The selection was based on

the criteria of information accessibility (are actors prepared to cooperate and is sufficient information available), use of energy sufficient and sustainable supply measures (e.g. double-glazed windows, solar panels, thermal storage), a fair distribution across sectors (housing, utility buildings), type of projects (cultivation, construction, building and area), types of clients (individuals, housing corporations, private organisations) and approach (innovation, integral approach and representativeness).
We developed a structured interview around a number of predetermined research topics: ambition, actors, measures taken, construction process and context of costs, policies & regulations. By approaching a topic from the perspectives of the various actors involved, it was possible to achieve a thorough way of understanding the success and fail factors in achieving sustainability. For each at least two other members of the project team were interviewed, such as the architect, contractor, sustainability advisor and/or a representative of the municipality. In some projects we also interviewed an external party, such as the energy supplying company or an additional sustainability engineer. In total we collected 73 interviews, which means an average of 3 to 4 interviews per project. Each interview was conducted by two researchers, recorded and written out. The interviews lasted between 45 minutes and three hours. The open answers were then categorized and analyzed with SPSS, together with the answers to the Likert scale questions. This paper discusses the results into the success and fail factors that relate to the cooperation and ambitions of the projects. It is based on the 'Inspiratieboek Duurzame renovatie (Building brains, 2010) in which the results are recorded from the analysis of all 21 projects.

RESULTS

Ambition

Literature (e.g. Van Bueren and de Jong, 2007; de Bruijn et al, 2002) suggests that the ambition of a project plays an important role in successfully realize a project. Our findings indicate that most actors agree on this because it supports the collaboration by developing integral sustainability ambitions, or as stated by one the developers: "Measures that the parties have embraced collectively influence the cohesion of the project positively." Quite a few respondents state that attention and time spend on the provision of a 'SMART' ambition in the initial stage of a project would therefore be beneficial for the further process. In this way, there is a shared frame between the project team members that can be evaluated at regular intervals to show the progress of the project. This is however easier said than done. The results of the interviews show that the concept of sustainability has different meanings among the various actors, but also within the same group of actors (see table 1). Most interviewees indicate that sustainability is about 'long term', 'integral' and 'the conscious use of materials'. Within the actor groups there are differences between the contractors that especially value the use of material (50%) and holistic approach (40%), and the architects who generally think in terms of integral approach and long term thinking (60%) in combination with the use of material (45%). According to the respondents the societal trend of sustainability doesn't necessarily go hand in hand with additional costs; 20% of the actors and 10% of the principals says that in principle there is no additional cost to sustainable construction. To the question of whether additional costs were made in their project, 50% indicated that the high level of sustainable ambition has led to additional construction costs which can be recovered over a longer period of time.

Table 1: Understanding sustainability according to the different actors

	Integral and long term	Holistic approach	Conscious use of materials	Trias energetica	Social sustainability
Client/principal	45%	20%	35%	10%	20%
Architect	60%	30%	45%	15%	15%
Contractor	35%	40%	50%	15%	15%
Sustainability advisor	45%	25%	45%	25%	20%
Municipality	40%	20%	40%	20%	15%

70% of the clients indicated that no clear sustainability ambition was established at the beginning of the project. For 10% of the respondents the ambition was too vague and for nearly 20% of respondents the ambition should have been more specific, measurable, acceptable, realistic and time-bound (SMART). Despite the fact that no real ambition was stated, about 40% of the respondents did indicate that maintenance, upgrading and/or renovation of the buildings was necessary, and almost 50% indicated that energy saving was the main goal of the renovation. Considering the fact that renovation is a sustainable option, sustainability became a central theme in these projects. So in many of these projects the ambition had grown in the course of the design and construction process because the opportunities arose. The respondents also indicated that when a higher ambition had been pursued from the beginning, probably even a higher level of sustainability could have been achieved.

According to the interviewees image and elaboration of the corporate social responsibility were a great motivator for the development of sustainable projects. Almost all the interviewees see that the importance of sustainability quickly increases, and that therefore alone they often consider the issue of sustainability. Many of the projects examined became known, often accidentally, as pilot projects and were considered exemplary for others. We have asked, in line with the Elkington's 3 P's of People Planet Profit, to indicate on a scale of 1 to 5 how much interest they have shown in the social, economical, spatial and ecological impact of construction (1 = no; 5 = very much). The actors gave most priority to the social importance (4.3) and spatial interest (3.8). The ecological interest (3.5) and the economic interest (3.5) have relatively the least importance, but in total all interests are quite important and well balanced. In these results the social pressure on sustainability also speaks. Yet, this outcome could have been influenced by the population chosen in this research because many projects were developed by housing associations, partly to increase the quality of the built environments in certain neighbourhoods.

During an analysis of the ambitions of the various parties, it appears that not one of the 75 respondents indicated to have the same ambitions as the client. Within the projects an overlap above 60% in aims could not be found. This indicates that if a project ambition exists, it is not to say that everyone is aware of this. One of the causes seems to lay in the fact that there is a lack of communication about the desired ambitions. As a result, the various actors act from their own experiences which could sometimes be against the expectations from other team members. If all parties are well aware of everyone's ambitions they could take this into account for further elaboration and realization of the plans.

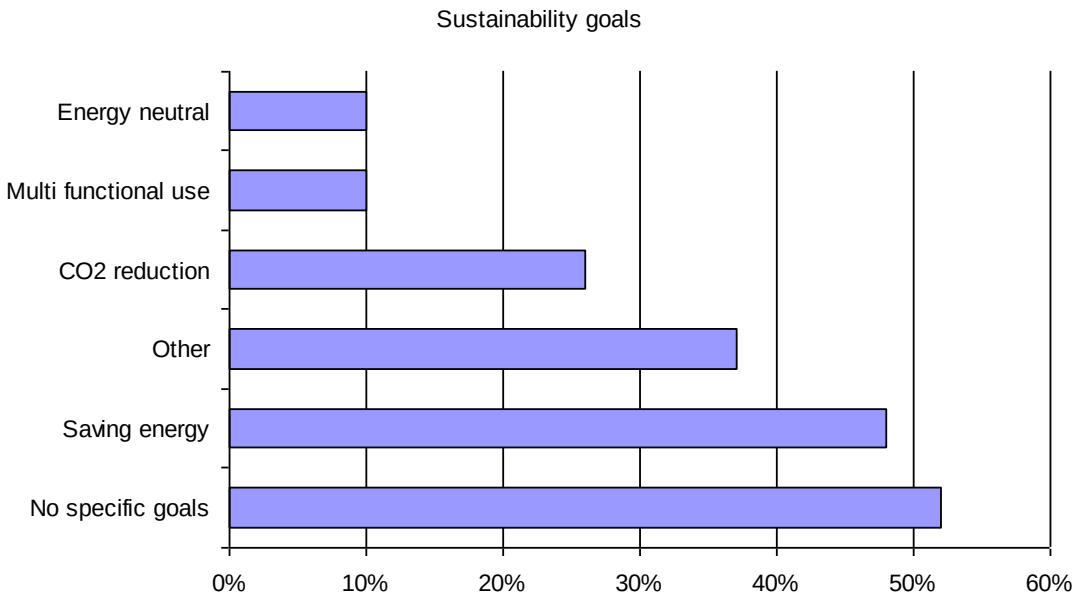


Figure 1: Pre-defined sustainability goals

Both for the projects in which a sustainability ambition existed at the start of the project and for the projects in which the ambition developed throughout the project, in 65% of the cases these ambitions translated that ambition into obtaining a (reduced) EPC standard and/or energy label. Figure 1 shows which goals were set in the context of sustainability. Saving energy and CO2 reduction appear to be the most used goals. However, the majority of the respondents indicated to have no predefined goals.
It seems obvious that if an ambition exists, the development is monitored during the project and evaluated in the end. In 30% of cases the actors however indicated that no monitoring of the goals and/or the ambition had occurred. A little over 30% of the respondents said that the energy meter was monitored after use, while 10% said that 'there were things monitored', but didn't know how and what. Almost 50% percent of respondents indicated not to know who was involved in monitoring of the ambitions, 20% says that it was the energy supplier, 10% indicator the client and 10% the consultant. In line with Häkkinen & Belloni (2011) the lack of monitoring also applied to the costs during the projects. In one of the projects the budget needed to be adjusted halfway because of the high ambitions, and another project proved to be over budget afterwards. One of the respondents recommended implementing a good monitoring of real-time costs throughout the construction process. Then the ensuing effects on the costs on the overall budget can be shown at every change of plan and the ambition can be fine tuned consequently. It is striking that most actors assume that monitoring had taken place, but that they can say little to nothing about the actual results thereof. This seems to be caused by the fact that there is little to no aftercare in the post-delivery and user phase of projects; nobody appears to feel responsible when the final payments have been made. This blocks the learning effect in construction. A good monitoring and feedback of the results to all actors could ensure that the actual impact and usefulness of sustainable measures becomes clear to all actors and experiences are not only based on personal perceptions.

The project team
The results also show that the composition of the project team and the level of enthusiasm are of great importance in realizing sustainable renovation projects. This is in line with the findings of Häkkinen & Belloni (2011) about Finnish sustainable building processes. The client of one the projects stressed that "the success of our project can definitely partly be

attributed to the involvement and collaboration of the team members; all actors have taken their responsibility". Consciously or not, the composition of the team also appeared to have an effect on the achieved sustainable results. If you opt for a sustainable architect or a sustainability consultant, it can be assumed that the level of sustainability of the project will higher. However, it was also indicated that especially the client and the sustainability expert/advisor influence the development of an ambition in the direction of sustainably. 45% of interviewees indicated that their previous experience with the client has played an important role in their involvement in the project. This means that at the moment previous collaborations and familiarity with parties still play an important role in realizing sustainability.

Next to the composition of the team, the functioning of the team members is also important. In virtually all projects it was indicated that a motivated and enthusiastic leader that keeps addressing the sustainability theme is very important. In a number of projects the client took on this role, but in others the architect, consultant, contractor or a supplier was the most enthusiastic actor on the area of sustainability. Personal motivation was usually the main source of this kind of enthusiasm and it was also indicated that this choice was influenced by the fact that the role “wasn’t claimed by others”. This means that in principle any actor could play this part.

Too many personnel changes within the team can be a stumbling block for the project and for the monitoring of a particular ambition. A project manager indicates that "it is very inefficient to constantly figure out how the original setting was. If none of the original setting is involved, the collective memory disappears. It is not known what the objectives and working methods were exactly." Although it a difficult to manage a long-term project from start to finish with the same team, a constant core of actors does seem to have a positive effect on the success of the project because the goals and ambitions are clear and shared. In this respects some of the interviewees mention that it is important that members of the team are selected based on their personality and competences instead of the firms they belong to.

Ang, Groosman & Scholten (2005) emphasised the importance of the project leaders. This was also found in this research. The respondents indicated that the project leader should in any case insist that the ambition is developed on a detailed level and surveyed throughout the process. This usually concerns someone with good decision-making skills. According to an adviser of a housing project many sustainable options should be explored and matched to the ambitions, "but this should not continue for ever and get out of control. At a given moment choices should be made and the package of measures should be finalized." In one of the projects the open mind of the project leader was mentioned as one of the success factors. This openness gave much space in exploring the many possibilities for the package of measures. In the end the indecisiveness however changed into a fail factor: "a success became a failure. If not thought in a single, fixed direction, taking decisions became hard. Always examining everything, we had many sessions and many opinions of experts have been won. This created certain unintelligibility." An open mind should therefore also be accompanied by a pragmatic approach in order to keep things going.

Despite the positive effects of involving a diversity of actors, the respondents indicated the way how parties were involved could have been improved. This does not only have to do with the timing (82% felt they got involved at the right time, 56% was involved from the start) but parties must be concerned with the role they play in the team and should be think along in creating integral solutions. As a principal of a housing project stated: "the installation engineer has the responsibility to apply an integrated design approach and should not from the individual identities." A hotly debated topic in the area of construction management is whether or not to involve a contractor in the initiative stage and/or design phase. The perception still exists (50% of the interviewees) that contractor are mainly involved to built

and that they do not have impact on the ambition level. In 8 projects the contractor was involved from the beginning on during the initial phase and/or design phase. The other actors indicated that they appreciated the early involvement of the contractor and so thought that he was involved on time. "A contractor should be taken in to consider the appropriate project-specific sustainable solutions," said a client of a housing project. A number of contractors also indicated themselves that they wanted to be involved earlier in order to improve the supply chain to deliver an optimal product and minimize failure costs. "The knowledge of contractors is currently too little exploited. We think that collaboration, plan development, and building relationships are more important than a one-time quick job. Long term vision and thinking of the contractor contributes to success".

Another success factor that was indentified in the research is the presence of sufficient knowledge within the project team. Especially for innovations project team members should be aware of the current sustainability options within their field. According to one of the advisors, consultants usually have short lines to keep up with experts and therefore have added value in implementing sustainable measures. In the same line of thinking one of the architects said that "Sustainability is not a layer on a building, but a part of the entire process." According to interviewees sustainability does not only occur in topics such as energy and fossil fuel but also in social and functional value of real estate. "Sustainability is also in the quality of the use: the living comfort and the environment. The building industry should think in values for the consumer/end user" as stated by one of sustainability advisors. Therefore "you first need to examine what these values are exactly." This means that input from the user is desperately needed (see e.g. Rohracher, 2001). In 9 of the 21 projects, the clients indicated to have successfully involved the users in the initiative stage, in one project they became involved slightly later, namely in the design phase. A large number of interviewees (38%) indicated that the end users were of positive influence on the project. Related to that, only 5% thought that users had negatively influenced the project outcomes. In one of the projects a targeted market research was performed because the users were unknown. This led to a good estimation of the living requirements and a smart solution for the diversity of the user needs. Remarkable was that even in projects were the need for the involvement of users was clear, interviewees indicate that the users could have been involved better and earlier. Further analysis showed that in 50% of the projects, communication only went into one direction: the users were only informed about the future changes or the use of the sustainable measures. Most of the time the users were not involved in the choice of options, while they have to deal with the buildings in the end. An important issue that contributes to the positive response of the user's appeared to be the understanding of their energy consumption. Because their energy usage was made transparent and they were able to track their own savings, a greater understanding of the necessary renovation was perceived. The residents got the legitimate feeling that the renovation had a clear advantage for them. In one specific housing project in the North of the country the users were so proud that they decided to change the name of the residential block: before the renovation they called the building a flat and after the renovation a full-fledged apartment complex.

Success factors

After the various components of the research were discussed in detail, we also asked about the general success factors of the project (see Figure 2).

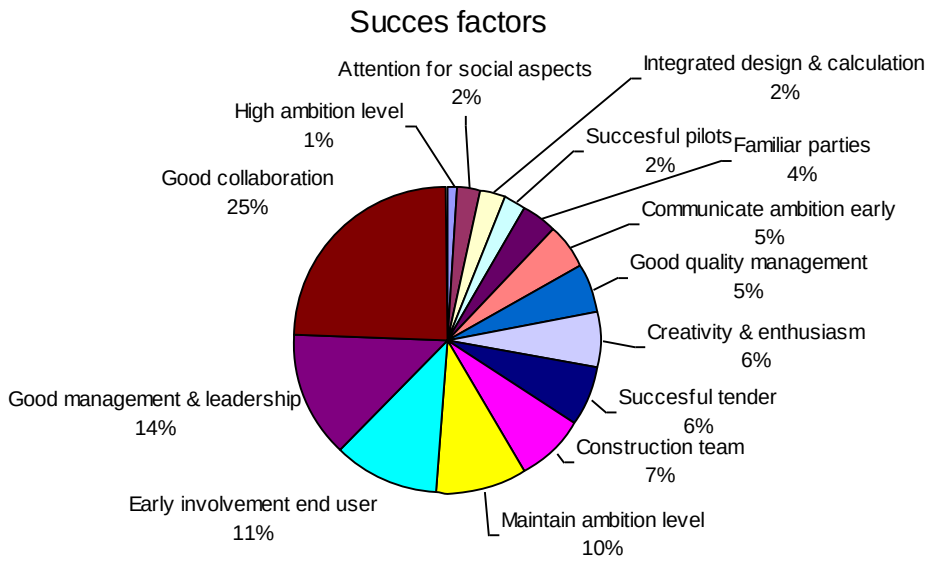


Figure 2: Success factors as indicated by the respondents

These factors can be divided into two themes: collaboration during the process and establishing goals. The collaboration factors related to the organization form and composition of the project team. Most of the projects were realized in construction team. Working in a construction team means that all parties are involved as early as possible. This means that collaboration and knowledge exchange can start from the early start. All team members (contractor, architect, advisor etc) think along from the beginning about the completion of the design and they know from the beginning what they have to each other. This makes it also easier to make adjustments and decision during the process. A successful construction team does require consciously selected partners that can complement each other as well. “It is all about the right people in the right places” according to a sustainability consultant. Several respondents emphasized the importance of good teams moving in perfect synchronicity with each other, and who know and each other. The atmosphere within the team also played a large role in many projects. In cases where the team members were very excited about the project, this enthusiasm turned out to have a positive effect on the commitment and the will to innovate. According to a project developer "an optimal package of measures was developed by this collaborative involvement. The main motivator for the innovation was not our own business interests, but the interest of end users. The team collaboratively sought to find a way to get the best return for the user." The results also indicate that good project and process management and process management are important factors to ensure a good cooperation. The project leader plays an important role in this. Except that he or she is supposed to be able to assess and monitor the goals or ambition, he or she must also be open to the possibilities around sustainable measures. In one project the 'open mind' of the project leader was highly praised. This project leader did not think in a single and fixed direction, but thought it was important to look at all the options available.

Good cooperation is also positively influenced by the presence of a sustainability ambition. As indicated earlier, in many of the projects insufficient attention was given to formulating and adopting the sustainability ambition. It is remarkable that in most of the projects the ambition to create a sustainable project was developed throughout the process; the project eventually grew into their sustainable ambition. Most of the actors consider the determination and monitoring of their ambition an important factor for improvement for future projects. Most of them even preferred a SMART defined one that could be adopted by all members of

the project team. However, it must be realized that recognized methods such as BREAAM, GreenCalc + or other kinds of energy certificates is no guarantee for a sustainable, functional and beloved building. It is the art of a design to apply an integral approach and not just tick of a list of boxes on order to earn points.
Another remarkable success factor is the positive effect of applying for a grant. First of all because of the feeling of victory when obtaining a grant after energy and paper work costly process – this really boosts the project. Secondly because to obtain subsidies clear demands and conditions must be fulfilled. The rules and regulations of these kinds of arrangements ensured that the team members had a clear goal and discussed their preferences before or during the start of the project. Applying for a grant motivated, stimulated, and also increased the will to innovate. This is not to say that all projects have to apply for grants to have a targeted sustainability ambition but it does indicate the effect of having quantifiably and unambiguous directives and measurable ambitions. So even though there is no money allocated a grant still works as a motivator. The other side of the medal is that "whole books and budgets should be submitted. This was so slow and bureaucratic. It is not worth a few thousand Euros".

DISCUSSION AND CONCLUSION

It is very difficult to get a clear perspective on the concept of sustainability that exceeds the level of the standard systems in practice. We found definitions in the range from long term perspective and conscious use of materials to active housing and feeling comfortable. The level of sustainability of the measures however also depends on the situation. In new buildings for example, double glazing or a HR combination boiler is not seen as a specific sustainable intervention because it is considered a default value due to the laws and regulations in Netherlands. In renovation projects these measures are often mentioned as first because characteristics of the existing situation have to be taken into account. As previously noted in literature (e.g. van Bueren and de Jong, 2007; Tryggestad et al, 2010), we found two ways to achieve a sustainable ambition and realize a renovation project in a sustainable manner: establish a shared ambition at the start of a project or develop an ambition during the project. In relation to the realization process of a sustainable renovation project we found four main success factors:

1) elaborating an ambition helps in the beginning helps but you can also develop it on the way;
2) having an enthusiastic leader has a positive effect on the project;
3) a construction team with an active contractor could improve the holistic design approach;
4) use the input from end users by communicating in two directions.

These factors do not seem to be very different from factors that contribute to the success of any building project or sustainable building processes in other countries (e.g. Häkkinen & Belloni, 2011; Horman, et al., 2006; Sodagar & Fieldson, 2008). Media attention is an effect that occurred in almost every project, but that only a very limited number of project members had actually been kept in mind. Some projects received a lot of publicity for the way how they realized their high level ambitions; others received it for the innovative way of working, for example on how they participated with the residents. Because of the media attention these projects are now used as PR resources by the different actors and their firms. This is beneficial for their reputation and is usually an elaboration on their objectives in the field as social responsible corporations. While the findings indicate there is no reason not to develop sustainable projects, these findings also show that sustainable renovation is not yet a habit in the Dutch construction industry. In line with Häkkinen & Belloni (2011) we could conclude

that normative regulations are needed because the voluntary approach did not cause a significant change. However, this is not easy (van Bueren & de Jong, 2007) and comprehends a lot of bureaucracy and public money. We therefore hope that the 21 projects as examined in this project are examples of ambitious renovation projects in which sustainability became a general value instead of a single inspirational action. If that is the case, one question remains: Why not sustainable?

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THE INTEGRATED MANAGEMENT SYSTEMS: THE ROLE OF THE MAIN CONTRACTORS

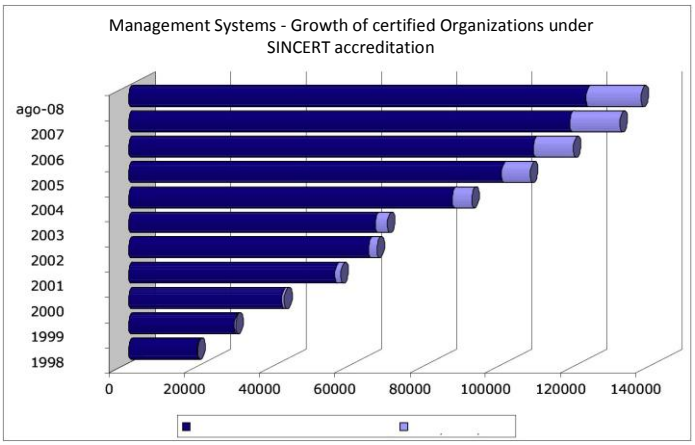
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Abstract
The authors examined the concept and qualitatively assessed the effectiveness of integrating different Management Systems (Quality Management System, Environmental Management System, Health & Safety Management System and, in case, Social Accountability Management System) established at Italian Main Contractors in order to improve the Contract Management.
Accordingly to findings gathered by the authors, Quality Management Systems are widespread in Italy and in Southern Europe over the last decade, because of a legal compulsory requirement stemming from the Public Works Acts enforced in 1994 and further developed in 2006 in conformity to European Directives.
Nevertheless, in spite of such a dramatic rise in the amount of certifications conforming to the ISO 9001:2008 Standard, the reliability of Quality Control-related procedures tremendously failed, being the corresponding rules quite often discarded in the field.
Actually, only a small amount of Large Private Clients awarded their own tenders to main Contractors available and wishful to comply with Quality Planning's clauses, while a large majority of public Clients seems uninterested in checking effective application beyond formality of the ISO 9001 standard.

Keywords: OHSAS 18000, SA 8000; Quality Management Systems, Health & Safety Management System;

INTRODUCTION
Very few Italian and Southern European Contractors are certified in conformity to the ISO 14001:2004 Standard and even less complying with the recent BS OHSAS 18001:2007 Standard.



(source: Musa, SINCERT, 2008)

Consequently, it is not surprising that neither Clients nor Contractors have any practical perception of the document PAS 99:2006, a BS specification aimed to bring together the shared requirements and to support the integration of Quality, Environmental and Safety requirements.
Social Accountability Management requirements (with reference to SA 8000) should find also place in such a perspective, if not for ethical reasons, at least to deal with unfair competition.
Whenever constrained to comply with possible requests established by the Clients, the best effort that Contractors display is intended to widen the scope of the basic Quality certification, installing inside the original Quality Management System the other ones.
Through this action, Contractors set up a pseudo-integrated Management System suitable to engender a sort of added value.

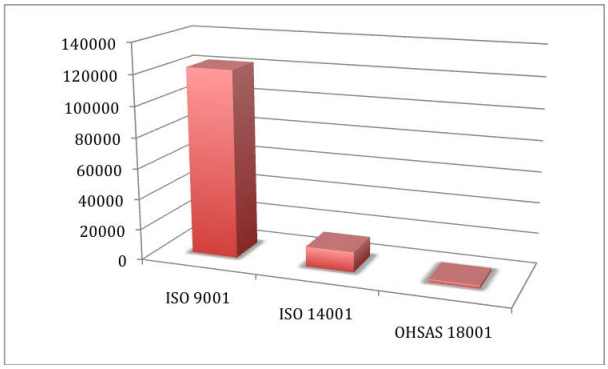
Aim, Objectives and Approach

The aim of this paper is to examine, in form of essay, the issues of Integrated Management Systems, and their fall out in Italy, and to report about some findings dealing with such an approach, highlighted in connection with a firm belief of the authors: the efforts made by the Client towards an effectively Integrated Management System could be easily made trivial whenever the Main Contractor is unable or unwilling to reflect the Management System rules into its actual behaviour.
Actually, only a small amount of Large Private Clients awarded their own tenders to main Contractors available and wishful to comply with Quality Planning's clauses, while a large majority of public Clients seems uninterested in checking effective application beyond formality of the ISO 9001 standard.
Moreover, amongst the different existing environmental and energy sustainability certification schemes for buildings, LEED is now at opening stage also in Italy, due to an effort of the Provincia Autonoma di Trento (a Local Authority in the Northern, colder part of Italy, endowed with considerable self-government capacities).
LEED, originally conceived for action in the U.S.A., does not deal just with performances of the buildings, it states specific obligations to the ownership on matter of construction technology and methods, starting from the construction stage.

Integrated Management Systems vs Performance Approach?

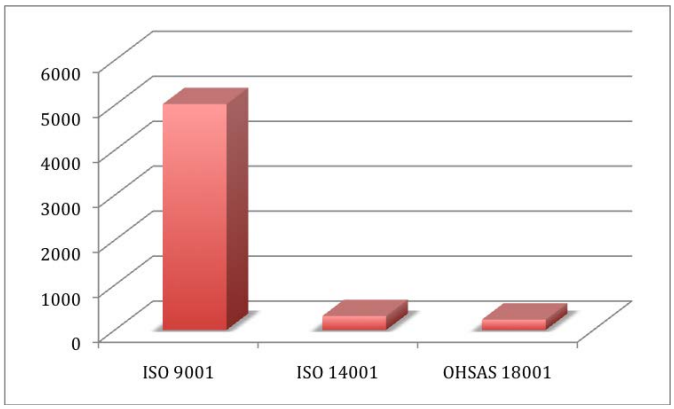
The LEED Certification Scheme is the last in order of time in a series of standards (usually non-mandatory standards) aimed to determine higher quality from General Contractors' behaviour. In this case, the certification scheme goes beyond a close scrutiny of the actual performance on duty of the building, and includes whole process aspects: design, components production, on-site building, environmental impact.
This approach involves a soft refusal somehow of the end-user performance approach (do-it-as-you-like, just make it work) in favour of a more holistic, systemic, back-looking approach (check performances, check the whole process and sum up the energy tidbits). In fact the purpose of LEED and LEED-like systems is to avoid high energy performing buildings obtained through unsustainable construction processes.
A more basic, less specific tool, the first as to spread and age, is of course the ISO 9001 standard, today updated to the 2008 release, which in fact evolved year after year from a starting imprinting of quality assurance. Especially, critical productions were the main target for this standard: installations for the military purposes (with specific benefits for European Contractors working on account of the US Army or the Navy), or nuclear power plants.

More recently a conscious attempt was made to implement ISO 9001 more stringently in terms of product quality, i.e. as assurance of adequate global performance of final products, as an attempt to manage and monitor apparently detached processes, like the selling process or the purchase/procurement process.
This perspective, basically non-mandatory, and conceived as a result of free agreement between Contractors and Clients, was made mandatory in Italy within public works procurement procedures: in the Nineties, a new "framework legislation" established the obligation for General Contractors to obtain an ISO 9001 Conformity Certification in order to be qualified to bid to Public Administrations for project of a certain importance (more than 500,000 euros)
Recent global data confirm the effect of a State enforced approach to ISO 9001 in respect of other Management Systems.



Conformity certificates issued today in Italy (source: ACCREDIA, 2009)

One of the many consequences of this is a difficult readability of the effective quality assurance level given by the different contractors: actually, while we can recognize very good and valuable certifications, on the other side some "QMS" can be found not worth the paper they are written on: which means that a Private Client can effectively assess the real quality of its bidders, while the Public Administrations are not allowed to exclude a bidder if it can provide an ISO 9001 certificate together with other non-technical requirements required for qualification.
The last data show even larger divides between Quality Management Systems and Environmental /Safety Management Systems.



Conformity certificates issued from January to September 2010

(source: ACCREDIA, 2010)

In Italy, in front of about 250 certification available schemes, QMS (Quality Management Systems) amount to more than 30 % of issued certificates. The Construction industry deploys at least 80 Certification bodies altogether, and more than 27 thousand ISO 9001 conformity certifications from its beginning: the building sector shows up consequently the most overworked certification block, and also regretfully the lowest technical literacy in the quality business.
We must consider also that the expertise hoarded within the Building sector in the field of the different Management Systems we are dealing with here (ISO 9001, ISO 14001 and BS OHSAS 18001) consists in a unilateral approach, limited to the Contractors via legislative approach, because in any case the same legislation does not require the same behaviour to the other main subjects of the process: Clients, Inspection Authorities, Design Teams, etc. Nevertheless, while Client, Designers and Public Authorithies are rarely "MS conscious", Suppliers are much more sensible to the issue, confronted as they are with more and more stringent requirements from a wider, more private market.
In any case, except for praiseworthy policies of a number of strong professional Clients (Public Clients, like Italferr, Infrastrutture Lombarde and others among them, or Private Clients), the unilateral mandatory approach to MS prevented from establishing a strong community able to share the vision, some practical principles and a common language.
Furthermore, total quality lip-service rhetoric (an empty rhetoric as far as the construction industry is involved today) was spent to cover the simple fact that "non conformity" is a phrase actually unfamiliar, outside strict contract's boundaries, in the dialogue between General Contractors and Clerks of Works.
A non conformity has to be necessarily reported by the contractual counterpart, and in any case Management Representatives and Quality Management Units are too often considered as antagonistic and estranged parts to the Site Managers of their own company.
Lacking in any case a systemic approach by all the subjects of the process, as seen above, this is the reason why the integration of different Models and Management Systems fails to be determinant.

Products or Processes?
The first question to ask deals about the amount of innovation determined in Europe by the mandatory introduction of ISO 9001 Management Systems: QMS standards are doubtless popular because they look easy, or even trivial ("who is not really unable to comply with them?"), and this faulty view never let to obtain full matching complement with product standards. Product standards are indeed more in the custom, even in their performance envelope after the New Approach, but they are much less insubstantial, and much more difficult to cope with: so the way it goes is "product standards are too complicated and too expensive to conform to, while QMS are for us, because we do know how work is to be done".
What mentioned above helps to understand how intimately International Standardised models may stem from a context where cultural appropriation results in technical behaviour sometimes even supported by certification processes. In other places and other contexts, as opposite, a deeper concern for technicalities about the built object leads to consider planning and construction methods themselves as a source of guarantee.
The Italian approach aims to reconcile the two visions analyzed above, offering a medial approach which, on one side countermands the most relevant aspects of both, on the other side delivers well-devised Designers (Architects, Architectural Engineers, Structural Engineers, Designers of Building Services, Landscape Designers, etc) to a job market which is unable to absorb all of them as designers; luck is, but not by chance, that their profile is very flexible; as a consequence, would-be Designers-to-be are instead absorbed by the

construction industry and its ancillary industries: their enrolment discounts the price of lack of knowledge in process management and control, and training starts almost from scratch, with the result of higher costs for the industry, no injection of authoritative contributions, and professional development based more on empirical parroting than over strong research in process innovation.
Leaving the complicated educational issue and going back to Contractors and sites, provocatively we might say this happens as a consequence that the attention given to management standard in Italy in the last 20 years is due more to their bad, widespread deployment, than to effective improvements obtained by the industry in terms of better behaviour towards their Clients and building process practices.
The role of the Management Representative was never pivotal - and it is not today - in company organization charts, neither when the MR was involved "just" in Quality Systems, nor when the MR's competence is widened to cover Integrated Management Systems.
QMS yesterday, IMS today, seem to be always peripherical to the real core of the business, of the financial issues and of the industrial relations between unions and companies.
All this considered, we might even question the choice of keeping today the all-purpose, all-industry scope of ISO 9001. Actually, the mandatory effect given to the standard by Italian Codes determined two opposite perceptions: at first, in the Nineties, the firm opposition due to the publicly declared "impossibility" to implement ISO 9001 according to the Contractors because of their "peculiar field of work"; later, and more and more today, the intrinsic "universal" scope of ISO 9001 is the mitigating circumstance for a trivial, almost lip service, implementation which leads to no significant action.

QMS, IMS and Innovation

In the background, stands the main issue of "innovation" in building site organization: is it a must-have? Furthermore, are Management Standard Schemes actually effective in such a direction? In one perspective, as an example, a comparison between a site of the '70s and a site of the '10s in Italy shows an absolutely significant evolution/innovation in provisional facilities (formworks, scaffoldings, truck mounted decks, glass pane vacuum pad grippers, safety provisions in general), handling machines (more and more performing tower cranes, sophisticated microelectronics controlled truck mounted cranes), road work machines, and not only machines in general, but also in building technologies and processes.
Minor changes we can detect instead (unless cases of more than accurate industrial secret protection) on subject of planning, controlling and monitoring, in spite of interesting and promising innovations proposed as a result of Home and European funded University Research: for instance a technology developed up to the field application stage employs transponders and wi-fi transmission networks to map workforce positions and to report the operating parameters of site machines, making available on the construction site the equivalent of a centralized monitoring and control centre of a "classical" factory.
In our knowledge, a sole exception of implementation of a somehow sophisticated, complementary technology is the usage of microtrasponders to tag and trace concrete specimens for law compliant testing purposes, in a major project in Central Italy.
In any case, process and procedure innovation which allowed the draft and the diffusion of ISO 9001, ISO 14001, BS OHSAS 18001 or other 9001-like standards (as SA 8000 in the field of social accountability) was the consequence of a "good will" approach of Clients who wished to minimize the risk of litigation along the buying-selling process. Such a "good will", solidly based on a possible mutual interest to minimize costs and to reduce processing times, proceeded from the empirical analyses of a great number of "sour cases", through the investigation of the reasons why something went wrong between client ad supplier. The drafting method itself explains why a mandatory approach to quality evaporates whenever

processes are under scrutiny, while it is much more effective if product quality is the involved.
In practical terms, a tools aimed to obtain harmony and concurrence in willing partners' business, is used (in Italy at least) as a certification basis to build up a confidence in Public Clients during the procurement process: in other terms, the chain QMS-certification-certificate leads to the gate of pre-qualification as entry point to the public works market. The reason why almost everybody enters the gate lies in our opinion, following the few data available, in the different attitude of the Public Client in respect of a Private Client.
If it is true that ISO 9001 was conceived under the Clients' initiative, and specifically under the pressure of their Purchasing Divisions, as a way to reduce costs and increase quality, then the success of QMS in the Client's perspective lies on the Client's willingness to implement a systematic effective watch and scrutiny over the execution and fulfilment of the contract: which means that not the mandatory presence of a QMS at the Contractor's office is the key, but - in case - the mandatory effectiveness of the Public Client. With due exceptions of course, a supplier Quality certification in case of an absconded Client may not be worth the paper it is written on.
It is a self-explaining paradox that the pre-qualification procedure regards QMS and its certification as documents to be delivered to the SOA (a private organization conceived to be witness of the fulfilment of pre-qualification requisites), and not to the Client.
This paradox may be explained by the peculiar atmosphere of the Nineties in Italy, in which the law makers of the age felt little confidence in the Public Clients and the awarding Authorities in general, and preferred to set up a guarantee mechanism which is fully external to the straight contract relationship Client-General Contractor.
Consequently, the law established as a fact the otherwise disputable theory that a subject not directly involved in the contract may effectively give guarantee where other internal means failed: such a course gave a job and a responsibility beyond the possibilities of Certification Bodies, authoritative as they may be.
So, the legislative philosophy adopted in the Nineties, beyond a per se non criticizable mutual benefit between Certification Bodies and Contractors, led to consider as insignificant or at least peripheral the contents of Management standards and practices in various fields (Quality MS, Environmental MS, Health & Safety MS, etc). In such a way, many Public Clients widely illiterate about MS contents and methods by themselves imposed do not even receive a conformity certification of their possessions, and above all fail to be real, interested promoters of standardized, even law regulated procurement processes.
The indifference of the Public Client, as a chain effect, induced unreasonable readings of the standards, an absolutely discretionary choice in the selection of building sites to be audited by the Certification Body to start with.

All-business standards and business-related standards

As a result, for instance, the Quality Plan requested by ISO 9001 is correctly understood, drafted and used just by very few Contractors: the Quality Control on site, if present, is the minor substitute of the requested extensive Plan, which is conceived by the standard as a wide-range, general, continuously updated Construction Management Plan, including detailed, specialized, most of all interconnected plans (Supply Plan, Resources, Work & Time Plan, Communication Plan, Work and Performance Control Plan, Logistic Plan, Financial Plan, and whatever plan a wise contractor can think of for the specific site). Even at educational level, due to the scant consideration reserved to management and organizational matters in Architecture and Building Engineering courses, it may not be easy to make

students aware of the difference, as they often reckon the two plans to be inverted (quality plan as a sub set of quality control plan).
The "vision" of ISO 9001, and its foundational process approach, which are suggested as a key to a successful development of a building site and to a profitable completion of a job order, is too in the majority of cases vilified to a few documents containing instructions for quantity and (sometimes) quality survey and (sometimes) to a field survey.
The deep understatement in which is held the role of QPs (Quality Plans) is leading to dire consequences specifically in a public works market in which tools for an efficient and documented job management are few and sparse. This perspective is certified by the effort of the law makers to insert in the process a relatively new character in Italy, the Public Process Manager: he/she is a individual, not an organization, an office or a department, a sort of Project Manager short of means and generally lacking specific experience. Further, the cardinal role of the briefing phase was introduced, but both the set up / execution of a Project Execution Plan, and the creation of a support unit including the project sponsor, were forgotten.
QPs were conceived by the standard maker to adjust the structure of the QMS to the peculiar aspects of different job orders from different Clients: in this role, QPs might have been - whether seriously adopted and not just formally issued - beneficial to lack of method and to the habit of issuing documents neither detailed nor in context.
On the other side, it is undisguised that the preference accorded both by Clients and Contractors to the realm of Quality Control during production points, in the management field, to something very near to the description/prescription approach in product standards field. This leads the companies to underestimate and understate the importance of thinking in terms of processes, possibly because an all-business standard like ISO 9001 cannot avoid to put the matter in ways misinterpreted as vaguely expressed, unspecific when not trivial. From this, a formalistic view follows, centred on "building police" inspections, sanctions and penalties, while the positive, prize oriented cut is not understood and ignored. Furthermore, quality records (simply "records" in the 2008 release), instead of being produced as a "natural" output of construction activities, are routinely postponed, and too often fabricated or misreported: the feeling towards quality records, and their pointless registration, only increases the bad reputation of QMS as formal, bureaucratic constraint.
Finally, the last questions. Are we allowed to conclude that QMSs did determine innovation in the building process? May a crudely simplified implementation of QMSs have obtained their scope, i.e. to trigger actions to remove the sources of uncertainty planted before the construction activity on site began? What meaning may have the continuous improvement concept when it's stuck to the sole Contractor, separate from its Clients and its joint-venture partners? Moreover, what is the perspective of investment in education and training when the bidding is done more and more frequently by temporary ventures of several Contractors with no interest to share procedures, management systems and education and training policies?
We should well keep in mind on this subject that ISO 9001 heavily emphasizes the role of training and education, but it excludes workforce management and union accords from its scope: is a reference to SA 8000, now ISO 28000-2010, enough?
What we have observed shows positive exceptions. Regretfully, lacking a systematic review of a significant amount of cases, it would be partiality or undue favour to report identities and references to specific job orders.
Nevertheless, we can outline undisputed situations in which Public Clients and Private Clients resolved to implement earnestly the QS standard: along the flow of those jobs, the process quality and the final product quality were effectively and positively oriented: which is, combined with the many negative examples above, crystal clear evidence of the miscalculation committed by the law makers when QS standards were limited only to

contractors' pre-qualification and to the decrease of bid bonds or guarantee bonds. At this point, it would be ungenerous to blame Certification Bodies as sole culprits: the limited scopes of the legislative approach themselves prompted the CBs to a slack behaviour as a matter of course, widely contributing to indulge in a trivial view of QMS. As it always happens, cultural shortage determines severe backlash in practical matters.

Beyond ISO 9001

The ISO 14001 Environmental Management System, as long as the LEED requirements, was in high favour at Clients, while it showed much more restricted usage by Contractors, especially in respect of ISO 9001. Yet, ISO 14001 is itself related to law requirements on matter of waste reduction and disposal in industrial activity. Beyond that, the standard is linked to BS OHSAS 18001, because the environmental issues are not disjointed from workers' health, which is of course environment-related.

ISO 14001, a standard ISO 9001-like, so conceived for its integration in QMSs, boasts wider success than its homolog, at least abroad: a well known application was sponsored by the Olympic Delivery Authority, who manages the job orders in view of the Olympic Games, London 2012.

As to BS OHSAS 18001, the running risk is of the same kind of ISO 9001: the British standard was recently recognized, in view of its becoming an European Standard, by the Italian legislation. The approach is too similar to what mentioned above: the certified Safety Management System is due to relieve the responsibility of owners and managers of building companies under criminal and civil law, if those subjects can give evidence that a health & safety management system was established. Absolutely correct in principle, this approach might easily skid towards purely formal documents leaving things worse than they were, with responsibilities ironically flowing in any case towards dead and injured workers. Few implementations are known at the moment, but it is not rash thinking to foresee in the health and safety field the same effects resulted in the quality management field: law constraints favouring widespread implementation might determine no factual application and scepticism as well.

Yet, a doubtless interest and innovation can easily be traced in OHSAS 18001: for instance, the requirement to investigate near misses accidents (keeping records and looking for causations, like aviation authorities investigate missed collisions events), not only actual accidents resulting in death or injury.

This kind of contents, likewise in ISO 9001 implementation, shows success whenever it actually determines a change in managers' thinking, and conversely leads to nothing if no cultural belief is induced. Like old Romans said "leges sine moribus vanae": laws are vane whether not absorbed in habits and custom.

System Integration

ISO 9001 and other mentioned standards were specifically conceived to be integrated. To support the efforts of integration, a "publicly available specification" was published by the British Standard Institution: the PAS 99 "Specification of common management system requirements as a framework for integration".

This pre-standard contains useful guidelines to build up an "Integrated Management System": purview of the PAS 99 is to help in creating a common frame of "general" management requirements, in number of six, as intuition can suggest and as ISO Guide 72 points out:

- Policy
- Planning
- Implementation and operation

• Performance assessment
• Improvement
• Management review

Generally speaking, the Integration of Management Systems is not a solution but an opportunity to go deeper into single subjects and scopes of the standards: actually, integration is worth in the measure it can widen the comprehension of the management about each standard scheme, and it can proceed beyond the sum of each standard scheme implementation.

In the specific field of the construction industry, system integration clashes both with the ineffectual relationship between Contractor/Client, and with the increasing practice of the JVs making the bidding. From this should stem the importance of Quality Plans, and of contributions given by Subcontractors and Suppliers.

Under those points of view, Management System integration stems from the basic asset of a Quality Management System. Which as a consequence shows that the construction industry, starting from non-convincing QMSs, will have even more chances to derail along the system integration process.

CONCLUSION

As a conclusion, the authors point towards two lines of action in the building field, at least for public works procurement and construction in Italy:

- first, give back tenability and authority to ISO 9001 implementation, through cultural and technical growth of Public and Private Clients, and through a thorough investigation about the implementation and certification of the scheme;
- second, innovate the processes active at the Contractors and their Subcontractors/Suppliers, deploying processes of integration among the requirements of richer, more articulate projects/contracts which might be defined under success of the point above.

Outside such a perspective, QMSs and their integration into IMSs would be expedient and beneficial only to commercial purposes of advice / certification markets.

Useful and correct as the standards may be, they would be to no avail effective to change the order of things. The rush to enforce new standards, and even more to enforce them through the law, all the more so as one still sees unaccomplished precedents, strikes as misguided at best. Something is needed "from the heart" here, because we are confronting cultural and educational problems, not simply technical and economical problems. Quality, Environment, Health and Safety, Social Accountability, and other concepts of that kind, are matters of culture and education, and their solution needs a cultural, educational, heartfelt response, oriented to make clear that there are no savings in cutting quality, in being harmful to the environment, in understating and undertreating health and safety, in downsizing social responsibility running Voodoo Economics and importing cheap labour, in short in sparing brainwork and substituting paper to specific, well coordinated efforts to solve the core of the challenges.

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PARTICIPATION IN COLLECTIVELY SOLD PRIVATE RENOVATIONS

(working paper, do not cite without permission)

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Abstract

Several pilot projects have spawned an increasing number of schemes involving individuals in renovation. A well known and awarded (World Habitat Awards 2008) project is the "Wallisblok" also known as "De Dichterlijke Vrijheid". This project involved the sale (for a symbolic amount) of a run down building block to a collective of future homeowners. The building block was in a poor technical condition and the collective owners had to (re)design and renovate the building block according to requirements set by the municipality. These requirements included both the quality of the renovation as well as the minimal investment. This scheme has been exported, copied and repeated due to its success. However, the schemes are different in several aspects, for example the price has never been as low as it was in the first project.

In the evaluations that have been written on the projects and especially on the Wallisblok, several gains are mentioned. Amongst others, neighbourhood improvement, home and street quality improvement, personal control over housing quality, participation amongst owners, strengthening of neighbourhood bonds and collective (neighbourhood) maintenance are mentioned (Sour 2009). Moreover effects that touch on demographic characteristics of the neighbourhood (attracting high income new residents, Van Der Laan 2009), on reaching environmental goals (climate change, Van Hal 2009) and contribute to diminish general socio-economic problems in the neighbourhood.

In this paper an overview of the stated effects and experiences is given and these are compared with the envisioned effects at the initiation of the project. The paper draws upon other (Dutch) evaluations and on literature that addresses similar effects. This paper is limited to a literature review focussing on the description of the project, its aims and effects. For the final conclusion, the effects of the project are put in perspective of scale and the competences of the collective that are necessary to create a successful project. Implementation possibilities of the scheme for use in more generalized housing and regeneration situations are mentioned keeping the limitations in mind. Thus the paper aims to give access to the characteristics of the project and to make an international interpretation of the scheme possible.

Keywords: Wallisblok, klushuizen, commissioning, empowerment, social diversity

INTRODUCTION

The "klushuizen" or DIY-homes (Do It Yourself) project in the municipality Rotterdam was initiated in 2003 by an architect (Ineke Hulshof) and process management agency

Urbannerdam (in person by Frans van Hulten) with the renovation project „Wallisblok". The project scheme that was designed based its approach on two observations. The first was that houses in the area of the Wallisblok were rundown but that their structural rigidity was still suitable to be renovated. The second observation concerned the poor social quality and/or the poor living conditions in the area. As a result of the poor quality in the area the neighbourhood was labelled as a problem neighbourhood by the national government (VROM 2000). Moreover, the area surrounding the Wallisblok was assigned a „hotspot" status by the municipality in 2002 (Rotterdam 2003a). The Rotterdam hotspots are unsafe locations with a problem accumulation, such as a poor physical quality, vacated dwellings, poor inhabitants, nuisance from prostitution and drugs related activities (Rotterdam 2003a). The municipality invited Urbannerdam and Hulshof architects in 2003 to create an approach to change these locations" characteristics in such a way that the hotspot status could be nullified.
The commenced basic idea was to get a collective of new homeowners to buy the complete housing block, make them renovate the houses to a high quality level and to live there for at least two years. In this way both the physical problems and the social problems would be addressed (e.g. VROM 2006). Due to the success of the Wallisblok, the municipality decided for a bigger project with more houses and the DIY-homes project was born and named „169 klushuizen".
Since the first idea in 2003 and the start of the first project, around 450 houses have been delivered in Rotterdam and transformed into nearly 200 bigger homes. The objective of this paper is to give insight in the characteristics of the Rotterdam based DIY-homes scheme. An overview of anticipated effects and effects that are found in several evaluations is given and the contributed effects are discussed. The central question of this paper is: what are the social, physical and financial effects of the collectively sold „Klushuizen". To answer this question the paper distinguishes effects that are aimed for and effects that are claimed to be found in literature. This paper is explorative in describing the goals of DIY-homes, evaluative in comparing results with the goals. The paper draws solely on literature study and project information as obtained from Urbannerdam. The paper concludes with suggesting adjustments for the scheme to make future projects even more successful.

The paper consists of five sections. In this first section first some background for the DIY-homes scheme and some theories that were found applicable are given. The second section consists of a general description of the DIY-homes scheme addressing the conditions for the scheme, the target group and primary goals. The third section illustrates the DIY-homes scheme using the Wallisblok project as a typical example. The physical characters, specific goals, investment scheme, design and renovation process and the results of the Wallisblok project are described. The fourth section presents the effects as found in literature attributed to the Wallisblok project and more in general to DIY-homes schemes. The effects are presented and reviewed. The fifth and final section contains some discussion and addresses the goals, effects and opportunities of the DIY-homes scheme. Finally, it suggests further research to measure the effectiveness of the scheme.

Origination of the DIY-homes scheme

Urbannerdams" office background suggests that the DIY-homes scheme can be traced back to the urge to get inhabitants in neighbourhoods more involved, to restore trust in the government and housing associations and to battle the generic urban restructuring approach (Van Hulten 2004). Van Hulten suggests a different approach for urban restructuring opposing the traditional one. The suggestion to institutional actors, such as the municipality and housing associations, is to rely more on a modest role in urban regeneration. The problem

analysis and the creation of a vision on the future of a neighbourhood are more important in this approach than executing the restructuring. To make this approach successful it is necessary to communicate a vision in an early stage of development. The vision should contain less actual plans to offer opportunity for the inhabitants to identify their contributions in the reaching the envisioned situation. Van Hulten thus suggests a role for the municipality that is to facilitate and initiate, rather than realise. At the same time it offers the opportunity for the municipality to be more susceptible to demands and wishes from the inhabitants. In this approach the interaction between local inhabitants needs to be stimulated and supported and is a mean and a goal at the same time. The approach should lead to an increase in property value, lower turnover rates, improved housing quality, active owners associations, reduction of nuisance complaints and increased social cohesion. This approach shows similarities with so called „area development" and „demand driven housing management" (e.g. Van Overmeeren and Zijlstra 2009) in the respect that the relation and involvement of actual inhabitants (should) prevail. However, for this paper some theoretical backgrounds are found in theories concerning gentrification, rather than management. The following paragraph shortly addresses some relevant backgrounds for the DIY-homes scheme.

Theoretical background for DIY-homes

The selection of the houses in the DIY-homes scheme is based on the neighbourhood, the quality of the building itself and the possible value-gap between them. This approach can be compared to the „rent-gap" theory from Smith (1987). This theory assumes that the factual price of a building, considering the state, location and size, is lower than the current actual price. This so called rent-gap or value-gap (the difference between potential price and present day market value) theory is used to explain gentrification of for example New York neighbourhoods (Smith 1987). Smith elaborates that through the first gentrification effects, the local economy will be influenced as well. Gentrification has, in this respect, effect on both physical and economical climate of the neighbourhood. But the social composition is effected as well. While prices are rising as an effect of gentrification, low income occupants move out, or are forced out, and higher incomes start to occupy the neighbourhood. Accordingly, the gentrification process has effect on three different pillars identified in the introduction: social, physical and economical.

The Wallisblok has been referred to as „gentripuncture" rather than gentrification (Van Eijk 2010, Hoofs 2005, VROM 2007, COS 2007, Crone 2005, De Jong et al 2008). Gentripuncture mainly differentiates itself from urban restructuring in scale and in the approach. Gentripuncture aimes at giving incentives by means of giving opportunities to gentrifiers (De Jong 2008) while restructuring focuses on renovation or demolishment and rebuilding large amounts of estates (Van Eijk 2010;21). Gentripuncture, a contraction of gentrification and acupuncture, could be placed in the state-led gentrification approaches as identified by Uitermark et al (2007). Uitermark et al argue that state-led gentrification is an actively chosen strategy by a coalition of governments and housing market actors to change the social composition of a neighbourhood to restore the social order and structure. Gentrification and Gentripuncture accordingly, can be seen as a global urban strategy (Smith 2002). Gentrification, as defined by Clark (2005;258) is ``a process involving a change in the population of land-users such that the new users are of a higher socio-economic status than the previous users, together with an associated change in the built environment through a reinvestment in fixed capital." Thus by changing the neighbourhood composition the gentrification strategy can fight problems as poor living conditions in neighbourhoods. The definition of gentrification can be recognized in the Dutch urban restructuring strategies as well. The restructuring strategies focus on replacing low rent-price, low-quality houses by homes aided for higher and middle income owner occupiers (Uitermark et al 2007, VROM,

1997; 2000; van Kempen and Priemus, 1999). Rotterdam is no exception and has been aiming to maintain and attract higher incomes to the city (Rotterdam 2003a/b, 2006). However, the success of these strategies are under debate and not yet proven (e.g. Van der Land 2004). The DIY-homes scheme can be placed in the context of "joint private project commissioning" (Collectief Particulier Opdrachtgeverschap (CPO) Blom 2009, NRP 2009) but that has been mostly limited to new construction (Blom 2009, Boelens 2010). For this paper the context is limited to effects related with gentrification.

DESRIPTION OF THE GENERAL DIY-HOMES SCHEME

The DIY-homes scheme can be interpreted in different ways. A building in a very bad shape can be named a DIY-project, which happens often by real estate agents. For this paper DIY-homes are defined as (Urbannerdam):

1) the buyer has a lot of influence on the design and realisation of the renovation and has been given the opportunity to manage and remodel both exterior and interior of the house;
2) the seller demands from the buyer a certain effort by requiring the buyer to:
    a. renovate according to a programme of requirements set by the seller regarding building standards (higher than the usual Buildings Decree) for example in means of energy, comfort and looks. In this way the quality of the renovation is controlled;
    b. live in his DIY-house for a given time (determined by the seller) to prevent the houses from being sold for a higher price and making it less interesting for property traders and to prevent speculation;
    c. to renovate the building block (only if applicable) in a joint effort of all the new buyers.

Requirements/Conditions

Besides the requirements that have to be met in relation to building quality, self-occupation and collective renovation some other requirements are demanded from the future homeowners. The future homeowners have to meet a financial criterion that asks them to be able to finance the purchase plus the estimated renovation costs.
After the completion of the collective renovation all the owners get a determined period to finish the interior of their homes themselves (or have it done by a building contractor). This period ranges from 6 to 12 months in order to keep the project going and to be able to check if the desired minimum renovation level has been lived up to individually as well.
The conditions need supervision and monitoring during the process of renovation and even after completion. The municipality provided the new owner occupiers with experts during the design and renovation process (see next paragraph) and used monitoring tools to check whether the conditions were met.
Over time these conditions changed a bit since their first use in the Wallisblok project and were optimized throughout the other collective projects. The basic three main conditions remained the same.

Target group

The target group of DIY-houses are mainly people who are willing to put a big effort (time and money) in a house, in a dilapidated neighbourhood. They like to realise their own desired living space and by their investment will be involved in the condition of their home and their neighbourhood. Depending on the location, possibilities and conditions, each scheme has it is own more specifically defined target group. Candidates can apply when new houses to be

sold are announced. The only selection criterion the municipality uses is the mentioned financial test. Candidates that prove to have sufficient financial means to pass the test are allowed to enter the drawing of lots to be assigned a place in the project. In advance the desired minimum quality of renovation has to be determined, budgeted and communicated, to minimize surprises (such as failing the test) and unexpected (extra) costs for the new buyers.
In general the features of the DIY-scheme are attractive because:

1) the new homeowner is in full control of the characteristics (quality and costs) of the property;
2) the requirements require both an effort from the homeowners as from the municipality;
3) the requirements guarantee banning of undesired tenures.

Primary goals of DIY-homes scheme

The initiator in the DIY-homes scheme is the municipality of Rotterdam. They own most of the DIY-homes offered in the scheme (eg. the homes in the Wallisblok) as a result of purchasing run down houses. Sometimes the properties are (formerly) owned by housing associations, mostly the properties are purchased from private landlords. The municipality states that the project should contribute to create "bigger, affordable dwellings, to create a more mixed neighbourhood and inhabitants" (Rotterdam, 2006). In the sale agreements the municipality addresses several „considerations". The agreement states that the physical and social living conditions in the area are poor and that the area was assigned a „hotspot". The municipality states to have invested national subsidies to restore the building quality (used on the foundations) and that the obliged renovation has to lead to "bigger, renovated houses that attract and are attractive for other occupants than actually present in the neighbourhood, leading to a more mixed neighbourhood." In these considerations the physical and social goals prevail. Zoethout (2005) signals that the context of lacking tools to control the housing quality and budget cuts at the municipality are a general driver towards the DIY-homes scheme. More in general, the municipality was searching for instruments to get inhabitants and owner occupiers to invest in their own living environment (Zoethout 2005, Blom 2009, Rotterdam 2003a, VROM 2006, Hoogstad 2007). According to Blom (2009) it is a challenge to find solutions for the question "how to attract buyers to a deprived area? How can you change a negative image of an area in such a way that the neighbourhood transforms to a trendy hotspot in a few years time?" Blom thinks that physical renovations, with or without subsidies, are not enough to improve the quality of an area. One of the reasons is that the properties owned by private landlords cater undesired tenancies as (illegal or overcrowded) pensions and sub-letting. Considering the distribution of tenancies in the neighbourhoods (Spangen for example consists for 95% of rental homes and 5% owner occupied homes) stimulating homeownership should be part of the approach. Blom assumes that owner occupiers are more strongly involved in the neighbourhood than rental tenants.
Hoogstad (2007) states that the primary goal of the municipality was to get the building block sold from their portfolio. According to Hoogstad the main question was how to attract potential occupants for the dwellings situated in the "deprived" area (Hoogstad 2007, compare Blom 2009). The privately commissioned collective renovation was the solution the municipality believed in to offer such a "niche" to attract "creative" people (amongst others Hoogstad 2007, Blom 2009).

General goals for the DIY-homes scheme can be summarized in being:

1. improving and guarding housing quality (larger, diversified, renovated);
2. improving and sustaining neighbourhood compositing (different from present neighbourhood composition, higher incomes, creative people);

3. improving economical viability (giving financial incentive to attract and stimulate investments);
4. fighting undesired tenures (sub-letting, illegal pension holding).

Thus leading to an overall improvement in the area and removing a hotspot appointment. The effects can be identified through differentiation in physical housing stock characteristics, raises in average housing values and improving the inhabitants‟ judgements on safety and the quality of the living environment. These goals are enforced by the terms and conditions set by the municipality in the sale agreement and work along several mechanisms such as attracting higher incomes to the neighbourhood and improving the image. Furthermore it is believed that the new homeowners shown a greater commitment to both home and neighbourhood as a result of the investments they have made in time, effort and money. The new homeowners are expected to have higher incomes and different backgrounds than the existing inhabitants in the neighbourhood, thus leading to differentiation and an increase in purchasing power in the neighbourhood. Further living quality improvement could be reached as a result of a role-model effect both socially and physically.

The architect and process manager (Ineke Hulshof and Frans van Hulten) are cited “if a municipality or housing association develops such a project it undoubtedly ends in an unpopular project full of compromises. … people are willing to live in such a project but not when it is situated in a neighbourhood like Spangen, they are only willing to [live there] when they get full control [over the renovation and design].” Ditty Blom is cited “they want a lot of floor surface and space, and most of them have dreamed for years of a home that they can design and model to their own desires.” These quotations illustrate social goals (attracting a different target group, offering a home that can be fully controlled), economical goals (delivering value for money, loosing the building block from the portfolio) and physical goals (a home made to measure and solving poor living conditions in the area starting with the building block). The goal of the project could therefore be captured in terms of state-led Gentripuncture aiming for gentrification of the Spangen neighbourhood (Bosscher 2007).

DESCRIPTION OF WALLISBLOK PROJECT: the first DIY-homes scheme

The Wallisblok also known by the name the „De Dichterlijke Vrijheid‟ (the poetic freedom) is situated in the neighbourhood Spangen in Rotterdam, and the location is assigned a „hotspot‟ status (Rotterdam 2006, VROM 2006). The neighbourhood is referred to as the “drain” of the city, thereby collecting all the dirt and problems of the city (Crone 2005). It is an unpopular area dominated by non-Dutch-native inhabitants (over 75%, ibidem;4). The building block was heavily dilapidated and Spangen as a neighbourhood in general was considered a weak area of Rotterdam. Spangen was well known for its bad reputation. The properties were previously owned by private landlords that neglected the buildings. The municipality bought different poorly maintained properties in the building block since 1998 (Sour 2005) and boarded them up. The municipality has legal tools and had the means to intervene in „dangerous‟ housing situations. The municipality can force a homeowner to improve the housing quality when it becomes dangerous according to the building law. When an owner does not comply, the municipality will commission the renovations themselves and forward the bill to the homeowner or owning landlord. When the homeowner thinks the investment is more expensive to be worthwhile, the municipality can offer to buy their properties from them, renovate the building according to the safety standards and sell them again. This method was used in many cases and is known as the Aankoop-Verbeter-Verkoop concept: buy-improve-sale concept (Blom 2009;35). As a result of the regulations, the

municipality was able to buy the properties relatively cheap. Most of the houses remained boarded up to 2003 and thereby enforced the negative image of the area.



Figure 1: *picture Wallisblok before renovation (2004)*

Physical characteristics

The architect and process management company were invited by the municipality to explore the options of renewal and came to the conclusion that the Wallisblok:

- Was in a poor physical condition and needed a full renovation including the interior, the foundations, roof and the rear facades;
- Represents a high architectural value block since it is constructed in the 1930‟s typical Amsterdam School style;
- Would cost an equal amount to renovate as it would to be demolished and rebuild or redeveloped.

As a result, the advise was to renovate (Blom 2009). Crone (2005) and VROM (2006) emphasize the poor physical quality and stress that the municipality will improve the quality of the building foundation if necessary before the houses are actually sold.

Specific project goals Wallisblok

Renovation is a clear goal and according to the sale agreement, the quality aim is to create not just bigger homes, but to ensure the quality by demanding new-built standards. Improving the physical and structural quality of the homes thereby is important to attract future occupants and preferably is realised before the homes are sold. This is necessary since the image of the area is too bad to attract occupants (Blom 2009).

Joint private project commissioning, mixing (attracting high incomes) and improving the image of an area are goals within urban renewal (Berkelbach 2006). Attracting high incomes and revitalising an area can be part of a gentrification strategy as well.

Agricola and Helleman (2006) place the Wallisblok in the urban renewal background aiming for social cohesion, citizen participation and urban mixing (ibidem;12). According to them especially the link between the social and physical urban regeneration is of importance.

The goal stated in VROM (2006) was to increase owner occupancy in the neighbourhood and to reach dwelling diversification. The follow-up projects have to improve the image of the neighbourhoods and have to contribute to the gentrification of Rotterdam (ibidem;6).

Investment scheme

The investment estimate excluded the costs of purchasing the properties and the costs for improving the foundations. Using subsidies (ISV1 and 2 national subsidies for urban renewal and IPSV national subsidy for innovations in urban renewal, Blom 2009;46) the renovations of the foundations could be paid for by the municipality. Considering the estimated value of the houses before and after renovation, the municipality decided to „give away" the building block to a collective of future owners. In fact the Wallisblok was sold for a single Euro per buyer. In return for a free (in later projects a cheap) home, the future owners had to meet the conditions mentioned.

The price is determined by valuing the renovated property minus the investment costs. This price is (should be) lower than the property"s value in its present state. This method of pricing is necessary to make the project interesting and affordable for future buyers. For the Wallisblok it turned out that the municipality had to sell the houses for a single Euro, later projects were never this cheap since the quality of the properties wasn"t as bad as in the Wallisblok.

It is required for the new homeowners to renovate the building block (if applicable) as a collective. They have to act as one private commissioner. The owners have to come to one general renovation plan. The advantage is that they share the costs of the collective renovation equally (according to purchased floor area in square meters) and thus should be able to get a relatively good price for the works commissioned.

The design and renovation process

After the announcement of the Wallisblok being "given away" in November 2004, there where over 400 interested potential buyers of which 39 decided they wanted to take this challenge and finally formed a collective of homeowners called "De Dichterlijke Vrijheid". The (design) freedom, collective and the price aspects attracted the new homeowners to the project. The costs for a single floor apartment were estimated on €70.000 and € 200.000 for a four storey house (about 160 square meters).

During the process the buyers got assistance from experts. The design and planning process was accompanied by the process manager (Urbannerdam) and architect (Hulshof) and there were municipal permit experts involved, guiding the buyers through the different phases of developing their own homes. The process manager had knowledge of the entire building process and more importantly had knowledge and experience in controlling group dynamics. The architect assisted in designing the wishes and desires of the homeowners and had knowledge about technical and process matters. The future occupants were closely involved by the experts so to become experts themselves on different aspects of the building process.

To get things started, workshops were used to determine housing preferences on which the later parcel layout was based. Groups of buyers were formed which investigated specific terrains. The formed building group of homeowners acted as the private commissioner and formulated the groups" collective wishes. Another group of owners formulated the sustainable investments and another group made a plan for the collective garden.

Result

The Wallisblok project turned 96 dilapidated units into 39 renovated, high quality, inspired and unique homes. As a result the building block was preserved, the architectural value was kept, the facades renovated and the run down image of the street improved (compare figures 1 with figures 2).



Figure 2: *picture Wallisblok after renovation (2008)*

EFFECTS OF FIRST DIY-HOMES PROJECTS

In 2010 a total of up to 450 houses have been offered in the DIY-homes scheme and that has led to improvement of and occupancy of nearly 200 remodelled homes. About 57% of the houses has been offered in some sort of a collective scheme while the other houses became individual homes that were no part of a collective. The DIY-homes are mainly offered in three neighbourhoods of Rotterdam: Delfshaven (Spangen), Feijenoord and Charlois.

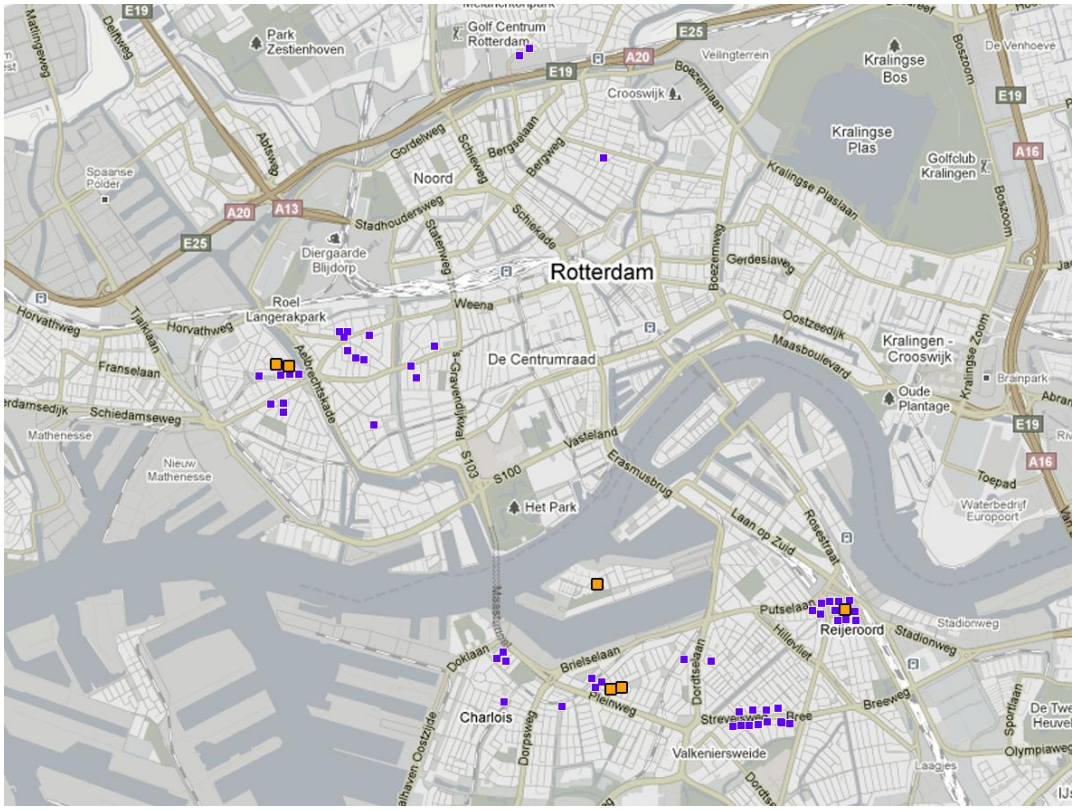


Figure 3: *geographical overview of DIY-projects in Rotterdam. (Orange squares represent collective projects, blue squares represent individual homes)*

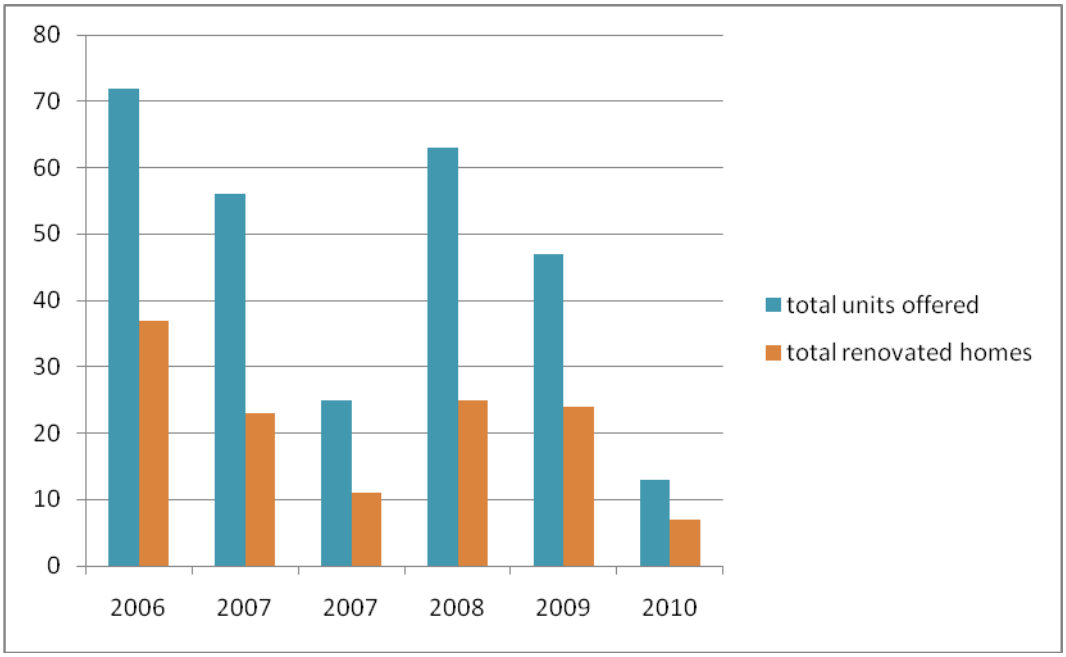


Figure 4: *Timeline and number of homes offered (both collective an individual DIY-homes)*

Selection criteria for homes and neighbourhoods

Selection criteria should be (Zoethout 2005) that the houses are part of a single building block and all houses in the block are included in the scheme. Preferably the area is close to the city centre, the dwellings are cheap or preferably free and worth an expansive renovation. Buildings with ‟30‟s architecture are preferred (ibidem;49).

The houses to be offered are preferably run down since the lower quality will lower the price as illustrated in the investment scheme and calculation of the sales price. The lower price and poorer state offer the future owner more possibilities and at the same time is gives the municipality a justification to demand (more) conditions.

Some warnings are issued by Zoethout as well: the group of new owners cannot be much bigger than 36 to ensure that decisions can be made and meetings will be fruitful. But there is a minimum group size as well, if the group consist of less than about 8 buyers the amount of available time and effort and therefore work being done and knowledge within the group is reduced. Good planning and guidance is essential. Moreover, Zoethout believes the scheme is not applicable in deprived areas, the future inhabitants need to have faith in the future of the area.

Blom (2009) is clear about the economical aspect from the municipality‟s point of view. Other housing investors, such as housing associations, didn‟t manage to envision a financially feasible project in the Wallisblok case, even including subsidies. The buy-improve-sale scheme therefore wasn‟t working and an alternative had to be found. Giving the houses away was left as the only solution (ibidem;39). The scheme was financially backed by a housing association from Rotterdam (if the houses weren‟t sold, however free, the association would do the obliged renovation investment, Blom 2009, De Jong et al 2008). The selection criteria for the possible DIY-homes schemes can thus be supplemented by the need for a value gap and by the availability of subsidies to bridge the negative investment.

Berkelbach (2006) states that inventiveness and a social attitude are needed in the future owners to be willing to join in a (collective) DIY-homes project. To attract the future inhabitants and keep them from withdrawing from the project it is essential to be honest and give an estimation of the costs that is feasible (De Jong et al 2008).

Project name	Period	Area	No. dwellings before-after renovation	Sale price-investment	Remarks
Wallisblok (Dichterlijke vrijheid	2004-2007	Spangen/ Delfshaven	96-36	0/unit 200.000/dwelling	First pilot project
Kleine Kop Vosmaer (Blauwe Vos)	2006-2009	Spangen/ Delfshaven	39-18	10.000/unit 1.400/m2	
Verschoor 2	2008-2011	Tarwewijk/ Charlois	15-5	110.000/dwelling 65.000/dwelling	partly renovated before sale
Beukblok	2007-2010	Hillesluis/ Feijenoord	16-6	0/unit 1.200/m2	Initially non-sold apartments got partly renovated before selling
De Driehoek	2007-2011	Katendrecht/ Charlois	85-36	15.000/unit 1.500/m2	Offered in collaboration with Nieuwe Unie housing association (Woonstad)

Table 1: *Overview of characteristics of the collective projects realised (Urbannerdam 2010).*

Stated effects of the Wallisblok project and DIY-homes

Van der Laan (2009, minister of VROM at that time) concludes that there are three main reasons to stimulate DIY-homes schemes. The first is the positive effluence on the neighbourhood of DIY-homes. He feels the scheme should be used in deprived areas since inhabitants are the first to notice problems and the first to have ideas on solving them. Secondly the scheme gives tenants full control over the housing quality. Third and last he concludes that the bond between occupants created during the renovation will have an effect on the collective maintenance of the homes and of the neighbourhood.

De Jong et al (2008;40) summarizes the effects of the Wallisblok project in 7 "lessons". The DIY-homes "stimulate social cohesion in the area (1); stop the downward spiral of degeneration (2); increases owner occupancy (3); diversifies the housing stock (4); attracts people with higher education levels and incomes (5); comply to individual housing demands leading to diverse and extraordinary homes(6); led to an increased confidence within the municipality in the scheme and its outcomes (7)." De Jong et al don"t state any economical effects but oppose the effects to the investments: between 70.000 and 350.000 Euro per dwelling per individual household. And an additional investment from the municipality of 35.000 Euro per dwelling excluding the additional costs for foundation repairs.

Now an effort is made to distinguish the different effects according to the distinction made between physical, social and economical effects.

Physical

The homes created are extraordinary (De Jong et al 2008) and got published in the (Dutch) Architectural Yearbook (Blom 2009, Van Hulten 2008). Zoethout (2005) states as positive results that "characteristic buildings" are maintained instead of demolished. The dwellings are more diversified (ibidem, De Jong et al 2008), became considerably bigger (Boonstra 2008, De Jong et al 2008, Sour 2009), and contain some very special lay-outs (Van Hulten 2008, Sour 2009). VROM (2006) states that the goals of increasing owner occupancy in the neighbourhood and dwelling diversification has been reached.

The project has been mentioned in relation to sustainability questions such as energy consumption, CO2 reduction and climate change as well (Van Hal 2009). At least they are renovated to high quality standards (Boonstra 2008). The aspects of physical neighbourhood improvement, home and street quality improvement and collective (neighbourhood) maintenance are mentioned, but more in relation to the social effects of the project. The Wallisblok received three awards. The World Habitat Award for the preservation of the valuable buildings, offering affordable homes and triggering local regeneration (World Habitat Awards 2008), the Job Dura Award for the contribution to safety in the area and stimulation of the rehabilitation of the area in the neighbourhood (Job Dura Fonds 2006) and the Innovation Award at the Nationale Renovatiedag in 2009 for innovation in the building process and contributions to social and economical structure of the neighbourhood (NRP 2009).

Social

The Wallisblok attracted 60 new inhabitants to the neighbourhood. The inhabitants have high incomes, which is consistent with the ambitions of the municipality (Zoethout 2005, Boonstra 2008). The inhabitants are a stable group and create a child friendly environment (Van Hulten 2008;45) at least in the inner garden (Van Hulten 2008, De Jong et al 2008). Inhabitants experience the shared responsibilities as pleasant and the inhabitants remain enthusiastic despite the hard work and long hours that had to be invested in the project (De Jong et al 2008).

Blom (2009;41) concludes that the DIY-homes attracted a completely different group of inhabitants to the area. She calls them dynamic urban people and the group is typified as "active with the city and street" and they "actively choose for a neighbourhood". The group is creative: architects, artists, designers and photographers. They are "pioneers" that choose for the control, freedom of choice and good value for money (ibidem). VROM (2007) typifies the group as the "creative middle class" rather than non-Dutch natives. Berkelbach (2006) calls the inhabitants highly educated as well. The inhabitants self-select (VROM 2006) and have the „perfect profile". This profile consists of creative people with high incomes and freelance occupations, that share "ideological motives" and are "empowered" ("weerbaar" VROM 2006). SCP (Gijsberts and Dagevos 2007) states that the owners of the DIY-homes are "frontrunners" and is one of the few successful measures to have a positive effect on social cohesion (Hoogstad 2007). De Jong et al (2008) refer to the Wallisblok effects as social climbing of the tenants. This „climbing" mechanism is referred to as empowerment as well (e.g. VROMraad 2006). In this case the main aspects of the process involve homeownership and control over the dwelling (De Jong et al 2006;42). Van Hulten (2008) refers to the strength of the group and the control they expressed in the project. Without these characteristics the Wallisblok project would not have succeeded in his eyes. It could be explained through motivation and shared opinions (ideology and ambition) of the group. De Jong et al (2008;44) conclude that the new inhabitants are a closely knit community consisting of the creative class (according to Florida).

The DIY-homes have led to cohesion amongst the tenants has been created as a result of intensive collaboration in the renovation and design phase (Zoethout 2005) and shows in the number of groups formed to get things done in the building block and surroundings. The project has contributed to create a more positive image of at least the neighbourhood (Van Hulten 2008;45). A tenant admits to have chosen for the DIY-homes partly out of idealism "we don‟t want to become a white enclave" (Hoogstad 2007). This statement was also found in Sour (2005;45). Some inhabitants themselves claim that the social cohesion within the group is an important factor (De Jong et al 2008). The social cohesion amongst the new inhabitants generates another valuable aspect besides the quality of the house itself (De Jong et al 2008;48). VROMraad (2009) signals that DIY-homes illustrate and generate cohesion and involvement with the living environment.

One of the advantages is that the housing consumer becomes a housing prosumer (after Toffler 1980) and models and thereby creates their own home and living environment. Hoogstad (2007) cites some tenants just after they moved in "we have created our own dreamworld", "an ideal housing situation … where I can settle" (De Jong et al 2008;48).

The effects on the neighbourhood are less simple explained. The safety index has improved (10point scale) from a 4,6 to a 7 at the moment the first homes are inhabited (2007, COS 2007). Major problems in the area have been solved such as related to drugs, homelessness and prostitution (Hoogstad 2007, Blom 2009). De Jong et al (2008) cite an inhabitant that mentions smashed windows and other nuisances in the neighbourhood. But the inhabitant recognises the attractive force of the Wallisblok as well. In its wake all kinds of activities are coming to Spangen and thereby having a positive influence on the image of the neighbourhood.

Urban restructuring could lead to inhabitants protesting against demolishment. Since the houses in Wallisblok were already vacant, it was decided to renovate in stead of demolish and built new houses, the inhabitants of the neighbourhood did not protest the approach. But some uneasy feelings have been expressed (Zoethout 2005;42). And Aussen (2010) concludes that the old inhabitants of Spangen are not really interacting with the new inhabitants of the project. However, the project hasn‟t led to feelings of displacement as could be found in gentrification literature (e.g. Hamnett 2003, Atkinson 2002). The old inhabitants of Spangen view the arrival of the new inhabitants as an achievement they themselves have made possible as a result of all their activities to reduce problems in the area. The different groups rarely meet and when they do some tension can be felt. The old inhabitant agree that the new inhabitants mainly live a different life withdrawn from neighbourhood activities. One of the arguments to support this is their communal (private) garden (compare amongst others De Jong et al 2008). As a result the new inhabitants are regarded as outsiders in the neighbourhood (Aussen 2010).

Economical

As stated among the social effects, the Wallisblok succeeded in attracting high incomes. This could lead to a more entrepreneurship and higher purchasing power (Van Der Laan 2009). Van Hulten (2008;45) sees this economical component as well. He states that the new inhabitants stimulate the local economy as a result of the high purchasing power. But the RMO is less optimistic. RMO (Hokken en Janssen 2005/RMO) concludes that integration won‟t be the case since the new inhabitants will find different schools for their kids, will do shopping in other stores and socialise at other places than the other neighbourhood inhabitants. Colantonio and Dixon (2009) conclude for the Rotterdam South area, but not especially regarding the DIY-homes, that housing mobility has not changed considerably and that social effects, as measured in different monitors, need more time to become visible and might take generations to show (ibidem; 65-69).

The total investment in Wallisblok is over 10 million Euro, of which 6 million by the inhabitants (Berkelbach 2006;186). De Jong et al (2008;44) conclude that the inhabitants got themselves a owner occupied home with new built quality for a price of 200.000 euro per 130 sq meter. Zoethout (2005;34) illustrates the average price per square meter in Wallisblok is 1150, while the average of Rotterdam is 1635 and for the neighbourhood it is 1246 (prices 2004). Close reading reveals some differences in the stated investments. However, the homes can be considered a "good deal" and the inhabitants feel that they got a good deal. The price-quality ratio is stressed by several authors as main point of attraction (Hoogstad 2007, Crone 2005, Zoethout 2005, De Jong et al 2008). However, De Jong rephrases an inhabitant that claims to have high housing expenditures as a result of obliged maintenance reservation and energy costs (2008;48).

Critical review attribution of effects to DIY-homes:

From the previous paragraph it can be concluded that in describing the DIY-homes most attention is put on social effects. These are the most difficult to measure (Deuten and De Kam 2005). The physical improvements can hardly be debated. The economical aspects might be to soon to be measured and might face difficulties as well. Contrary to Van der Laan (2009) who advises to use the DIY-homes more often, Agricola and Helleman (2006) conclude that no generic advice can be given on how to reach successful renewal. The size of the project is debated as well. De Jong et al (2008;42) state that for gentripuncture effects to be found, a minimal amount of 20 (new delivered) dwellings is needed. Van Hulten (2008) states from a process managing point of view that 40 dwellings is the maximum project size. SCP concluded that DIY-homes are one of the few ways of increasing cohesion in neighbourhoods. Sceptics doubt the SCP conclusions. And Blom responds "I still have to find out if the DIY-homes are the magic wand. … talking about integration, this project still has to prove itself" (Hoogstad 2007). Zoethout concludes that the DIY-homes accomplished to attract inhabitants to the neighbourhood that have specifically chosen to invest money, time and creativity in the neighbourhood. However, if this leads to gentrification has still be seen. Note that the scale of the project in the neighbourhood is small and that the effects of mixing are debated (Bolt and Van Kempen 2008, Boonstra 2008). Some sources contradict each other. Zoethout (2005) claims that the scheme is applicable to these deprived areas where people have faith in a prosperous future. Others, as Blom and Van der Laan (2009) praise the scheme to be applicable in deprived areas without making any reservations.

The downside is that the DIY-homes are relatively expensive for the municipality (Zoethout 2005). Blom (2009) gives an estimation of around 100.000 Euro per dwelling in case of the Wallisblok and signals that without available subsidies the project wouldn't have been feasible at all. Blom has the opinion that for housing associations with dilapidated properties in their portfolio, the scheme is much more feasible. But housing associations are reluctant to use the scheme because they approach the sale from a profitable point of view that makes the homes more expensive and thus less attractive (Blom 2009;49). VROM (2006) signals that a similar project (as the Wallisblok but executed by a housing association) has experienced difficulties to be sold. The project offers less modelling options and is situated just a few blocks away from the Wallisblok. The price of the project is considerably higher (opposed to "free") and the marketing used to promote the houses is poor. The media attention for the "free" homes was tremendous and even got on the national evening news. In the Wallisblok case, the municipality intervened actively by buying the properties located in the hotspot and used a more assertive and repressive policy to battle the existing problems in the hotspot areas (Blom 2009). The effects assigned to Wallisblok and DIY-homes might as a result, rather be related to the municipal actions than the result of the new inhabitants moving in (De Jong et al 2008;44).

It is not possible to attribute all the signalled improvements in Spangen to the Wallisblok project since the municipality and housing associations intervened in many different ways (Boonstra 2008, De jong et al 2008, Van Hulten 2008, Hoogstad 2007).

DISCUSSION

There seems to be some shift in the attention for the Wallisblok project. From the outset of the project, aiming to attract high incomes and to solve the hotspot problems, now the focus is more on social goals. The literature used in this paper does focus on the success of the project but lacks a proper evaluation based on the stated goals. The literature doesn‟t seem to be too critical and at the same time the methodologies used are debatable (but is beyond the scope of this paper). In depth analyses are yet to be made, for example an extensive evaluation of the neighbourhood effects has not been conducted. The number of projects will now allow for such an evaluation. The scale and contribution of effects to the scheme will however prove to be difficult.

It is clear that the project succeeded and might have reached more goals than initially aimed for. The goals desired by the municipality, such as getting inhabitants with higher incomes in the DIY-homes, have been reached. Housing diversification has been reached and characteristic buildings have been preserved. The cohesion amongst the inhabitants is good as a result of intensive collaboration and the safety in the neighbourhood has improved but might be a result of the municipal actions.

The owners were willing to invest in the renovation and to choose for the neighbourhood despite the problems. The cohesion within the group might have effect on the neighbourhood; at least the owners are willing to invest the award money in the neighbourhood. This offers an opportunity for additional quality improvement and might lead to more meetings with old inhabitants. However, the bonds between the two different groups are mostly not existent. For social cohesion to be found a different research approach is necessary. The empowerment effects as mentioned by De Jong et al are debated since the attracted group is self sufficient; high educated and has a high income (Elsinga et al 2009). If the selection criteria are to match low incomes, empowerment through ownership might be feasible.

For the project to be successful the value-gap must be present and preferably there are additional subsidies available to finance the renovation. The building has to have some kind of quality; in the location, building or a low price, but preferably in a combination of those three. The DIY-homes have been applied mainly in Rotterdam but other municipalities have shown interest. For example The Hague has already tried a first building block and Arnhem sold DIY-homes both individually and collectively. As long as the value-gap is present the scheme could be applicable. People from Denmark and Great Britain have shown interest in the scheme as well. This paper did not go into international schemes but it should be possible to be exported to other countries. In general this scheme offers a solution for countries where housing quality can be enforced (by governing bodies) and housing market is skewed due to tension on the housing market. However, it demands an investment by municipality to make it possible. For example, in shrinking areas the possibilities to acquire beneath economical value are present, but individuals or commercial entrepreneurs could respond to the opportunities themselves. However, a collective approach, backed by a housing association or municipality, might prove successful in attracting inhabitants. The collective approach guarantees that a building block can be renovated at once and gives a financial advantage over individual renovations. As a result the risk is lower than when a project developer is involved especially in the present difficult housing markets. Maybe the most important factor

is that all the new homeowners are involved from the start of the project, are highly committed and impatient to live in their project.

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SUBCONTRACTOR SELECTION BASED ON DATA ENVELOPMENT ANALYSIS

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Abstract
In today's construction market, subcontractors execute significant portions of construction work. Subcontractors lessen resource requirements faced by general contractors and provide specialized expertise to construction projects. The reliance of general contractors on subcontractors to execute major portions of construction work makes the success of construction projects highly susceptible to the performance of these subcontracting organizations. As a result, subcontractors' selection decisions are of crucial importance to general contractors bearing in mind that such decisions are exercised by general contractors multiple times in every single project. This paper contributes a Data Envelopment Analysis (DEA) model to guide general contractors in their subcontractor selection decisions.

Keywords
Subcontractor selection; Decision Support system; Performance measurement; Benchmarking; Data envelopment analysis.

INTRODUCTION

For almost the last two decades, subcontracting has been utilized extensively in the construction industry. Several researchers indicate that it is common to subcontract the majority of construction work to subcontractors (Hinze and Tracey, 1994; Kumaraswamy and Matthews, 2000; Shash, 1998; Wang, 2000). It is expected for this trend to continue in the future (Ng et al., 2008 a, 2008 b; Arditi and Chotibhongs, 2005; Wang and Liu, 2005).

Subcontractors help general contractors to overcome problems related to the need for special expertise, shortage in resources, and limitation in finances (Elazouni and Metwally, 2000). The operations of the average general contractor are not sufficiently extensive to afford full-time employment of skilled craftsmen in each of the several trade classifications needed in the field (Arditi and Chotibhongs, 2005). Subcontracting allows general contractors to employ a minimum workforce in construction projects and promotes specialization. It capitalizes on the skills of trade specialists and copes with the fluctuating construction demand (Ng et al., 2003). Arditi and Chotibhongs (2005) advocate that the use of subcontracting has proved to be efficient and economical in the use of available resources. Subcontracting might improve quality and reduce project time and costs (Ng et al., 2003). Qualified subcontractors are usually able to perform their work specialty more quickly and at a lesser cost than can the general contractor (Arditi and Chotibhongs, 2005).

The reliance of general contractors on subcontractors to execute major portions of construction work makes the success of construction projects highly susceptible to the performance of the subcontracting organizations. As a result, researchers emphasize the

importance of selecting appropriate subcontractors (Kumaraswamy and Matthews, 2000; Ng et al., 2008 a&b; Arditi and Chotibhongs, 2005; Arslan et al., 2008; Tserng and Lin, 2002).

Despite this almost two-decade practice of subcontracting significant portions of construction work and the realization of the vital impact of subcontractors' work on overall project success, little research has been conducted to aid general contractors in their selection of subcontractors. Literature review reveals only few models that address this important decision-making issue that is exercised by general contractors multiple times on every single project.

Albino and Gravelli (1998) propose a neural network approach for subcontractor selection. Ko et al. (2007) critique the approach proposed by Albino and Gravelli (1998) because of the difficulties associated with identifying network topology and membership functions. Okoroh and Torrance (1999) develop a knowledge-based expert system using fuzzy logic. Lin and Chen (2004) argue that limitations of the fuzzy logic include the fact that the membership function of natural language expression depends on the managerial perspective of the decision-maker. Lin and Chen (2004) add that another limitation is that the computations of a fuzzy-weighted average is still complicated and not easily appreciated by managers.

Tserng and Lin (2002) propose an Accelerated Subcontracting and Procuring (ASAP) model that is based on eXtensible Markup Language (XML) and portfolio theory in financial management. ASAP helps general contractors to select subcontractors by deciding on an appropriate tradeoff between risk (i.e., cash flow) and profit for different combinations of subcontractors. However, ASAP is based on the assumption that all considered subcontractors are recognized as qualified subcontractors.

Luu and Sher (2006) develop a case based reasoning procurement advisory system for subcontractor selection. In this system, subcontractor selection cases are represented by a set of attributes elicited from experienced construction estimators. Ko et al. (2007) develop Subcontractor Performance Evaluation Model (SPEM) based on an Evolutionary Fuzzy Neural Inference Model (EFNIM). Ko et al. (2007) indicate that a limitation of their model is that both quality and accuracy of training data are crucial to its performance.

Arslan et al. (2008) propose a web-based subcontractor evaluation system called WEBSES. WEBSES determines a weighted average score for considered subcontractors based on 25 evaluation criteria, which are assumed of identical importance. Generally, it is well-accepted that weighted average scores have an inherent weakness due to the biases introduced in the development of the weights and the additive assumptions utilized in the computations of the weighted score average.

Existing models of subcontractor selection are useful in guiding contractors in their selection decisions. However, new methods are still needed as they offer new insights to both researchers and practitioners. Additionally, it is recommended that a general contractor utilizes multiple methods when exercising selection decisions.

This paper contributes a Data Envelopment Analysis (DEA) model to guide general contractors in their subcontractor selection decisions. The proposed DEA model is highly flexible. It can be easily tailored to reflect a general contractor's criteria for subcontractor selection. This flexibility includes number and type of factors considered in the analysis. More importantly, the proposed approach provides a framework for selection decisions at

large. The DEA model is well-suited to guide organizations that are exercising selection decisions.

DATA ENVELOPMENT ANALYSIS MODEL FOR SUBCONTRACTOR SELECTION

This section discusses selection criteria for subcontractors, DEA background, methodology, and mathematical form. The section concludes with an example to illustrate the proposed DEA model for subcontractor selection.

Identifying the selection criteria

In making selection decisions of subcontractors, construction researchers call for an evaluation that is based on a set of criteria. Several researchers have isolated factors that impact the selection decision. Examples on these factors include: number of years in business, highest value of relevant subcontracted work completed in the past, number of relevant projects completed, previous relationship with the contractor, financial capacity, completion of job within time, standard of workmanship, quality of materials used, delay in payment to labor, failure to adhere to subcontract provisions, safety record (incident rate), and non adherence to relevant environmental regulations (Ng and Luu, 2008; Ng et al., 2008a, 2008b; Arslan et al., 2008; Ko et al., 2007).

Table 1 shows variables that are considered in the proposed DEA model for subcontractor selection along with their method of measurement.

Table 1: *Variables that are considered in the DEA model for subcontractor selection*

Variable	Method of measurement	Input/Output
Number of relevant projects completed	Number of projects	O1
Highest value of relevant subcontracted work completed in the past	Dollar amount	O2
Financial capacity	Subjective scale of 1	O3
Completion of job within time	(lowest) to 10 (highest)	O4
Quality of workmanship		O5
Failure to adhere to subcontract provisions		I1
Delay in making payment to labor		I2
Non adherence to relevant environmental regulations		I3
Safety record	Incident rate	I4

Data envelopment analysis (DEA)

DEA was developed by Charnes et al. (1978, 1979, 1981). Nowadays, DEA is well-deployed in other industries with many papers published on its utilization for performance measurement and decision making. DEA deployment in construction is still limited. Examples on construction-DEA research include the work of El-Mashaleh (2003, 2010), El-

Mashaleh et al. (2001, 2005, 2007, 2010), McCabe et al. (2005), Pilateris and McCabe (2003), and Vinter et al. (2006), Cheng et al. (2007), Chiang et al. (2006), and Xue et al. (2008).

DEA is a non-parametric linear programming approach that is designed to compare and evaluate the relative efficiency of a number of Decision Making Units (DMUs) (Charnes et al., 1978). These DMUs can be organizations, business units, universities, etc. For the purposes of this research, DMU refers to a subcontractor.

Thamassoulis (2001) explains that DEA is non-parametric because it allows efficiency to be measured without any assumptions regarding the functional form of the production function or the weights for the different inputs and outputs. Charnes et al. (1978) realize the difficulty in seeking a common set of weights to determine relative efficiency. As a result, DEA allows each DMU to adopt a set of weights to determine its relative efficiency compared to other DMUs. Each DMU is allowed to adopt a set of weights, which shows it in the most favorable light in comparison to the other DMUs. Consequently, McCabe et al. (2005) argue that a DMU that is inefficient with even the most favorable weights cannot argue that the weights are unfair.

DEA is based on an input-output framework, where inputs are minimized and/or outputs are maximized. Cooper et al. (2000) provide the following data selection criteria for inputs and outputs:

- Numerical data are available for each input and output;
- The items (inputs, outputs and choice of DMUs) should reflect an analyst's or a manager's interest in the components that will enter into the relative efficiency evaluations of the DMUs; and
- The measurement units of the different inputs and outputs need not be congruent. Some may involve number of persons, or areas of floor space, money expended, etc.

Bearing in mind the above input/output selection criteria and the fact that inputs are minimized and outputs are maximized, we categorize the first five variables in Table 1 as outputs. To the contrary, the last four variables of Table 1 are classified as inputs.

DEA makes use of linear programming to determine which of the set of DMUs under study form an envelopment surface. This envelopment surface is called the efficient frontier. The efficient frontier is "made up" of efficient DMUs. Figure 1 shows an example of an efficient frontier for a simple one input-one output case with only 5 subcontractors under consideration. The slope of the line connecting each point to the origin corresponds to the output per input. The highest slope is for the line connecting the origin through Sub2. This line is called the efficient frontier. Note that the efficient frontier touches at least one point and all points are therefore on or below this line. The frontier "envelops" all the data points suggesting the name data envelopment analysis.

DEA provides a comprehensive analysis of relative efficiency by evaluating each DMU and measuring its performance relative to the efficient frontier. DMUs that lie below the efficient frontier are considered inefficient compared to the DMUs that "determine" that frontier. As such, Sub1, Sub3, Sub4, and Sub5 in Figure 1 are considered inefficient compared to Sub2.

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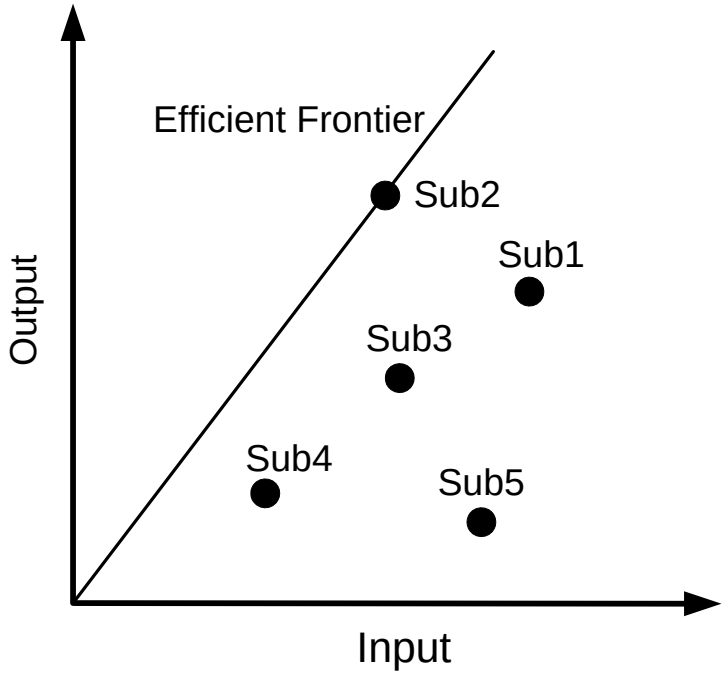


Figure 1: *Efficient frontier*

A limitation of DEA is the fact that its discriminatory power depends on the number of DMUs in comparison to the number of variables (inputs + outputs). A rule of thumb indicates that the minimum number of DMUs should be 3 times the number of variables (Charnes and Cooper, 1990). However, Ellis (2003), Wang (2002), and Cheng et al. (2007) relaxed this requirement by creating an "Ideal" DMU. An Ideal DMU has the lowest values of inputs and the highest values of outputs (Cheng et al., 2007).

The mathematical form of DEA

The mathematical form of DEA is shown below (Equations 1-4). For a detailed discussion, readers are referred to Thamassoulis (2001), Cooper et al. (2000), and Coelli et al. (1998).

Assume that we have n DMUs ($j=1,\ldots, n$) with m input items and s output items. Let the input and output data for DMU_j be ($x_{1j}, x_{2j}, \ldots, x_{mj}$) and ($y_{1j}, y_{2j}, \ldots, y_{sj}$) respectively. Note that we measure the efficiency of each DMU once. As a result, we need n optimizations, one for each DMU_j to be evaluated.

$$\max\ \theta_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \qquad (1)$$

$$\text{subject to}\ \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \qquad (2)$$

$i=1,..., m;\ \ j = 1,..., n;\ \ \ r=1,..., s$ (3)

$u_r , v_i \geq 0$ (4)

Where:
θ_0 = the measure of efficiency for DMU_0 (the DMU under evaluation), which is a member of the set $j = 1, ..., n$ DMUs.
u_r = the output weight, which is determined by the solution.
v_i = the input weight, which is determined by the solution.
y_{r0} = the known amount of the *rth* output of DMU_0.
x_{i0} = the known amount of the *ith* input of DMU_0.
y_{rj} = the known amount of the *rth* output of DMU_j.
x_{ij} = the known amount of the *ith* input of DMU_j.

The objective function is to maximize the efficiency of DMU_0 (the DMU under evaluation). This is done by maximizing the sum of DMU_0's outputs divided by the sum of its inputs (Equation 1). Equation 2 means that the efficiency of all DMUs is ≤1.0. This implies that all DMUs are either on the efficient frontier or below it, and that the efficiency scores range between 0 and 1.0.

Therefore, in DEA terminology, efficient DMUs are given an efficiency score of 1.0. Inefficient DMUs have an efficiency score that falls in the following range: 0≤ efficiency < 1.0.

Illustrative example

To illustrate the proposed DEA model for subcontractor selection, let's consider the data shown in Table 2. Ten subcontractors are considered for selection with 5 outputs (O1-O5) and 4 inputs (I1-I4). Outputs and inputs refer to the ones shown in Table 1. For the sake of demonstration, we limited the number of DMUs to 10 and the number of variables to 9. However, note that DEA can handle tens of variables and thousands of DMUs.

Table 2: *Example data*

Subcontractor	O1	O2 ($)	O3	O4	O5	I1	I2	I3	I4
Sub1	7	279,520	7	5	2	6	9	2	9.4
Sub2	4	267,615	4	2	5	5	8	9	8.3
Sub3	6	225,688	6	5	8	5	8	3	12.0
Sub4	4	199,461	4	6	9	6	7	8	11.1
Sub5	2	232,589	2	9	8	6	9	2	8.8
Sub6	3	287,398	3	2	4	5	2	1	7.4
Sub7	1	213,333	1	4	3	4	1	3	7.3
Sub8	2	241,576	2	6	7	6	7	8	7.6
Sub9	3	143,244	3	5	1	5	4	3	9.0
Sub10	4	215,815	4	6	7	5	2	1	8.2
Ideal Sub	7	287,398	10	10	10	1	1	1	7.3

Given the fact that we have 9 variables, this means that at least 27 DMUs are needed to keep the discriminatory power of DEA. Since we only have 10 DMUs, we need to create an Ideal Sub. As indicated earlier, an Ideal DMU has the most favorable outputs and inputs. Starting with O1, an examination of number of relevant projects that are completed by a subcontractor in Table 2 indicates that Sub 1 completed 7 projects. This is the largest number of projects across all subcontractors. Consequently, O1 for the Ideal Sub equals 7 as shown in Table 2. Similarly, when considering O2, we notice that Sub 6 executed the highest value of relevant subcontracted work for a sum of $287,398. As a result, O2 for Ideal Sub is set at the same dollar amount of Sub 6 as shown in Table 2. For the remaining outputs, the value for every output for the Ideal Sub is 10, since this is the most favorable value. For inputs (I1-I3), the contrary is true. The value of these inputs is 1, since this is the most favorable value. The last input (I4) is calculated based on a formula, where different countries utilize different formulas. OSHA recordable incidence rate which is utilized in the US construction industry is a good example for such formula. It is shown below for demonstration purposes.

Incidence rate = No. of incidents * 200,000 hours / No. of hours worked

It is common knowledge that lower incident rates reflect better safety performance. Table 2 shows that Sub 7 has the lowest incident rate with a value equals 7.3. Consequently, this value is used for the Ideal Sub as shown in Table 2.

The DEA solver software of Cooper et al. (2000) is used to run the DEA model. Table 3 ranks all considered subcontractors (Sub1-Sub10) and shows their efficiency scores. Note that subcontractors (Sub1-Sub10) are rated in comparison to Ideal Sub, which has an efficiency score of 1.0. The rest of subcontractors (Sub1-Sub10) have efficiency scores that are less than 1.0.

Since Sub1 has the highest efficiency score (0.78) among all considered subcontractors, we consider this subcontractor as our first choice in executing relevant construction work.

Table 3: *DEA results*

Rank	DMU	Efficiency Score
1	Ideal Sub	1.0
2	Sub1	0.78
3	Sub5	0.75
4	Sub10	0.70
5	Sub8	0.67
6	Sub4	0.59
7	Sub3	0.51
8	Sub2	0.50
9	Sub6	0.43
10	Sub9	0.41
11	Sub7	0.40

The above example demonstrates how the proposed DEA model is utilized to select one subcontractor out of 10 potential subcontractors. The proposed DEA approach combines 9 criteria to aid in the selection process. The model results in efficiency scores rating every subcontractor in relation to the efficient frontier. The subcontractor with the highest efficiency score is selected to execute the relevant construction work. Consequently and

based on DEA results, general contractors can exercise more informed decisions when considering subcontractors for executing construction work.

For demonstration purposes, the illustrative example is based on 10 subcontractors and 9 variables. However, note that DEA can handle tens of variables and thousands of DMUs.

CONCLUSIONS

Subcontractors' selection decisions are of prime importance to general contractors. These decisions are exercised by general contractors multiple times on every single project. This paper contributes a DEA model for subcontractors' selection. The proposed DEA model is highly flexible. It can be easily tailored to reflect any general contractor's criteria for subcontractor selection. This flexibility includes number of DMUs and number and type of factors that are considered in the analysis. More importantly, the proposed approach provides a framework for selection decisions at large. It is well-suited to guide organizations that are exercising selection decisions.

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COST INFORMATION IN ENERGY BILLS FOR HOUSEHOLDS EFFECTING THE ADOPTION OF ENERGY TECHNIQUES

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Abstract
Financial appraisal is an important aspect in adopting techniques that reduce the (fossil) energy use of buildings. When financial appraisal of an energy technique takes place, fixed prices for the form and amount of energy are often used and are multiplied by the estimated amount of energy savings. However, after a certain time period an energy bill for the user of a building only partially shows variable prices depending on the form and amount of energy. Many costs mentioned by a common energy bill are time related or are related to the national political regime. Infrastructural costs depend on the type of connection you have to the grid. These costs form an annual fee. The VAT or additional energy taxes that need to be paid, depends on the political regime and are often expressed in a surcharge in terms of percentage. This paper focus on the differences between marginal and average energy costs and the differences in variable and fixed energy costs. The impact price differences have for the financial appraisal of energy saving techniques for multiple actors is shown by conducting a comparative study on energy bills. It shows that marginal energy costs are significantly lower than average energy costs.

Keywords: investment appraisal, energy costs, consumer, energy bill

INTRODUCTION

Within the European Union (EU) the energy use by the built environment is more than 40% of the total energy consumption (European Council, 2002). Many measures exist and are being developed to reduce the energy use of residents and their houses. Nevertheless, during the last decades Dutch residents seem to be confronted with increasing electric energy use and increasing energy prices. In the time period 1985-2008 the average electricity use of a Dutch household increased by 25.8% (EnergieNed 2010a). According to Statistics Netherlands (2011) the energy prices for natural gas and electric energy more than doubled in the time period 2000-2009. The average natural gas consumption per household was reduced by 34% in 2008 compared to 1985 (EnergieNed 2010a).
Multiple scholars (e.g. Shin, 1985; Hutton et al, 1986; Wilhite & Ling, 1995; Edelstein & Kilian, 2009) paid attention to the relation between energy use and energy prices. On the one hand much research was conducted using the energy bills of households, offering valuable data regarding the annual energy use and energy costs for a household and house with specific characteristics. On the other hand, focusing on the development of energy measures to reduce fossil energy use another group of scholars and practitioners can be distinguished

that uses average energy prices to give insights in the financial savings of the introduced measure. Boonekamp (2007, p. 137) states that the financial *benefits are saved energy times mean price*. The reduction in energy costs by adopting new energy measures is often computed based on energy use and costs in the past as expressed by energy bills of the household where the energy measure is introduced.

In 2002 two Swedish studies focused on the preferences of customers regarding their electricity bills (Sernhed at al, 2003). The study of the Swedish Energy Agency showed that nearly 90% of the responding households wanted to be alerted, when their energy use suddenly increases. Approximately 75% indicated that they want to have a graphical presentation of the actual energy use compared to the energy use in the same month one year earlier. Around 65% wanted to have tips to reduce the energy use and just about 50% indicated that they wanted to have comparative statistical information from a comparable household.

Research of Wilhite & Ling (1995) in Norway already showed that better feedback on energy bills led to a more energy-conscious consumer. In the third year of their experiment the group of consumers receiving a more informative energy bill reduced their energy use by 10% compared to a control group receiving a traditional energy bill. The principle of providing information about the energy use and about energy saving via an energy bill is a form of indirect feedback (Darby, 2006). The immediate information from a meter or monitor showing the current energy flows in a building is considered to be direct feedback.

In order to know what the actual financial benefits of an energy measure are, one needs to know how energy costs can be influenced by residents and energy techniques. Therefore, we wonder 1) what developments there are regarding energy prices and 2) how the constitution of energy bills and the adoption of energy techniques by households are related. This paper presents a research on energy costs in energy bills for Dutch households. More than eighty energy bills were collected addressing the energy use and costs of seven households over multiple years.

The following section addresses the research methodology. Section three describes four categories of costs mentioned in the energy bills for consumers. Section four sets out the general developments regarding energy prices for the different cost categories. In section five the results of the empirical research among seven households are addressed, before closing the paper with a section six stating the conclusions.

RESEARCH METHODOLOGY

To learn about the composition of energy bills and the costs specified in energy bills, multiple energy bills were collected. The energy bills are related to seven cases of Dutch dwellings (see for specifications Tabel 1).

Table 1: Specifications of the case study objects (see for more details Entrop et al, 2010).

	House 1	House 2	House 3	House 4	House 5	House 6	House 7
Year of construction	1925	1939	1948	1964	1972	1982	1992
Building type	Detached	Row	Semi-det.	Row	Row	Row	Semi-det.
Habitants	5	5→2	2	2→1	2	2→4	2
Total floor surface (m^2)	170.95	102.74	145.04	148.74	174.98	100.45	124.17
Surface shell (m^2)	440.2	196.9	262.1	296.2	214.1	158.3	232.5
Energy Index	1.87	1.85	2.46	2.11	1.76	1.41	1.02
Energy Label	D	D	F	E	D	C	A

Due to differences regarding building characteristics and household characteristics these houses also have different energy usages regarding quantity and form. For example cases 6 and 7 do not use natural gas, because they are connected to district heating. Based on building characteristics House 7 can be regarded as the most energy efficient object and House 3 is the least efficient. This is expressed by an Energy Index and Energy Label as is being used all across Europe, since the introduction of the European Energy Performance of Buildings Directive (European Council, 2002).
The households provided more than eighty energy bills from the time period 1987-2010. The energy bills were dispatched by nine different companies, namely Cogas, Elektran (nowadays MainEnergy), Eneco, EnergieDirect, Essent, GreenChoice, MainEnergy, Nuon, and PNEM (nowadays Essent).

Some difficulties exist when you want to compare energy costs of different households:
The format of the energy bills differs per energy company. The sequence of the individual services will for example differ. Some companies directly add Value Added Tax to the costs for individual services mentioned in the energy bills. Other companies add up the Value Added Tax in the end to the total sum of costs. For this reason it is necessary to specify some universal cost categories, which will be the subject of the next section;
The form and amount of used energy differs per house. District heating, natural gas and electric energy are three forms of energy commonly used in the Netherlands, but each can be used for different purposes and in different amounts. When the financial benefits of energy measures are addressed, it is therefore important to reflect on the way the energy price per m^3, per kWh and/or per MJ was calculated and which variation can exist in regard to this energy price. An electric conversion rate of 3.6 MJ/kWh was used, so no compensation for the electricity production was incorporated. A conversion rate for natural gas of 35.17 MJ/m^3 was used, being the upper caloric value of natural gas in the Netherlands.
The time periods will differ per house and are seldom exactly one year. An additional difficulty in this matter is that electric energy use and natural gas consumption are disproportionate to the number of days, because of differences regarding ambient temperature, wind speed and the availability of natural daylight. When collecting the data, start dates and end dates of the time periods specified in the energy bills were listed. In this paper this specific issue is of little relevance. The time periods were assigned to calendar years by means of rounding off.

Attention will be paid to the composition of the costs, developments regarding price levels and to the level of flexibility to influence the energy costs being a household. The last aspect will be important in financially analysing energy measures that reduce the energy use or make the energy use more sustainable in terms of the use of renewable sources.

COST CATEGORIES ON ENERGY BILLS

The basic raison d'etre of an energy bill for an energy company is to receive payments for the delivered product being a certain amount of fossil fuels, thermal energy and/or electric energy. From the point of view of the customer an energy bill needs to specify the delivered product or products, the costs per product (including and excluding VAT) and details of how the payment needs to take place. The basic principle underlying an energy bill does not differ from a bill for clothing or groceries. However, big differences are 1) clothing and groceries are tangible and energy is not and 2) clothing and groceries are directly paid for. The costs of energy use are often billed once a year, after doing eleven monthly payments in advance.
The studied energy bills show many different subjects where the consumer is billed for. In the past it was common to incorporate the costs of cable television and radio. Besides these not to energy related costs, one of the energy bills still mentions up to 23 different costs that are related to the household's energy use.

Analysing the Dutch energy bills, the different energy costs can be divided in four main categories:

1. Product costs: costs for consuming fossil fuels or using electric energy;
2. Transport costs: costs related to the transport and infrastructure enabling the provision of fossil fuels and electric energy at a certain address or connection;
3. Measurement costs: costs involved in measuring the amounts of delivered fossil fuels and electric energy at a certain address or connection;
4. Taxes: additional costs due to legislation, strongly depending of the political regime.

Comparing the Dutch energy bills with some Australian, Swiss and German energy bills of eight different companies, it shows that in these countries the measurement costs are not addressed by the energy bills. In general it can found that the number of different costs in these foreign energy bills is smaller.

Product costs

Natural gas is the most common used fossil fuel in the Netherlands to heat living space and heat tap water. In many dwellings natural gas is also used for cooking. Nevertheless, electrified ways of cooking became more popular in the last decade due to the introduction of multiple new systems using induction and ceramics.
A Dutch user of electric energy can choose to be priced based on a single tariff or a double tariff. During night time the electricity prices are low and during day time high. Depending on consumer behaviour and specific energy prices, a single or double tariff can be financially preferred. Besides these variable costs, fixed annual costs for delivering the electric energy are charged.
Four percent of the approximately seven million dwellings is heated making use of district heating (EnergieNed, 2010a). In this case study houses number 6 and 7 are connected to district heating, representing this category of dwellings. The price of heat is every half year calculated on the basis of a comparison between a house connected to the gas grid and a house connect to district heating. An averaged electric energy use and an averaged natural

gas use and their accompanying prices are compared to the situation of a dwelling connected to district heating. By using this method the energy companies and the government try to guarantee that in both situations the owner needs to pay the same price for fulfilling his or hers energy needs. The three main subcategories of product costs are described in Table 2.

Table 2: Different subcategories of product costs involving energy.

Cat	Variable	Description
Product	Price of producing and providing natural gas	Natural gas is provided for a price per cubic meter €/m^3 and a relatively small annual fee €/year. In the Netherlands the price of natural gas is related to the international oil price. Besides these variable costs, some fixed annual costs for delivering the natural gas are charged €/year.
	Price of producing and providing electric energy	Electric energy is provided for a price per kilowatt hour €/kWh and a relatively small annual fee €/year. In general electric energy is being produced by making use of natural gas, coal and biomass. A single or double tariff system can be applied. The latter results in a relatively high tariff during daytime and a low tariff during night time
	Price of producing and providing heat	Thermal energy for households is provided for a price per gigajoule €/GJ based on the Not More Than Different principle, stating that district heating should not be more expensive to consumers than using natural gas directly for heating purposes.

Transport costs

The Netherlands, with a surface less than 34.000 km^2, have a dense natural gas network with a total length of almost 139.000 km to provide 6.981.100 connections in buildings natural gas. The electricity network encompasses 259.241 km and 7.872.000 connections. The multiple small and large scale district heating networks have a combined length of approximately 4.711 km (EnergieNed, 2010a). The costs for the infrastructure are billed on the energy bills as described in Table 3.

Table 3: Different subcategories of costs involving the transport of energy forms.

Cat	Variable	Description
Transport	Price of transporting natural gas	Infrastructural firms maintain and improve the gas grid. A price per cubic meter of natural gas €/m^3 and/or an annual contribution per connection €/year needs to be paid by the consumer to the network company.
	Price of transporting electric energy	Infrastructural firms maintain and improve the electricity grid. A price per kilowatt hour of electric energy €/kWh and/or an annual contribution per connection €/year needs to be paid by the consumer to the network company.
	Price of transporting heat	Based on the principle that owners of a house connected to a gas grid pay the same connection costs as a house connected to district heating, house owners will pay an annual contribution for their connection to the provider of district heating €/year.

Measurement costs

In all buildings with a connection to the natural gas network and to the electricity grid meters are installed to measure the amount of energy used. These meters are owned by companies applied to measuring natural gas and electric energy flows. Compared to the other costs the measurement costs are in a standard household relatively low. In the case of district heating

the costs for measuring the energy use are incorporated in the delivery and transport tariffs (see Table 4).

Table 4: Different subcategories of costs involving the measurement of energy use.

Cat	Variable	Description
Measurement	Natural gas meter	An annual rent needs to be paid by the consumer for using a natural gas meter €/year. Maintenance costs and costs for reading the meter to check the actual energy use of households are included in the tariff.
	Electricity meter	An annual rent needs to be paid by the consumer for using an electricity meter with one or two counters for a low tariff and high tariff pricing system €/year. Maintenance costs and costs for reading the meter to check the actual energy use of households are included in the tariff.

Costs due to taxation

In the time period 1987-2010 multiple forms of energy taxes were introduced and one has already been abandoned. Energy companies function as an intermediate in collecting these taxes. At this moment the Regulating Energy Taxes (RET; Regulerende Energiebelasting) and Value Added Tax (VAT; Belasting Toegevoegde Waarde) form the fourth category of energy costs (see Table 5).

Table 5: Different subcategories of costs involving taxation of energy use.

Cat	Variable	Description
Taxes	Regulating Energy Taxes (RET)	In 2010 a standard household pays € 0.1114 per kWh of electric energy (excluding VAT) and € 0.1629 per m³ of natural gas (excluding VAT) to the government.
	Tax Credit Regulating Energy Taxes (RET)	An annual tax credit applies for the use of electric energy of € 318.62 (excluding VAT) per household per year.
	Value-added tax (VAT)	The value-added tax accounts for all (energy) products and the regulating energy taxation. In the Netherlands the VAT rate is 19 %.

GENERAL DEVELOPMENTS ENERGY COSTS

The average electricity use of a Dutch household was 2829 kWh/year in 1985 and 3558 kWh/year in 2008 (EnergieNed, 2010a). According to Statistics Netherlands (2011) the electricity prices increased from 0.278 €/m^3 for natural gas and 0.125 +/- 0.005 €/kWh for electric energy in 2000 to 0.591 €/m^3 and 0.282 +/- 0.019 €/kWh respectively in 2009. The average natural gas consumption per household was reduced from 2475 m^3/year in 1985 to 1625 m^3/year in 2008 (EnergieNed, 2010a).

The early energy bills in our collection show that consumers were billed for delivery costs only. Variable delivery costs per cubic meter and per kilowatt hour and relatively small fixed charges were billed for natural gas and electric energy. In later years 2000-2005 it can be seen, depending on the specific energy company, that variable and fixed costs for the transport of natural gas and electric energy use were charged for using the grids.

The variable costs for transport came to an end by the first of January 2009, when a fixed annual fee was set based on the capacity of the individual connection. Depending on the specific network provider the fixed costs for a connection to the natural gas grid were in 2010 approximately € 100,- to € 110,- per year for a basic connection up to 10 m^3/h. In the same

year the fixed costs to be connected to the electric energy grid were approximately € 160 to € 180,- per year for a basic connection of 3x25 A or 1x40 A.
The energy bills indicate that measurement costs needed to be paid as a rent for the energy meters starting in the time period 2002-2005. These fixed prices gradually increased to approximately € 16,- to € 20,- per year for a gas meter. The fixed prices for electric energy meters move around € 25,- per year. These costs also include labour costs, when the meters need to be replaced or when the meters need to be read.

Table 6: Energy taxation in the time period 1987-2010 (a.o. CBS, 2010)

Year	Regulating Energy Taxes Gas €/m^3	Regulating Energy Taxes Electricity €/kWh	Environmental Quality Electricity Production €	Discount Taxes €	Value Added Tax %
1987-1988	-	-	-	-	20.0
1989-1991	-	-	-	-	18.5
1992-1995	-	-	-	-	17.5
1996	0.01452	0.01340	-	22.34	17.5
1997	0.02902	0.01340	-	33.94	17.5
1998	0.04325	0.01340	-	45.32	17.5
1999	0.07251	0.02220	-	75.77	17.5
2000	0.09448	0.03720	-	105.34	17.5
2001	0.12025	0.05830	-	141.58	19.0
2002	0.12400	0.06010	-	142.00	19.0
2003 January	0.12850	0.06390	-	142.00	19.0
2003 July	0.12850	0.06390	34.00	176.00	19.0
2004	0.14290	0.06540	39.00	181.00	19.0
2005	0.14940	0.06990	52.00	194.00	19.0
2006	0.15070	0.07050	52.00	197.00	19.0
2007	0.15310	0.07160	-	199.00	19.0
2008 January	0.15540	0.07270	-	199.00	19.0
2008 July	0.15540	0.07520	-	199.00	19.0
2009	0.15800	0.10850	-	318.62	19.0
2010	0.16290	0.11140	-	318.62	19.0

Taxes are strongly related to the political regime. In the time period 1987-2010 households needed to pay the common Value Added Taxes of a percentage of 17.5 % up to 20 % (see Table 6). In 1996 the Regulating Energy Taxes were introduced, nowadays often referred to as Energy Taxes. These taxes need to be paid per kWh of electric energy and per m^3 of natural gas and was increased up to € 0.1114 per kWh and € 0.1580 per m^3 in 2010. In that same year an annual discount was given of € 318.62 on the electric energy taxes. In the first time period 1996-2000 the discount was given as a deduction on the energy use in the form of 800 kWh of electric energy and 800 m^2 of natural gas.
In the time period 2003-2006 additional taxes were introduced to finance subsidies to reduce the emissions of the Dutch electric energy production. This so called Environmental Quaility Electricity Production (EQEP; Milieukwaliteit Elektriciteitsproductie) was directly settled in the general energy discount. Nevertheless, in this time period the RET still were increased, without compromising the discount tariff.

SPECIFIC DEVELOPMENTS ENERGY COSTS OF SEVEN HOUSES

Having described the national developments regarding energy costs, this section will describe the developments in energy costs more specifically for the dwellings in the case study and per cost category.

Product costs

A standard Dutch household with a connection to the gas grid and the electricity network is free in choosing one of the many energy companies to deliver natural gas and electric energy. One is free in choosing for a sustainable or so called “green” form of energy, in choosing for a certain quality level of services and in choosing (maybe most importantly) the price of the natural gas and electric energy. In other words one can freely choose for a certain product (natural gas and electric energy) with variable and fixed costs in the category “A. Delivery” as long as one is connected to the natural gas network and the power grid.
A household occupying a house connected to district heating is bound to the company that provides the heat and maintains the local heat infrastructure. The households occupying Houses 6 and 7 are not able to choose another company (in this case Essent Local Energy Solutions BV) that can provide heat in the form of heated water. These two households can only chose their electric energy providers. Nevertheless, when a household purchases electric energy without purchasing natural gas the fixed annual costs are often relatively high, because discounts often apply when natural gas and electric energy are purchased at the same energy company. With 48 to 54% in the last three years the delivery costs form the biggest part of the energy costs for the dwellings studied.

Transport costs

Based on its location, a house is connected to a certain part of the national gas grid and electricity network. The household receives a separate bill of the regional network provider or the costs are incorporated in the energy bill of the energy company delivering and providing the natural gas and electric energy related to section “A. Delivery”. There is no possibility for a household to switch to another company, when it comes to the transport of these energy forms, besides moving to another location outside the region of the former network provider. Therefore, transport costs can not be influenced by households through the adoption of more or improved energy techniques.
In the past a major part of the transport costs were related to the amount of natural gas consumed and electric energy used. Transport costs for the houses using natural gas in the case study were around 12 to 18% of the total energy costs. Since fixed annual prices are used, these percentages are for households with an average or high energy use decreasing. Houses 6 and 7 always pay annual fees. Based on the energy use they have higher transport costs than houses connected to the gas grid.

Measurement costs

The company responsible for providing measurement equipment and services was originally related to the regional network provider. Nowadays, the possibility exists for consumers to freely choose a certified company offering these energy measurement services. Nevertheless, not many consumers are aware of this possibility and little financial benefits can be expected in switching to another company. The measurement costs are relatively little, namely just around 2 to 3 % of the total energy costs.

Taxes
Again little influence can be exerted by households or consumers to reduce this particular category of costs. The taxes are partially variable in the way that per kWh electric energy and per m^3 of natural gas a certain fee needs to be paid. In the past a fixed amount of taxes needed to be paid to improve the environmental quality of energy products and a compensating fixed tax credit was offered. The discount for 2010 is high enough to reduce the energy taxes on ± 1000 m^3 of natural gas and ± 1400 kWh of electric energy. On top of the costs in all four categories A to D Value Added Tax (VAT) needs to be paid. A household that is able to bring back its energy use to below ± 1000 m^3 of natural gas and ± 1400 kWh of electric energy, will have a discount that even reduces the VAT. Nevertheless, in Houses 1 to 5 taxes over 2009 and 2010 are 34 to 36% of the total energy costs. Houses 6 and 7 are connected to a local heat network, which means that some taxes are incorporated in the heat delivery costs.

CONCLUSIONS

The energy bills of the eight houses in the case study show that many costs involving energy use are set and need to be paid annually. When the three categories variable costs, fixed (annual) costs, and taxes are used, it can be noticed that in 2008 on average the variable costs were 57.2% of the total costs. In 2010 this value was only 42.7%. The fixed costs increased from 14.2% to 18.5%. This means that in 2010 households had fewer possibilities to influence the energy costs by adopting new energy saving techniques than in 2008.
To make the difference between marginal costs and average costs more vivid, an example will be given considering the energy use of a standard Dutch dwelling. In this situation the most appropriate figures seem to be the figures that are being used in calculating the energy prices for district heating. In this way Houses 7 and 8 from the case study can also be regarded. EnergieNed (2010b) uses the following energy usages 1372 m^3, 4116 kWh and 34.99 GJ for the year 2010. The prices are taken from the Essent energy bills of Houses 4 and 8 (price level end 2009). The total energy costs are calculated as follows:

$$P_{energy;total} = (1 + \%_{vat}) \cdot (P_{energy;delivery} + P_{energy;transport} + P_{energy;measurement} + P_{energy;taxes})$$

Table 7: Differences between average and marginal energy prices in the Netherlands

	Electric energy /kWh	Electric energy /MJ	Natural gas /m^3	Natural gas /MJ	Heat /GJ	Heat /MJ
Average costs including taxes	€ 0.1948	€ 0.0541	€ 0.6339	€ 0.0180	€ 27.89	€ 0.0279
Marginal costs including taxes	€ 0.2273	€ 0.0631	€ 0.5105	€ 0.0145	€ 20.02	€ 0.0200
Relative price difference	+16.7 %	+16.7 %	-19.5 %	-19.5 %	-28.2 %	-28.2 %
Average costs excluding taxes	€ 0.1297	€ 0.0360	€ 0.3715	€ 0.0106	€ 17.21	€ 0.0172
Marginal costs excluding taxes	€ 0.0796	€ 0.0221	€ 0.2678	€ 0.0063	€ 10.59	€ 0.0106
Relative price difference	-38.6 %	-38.6 %	-27.9 %	-27.9 %	-38.5 %	-38.5 %

Using this equation the electric energy price is calculated as € 802.- per year. The natural gas price is € 869.72 per year and the price for thermal energy within an area using district heating is € 975.97 per year. Taxes have a strong impact on the energy costs, as can be seen

in Table 7. Furthermore, these calculations show that average and marginal prices strongly differ. Also the prices per energy form can strongly differ.
This leeds us to the conclusion that due to the increasing percentage of fixed annual costs over last years, the use of average energy prices can lead to financial analysis of energy techniques that are incorrect. The financial savings will in many cases be less than expected. Our expectation is that the use of marginal energy costs will lead to a more realistic result. In general all energy costs are rising every year. However, due to the adoption of multiple energy techniques by the different households the variable energy costs can partially compensate the rising fixed or annual costs. Finally, taking into account the adoption of energy techniques, standard price inflation and increasing incomes, the total energy costs are probably increasing less significant than statistical data tries to imply.
Nevertheless, from a financial point of view of the households we expect that the adoption of energy measures can be stimulated by changing the energy bills in two ways. The first way is to improve readability of the energy bills by decreasing the number of cost components. The Australian energy bills, we shortly addressed, with only one sort of variable energy costs and one sort of annual energy costs (before adding tax) shows how energy bills for households can be simplified. The second way is to increase the influence of variable costs per unit of energy, simultaneously decreasing the influence of fixed (annual) costs, which will increase the financial effects of energy saving techniques that are able to reduce the amount of energy used.

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THE ENERGY PERFORMANCE OF OFFICE BUILDINGS THROUGHOUT THEIR BUILDING PROCESS

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Abstract
Many innovative techniques and policy measures have been introduced to reduce energy consumption. Despite the high ambitions and societal pressures, the adoption rate of energy measures in office buildings is still low. Using adoption theories this paper provides a framework to analyse the adoption process of energy saving techniques in building processes. This framework is used to analyse the design and building processes of four Dutch office buildings. In these processes the roles of the stakeholders, in relation to the adoption of energy measures, are identified during every phase of the building projects. It enables us to better understand by which means certain stakeholders can exert influence on adopting or rejecting certain energy concepts and measures. The complex network of temporary relationships among stakeholders makes it hard to turn high ambitions into a broad adoption of multiple energy techniques, which can lower the energy use or which make use of renewable sources.

Keywords: stakeholder, decision making, energy measures, office

INTRODUCTION

The energy consumption in the built environment accounts for more than forty per cent of the total energy consumption in Europe (EC, 2002). Improving the energy performance of the built environment has an important impact on the reduction of carbon dioxide emissions and sustainability in general. Many innovative techniques have been introduced to lower the energy consumption or to use renewable energy sources, but the adoption of techniques is hampered by multiple barriers.
Innovative sustainable techniques differ in terms of complexity and costs. In some cases new techniques can directly replace the conventional product, in other cases large adjustments in a building have to be made. Energy saving techniques can reduce life-cycle costs, but often lead to higher investment costs. Although many measures are widely accepted in society and high ambitions regarding the energy performance of forthcoming buildings are often expressed during the initial phase of a building project, these ambitions are not always realised in practice. We expect that this can be related to the influence of specific stakeholders in the design and construction process of buildings. Policy measures focusing on the environmental impact (or more specific energy use) of buildings might not have the expected impact, if there is a lack of social acceptation of those measures (see e.g. Raven 2006). Therefore sustainable energy measures will not be successfully implemented as long as we do not have a clear understanding of the behavior of the main stakeholders in the construction process, e.g. architects, developers, builders, clients and end-users.
It is expected that the stakeholders involved in the building process are of influence on the adoption process (Cooke et al, 2007), whereby the ambitions stated by the clients before construction and the achieved energy performance after construction often do not correspond with each other, due to reduced budgets or the need for less investments costs during the

design process or architectural, constructional and installation failures during the construction process. In the whole building process some organisations or persons are only for a limited time path involved and all have different interests and targets. Therefore, many individual reasons to adopt or to reject energy techniques will exist.
Our objective is to make a contribution to the knowledge on decision making processes by developing a framework to analyse the influence of stakeholders on the adoption of energy saving techniques. Our framework is based on innovation adoption theories. We focused on the stakeholders who are involved in the adoption process of innovative techniques that lower the energy consumption or make use of renewable energy sources. The case studies are design and building processes of Dutch office buildings.

FRAMEWORK TO ANALYSE ADOPTION IN BUILDING PROCESSES

This section addresses the innovation adoption theory as presented by Rogers (2003). Afterwards innovation adoption processes will be placed in the context of the built environment. Finally, this section presents a framework to analyse building processes.

Adoption theory

Many studies have been published on adoption of innovations. Well-known is the work of Rogers that gives insights in which characteristics of energy saving techniques are relevant, how the adoption process can be phased, and which kind of adopters exist. His work is being used to come to a framework on the adoption process of energy saving techniques in the built environment.
Rogers (2003, pp. 12) states that: *an innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption*. In this paper the *idea, practice, or object* are techniques that lower the energy consumption or techniques that make it possible to fulfil the need for energy in a renewable way. The *individual or other unit of adoption* in building projects are a variety of stakeholders. A stakeholder is in our case an individual or organisation with an interest or concern in a building project. Not all stakeholders can exert influence on the progress and outcomes of a building project. The group of stakeholders that can exert influence is further referred to in this paper as 'actors'.
Rogers (2003) defines five attributes that strongly influence the rate of adoption of innovations, namely relative advantage, compatibility, complexity, trialability and observability. This means for example that a high level of complexity will more likely result in a lower adoption of an innovative energy saving techniques than a low level of complexity.
In the process of adopting or rejecting an innovation five phases are distinguished, namely (ibid., pp. 171-189):

1. Knowledge: in this stage an individual (in our case actor) is exposed to an innovation's existence and gains an understanding of how it functions;
2. Persuasion: the individual forms a favourable or unfavourable attitude toward the innovation. The mentioned perceived attributes are important in this stage;
3. Decision: activities are undertaken that lead to a choice to adopt or reject an innovation;
4. Implementation: this occurs when an individual puts an innovation to use;
5. Confirmation: in this stage the individual seeks to avoid a state of dissonance or to reduce it if it occurs.

Adoption processes in the building context

Dieperink et al. (2004) and Hartmann et al. (2008) stress the importance of studying adoption in its context. The specific characteristics of the context have to be understood in order to

analyse the decision-making process of innovations. Dieperink et al. (2004) for instance expands Roger's model by linking the adoption process with macro developments, technical aspects, economic aspects and the company's context.
The integrative model of Dieperink et al. (2004) explaining the diffusion of innovations offers a detailed structure to align motivations and arguments of actors for adopting or rejecting energy saving techniques. Vermeulen et al. (2006) elaborates on the model of Dieperink et al. (2004) by specifying first and second level variables, which explain the adoption of energy innovations for new office buildings. They mention that the actor's characteristics and the networks in which the actor participates have impact on the decision making process and therefore on the adoption rate. This network forms the heart of our framework.
Research of Hartmann et al. (2008) focuses on the adoption of innovations by professional public clients, in which four conflicting factors were strongly affecting the innovation perception of this actor. They offer a model of the adoption process that links the public dimension and professional dimension of the client with the innovation perception. These scholars see *risk* as an important additional innovation attribute. Risk by uncertainties can be reduced among others by bringing actors together in an early stage, by referring to similar solutions, and by cooperative behaviour.
Based on these studies we distinguish four contextual dimensions, namely: the characteristics of the actors in their segment of the construction industry, the context of the project, the macro developments, and the state of technology. The state of technology is based on Dieperink's "technical aspects" and Hartmann's attribute "risk". By specifying which techniques are in which stage of the innovation life cycle, risks can partially be assessed. Energy measures that have proven themselves are considered to be less risky than non-proven measures.

Framework to analyse building projects
Building projects can be characterised as inter-organisational projects. In building projects, where organisational connections exist adjacent to inter-organisational connections, decisions are taken in a complex context. In every phase of the building process actors and stakeholders join or leave. Different phases of building processes can be profoundly explained by using the process protocol of the University of Salford as specified in Table 1.

Table 1: *Phases in the design and construction process (Kagioglou, et al., 1998).*

Group	**Phases**
Pre-project phases	0. Demonstrating the need
	I. Conception of need
	II. Outline feasibility
	III. Substantive feasibility study & outline financial authority
Pre-construction phases	IV. Outline conceptual design
	V. Full conceptual design
	VI. Production design procurement & full financial authority
Construction phases	VII. Production information
	VIII. Construction
Post completion phase	IX. Operation & maintenance

This arrangement shows some similarities compared to the innovation decision process of Rogers. The awareness of a certain necessity and generating an attitude are prevailing in the first phases (phase 1 and 2). In the final drawings and documents, before setting a price for construction, adoption or rejection decisions need to be taken (phase 3). The construction process needs to cope with the installation procedure for the specific energy techniques

(phase 4). In the end the user of the building will experience if the techniques perform and really can save energy (phase 5).
In the building process at least ten actors can be considered to have direct influence in the adoption or rejection of energy saving techniques (see Table 2). The actors are involved in different stages of the building process. The trajectory to come from an energy saving concept to specific energy saving techniques, the contextual factors influencing the process, and the roles of the actors are included in our framework, being the horizontal axis (see Figure 1). The five phases of Rogers are expected to be only partially in line with the phases of the general design and construction process. Individual actors are persuaded and are taking decisions on energy saving measures at different stages in the process. In other words, the overall diffusion process consists of various personal adoption cycli which vary per actor. The vertical axis expresses the level of influence a certain actor has on the adoption of the energy concept, energy measure(s) or energy technique(s).

Table 2: *Descriptions of the ten actors regarded in this research*

	Actor	Description
Granters	Client – Principal (Cl)	Actor requesting the constructive service of a professional person or organisation. In some cases a client can be a property developer.
	Customer- User (Cu)	Actor making use of the provided building
	Warden (W)	Actor responsible for the supervision of and maintenance on the building and its location
	Property developer (PD)	Actor that converts land to a new purpose, especially by constructing buildings
	Project manager (PM)	Actor that plans, organizes, and allocates resources to come to a successful completion of a specific project (as specified by the client)
	Municipality (Mu)	Town or district having a local government that enforces building regulations
Takers	Architect (A)	Actor who designs buildings and in most cases supervises their construction
	Consultant (Cs)	Actor that provides expert advice professionally
	Contractor (Co)	Actor that undertakes a contract to provide materials and/or labour for a construction project
	Subcontractor (Sc)	Actor that carries out work for a company as part of a larger project
	Manufacturer (Ma)	Firm that fabricates construction components and/or materials

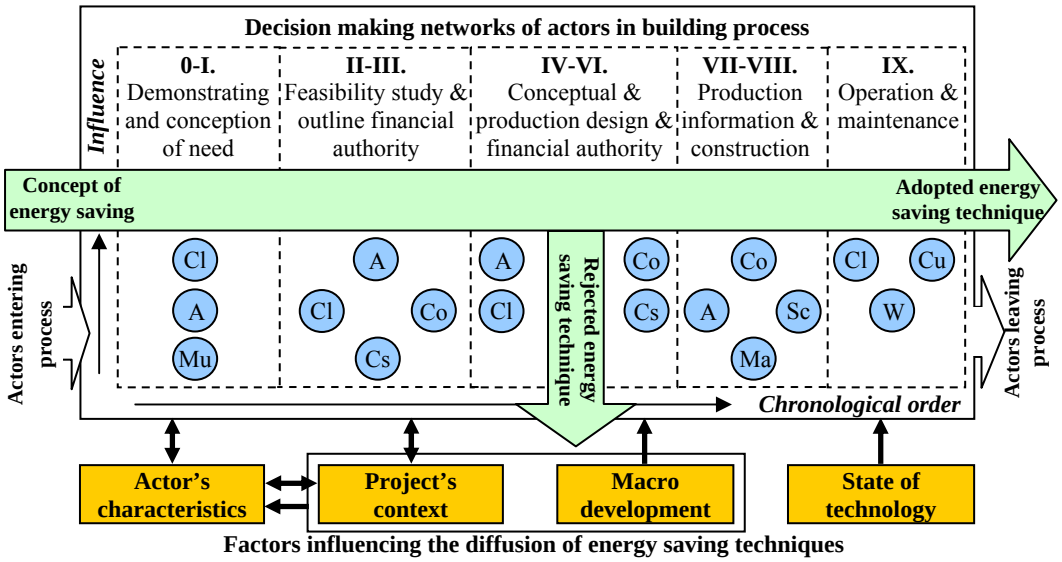


Figure 1*: Framework to analyse the adoption process in building processes.*

CONTEXT OF BUILDING OFFICES

In this section the framework will be operationalized in order to analyse social housing projects by specifying the context in more detail. There are multiple reasons to study the design and construction process of office buildings. Firstly, office buildings use relatively much energy compared to residential buildings. Especially the electric energy use can be significant higher. Secondly, among office buildings large differences exist in building design and in energy use (see Table 3). Thirdly, office buildings often have a relatively short economic and functional life time compared to residential buildings. Therefore, the rate of replacement is relatively high and new innovations or gained experiences can quickly be applied in new project reducing the energy use involved in operating and using this category of buildings. In this section we will further explain the context expressed by the four factors at the bottom of Figure 1.

Table 3: *Energy use of Dutch office buildings (SenterNovem, 2007).*

	Natural gas consumption ($m^3/(m^2 \cdot year)$)			Electric energy use ($kWh/(m^2 \cdot year)$)			N
	20 %	50 %	80 %	20 %	50 %	80 %	
Office buildings 200-500 m^2	6	21	37	35	109	182	44
Office buildings 500-10.000 m^2	6	13	20	32	85	138	37
Office buildings > 10.000 m^2	6	10	14	28	79	82	32
Office buildings insurance comp.	6	15	24	14	129	160	54

Macro development

The developments are clustered in political, juridical and economic events within the construction industry in the Netherlands during the time-period 1998-2010.

Political developments

National and regional governments often try to create conditions that support entrepreneurial activities in order to improve the employment rates in an area. Land plots to construct office buildings or industrial buildings is offered by municipalities for significant lower prices than plots for residential purposes. For companies that operate internationally the Netherlands tries to be as attractive as possible by offering good infrastructure, stable government, public security, well educated population and interesting financial conditions regarding taxes. The costs to run a company in the Netherlands need to be in line with the costs to run a company for example in Germany, Belgium or France in order to keep companies within borders.
Therefore regulations leading to increased investments costs for companies are not favoured. Regulation on the energy performance of office buildings and utility buildings are less ambitious than regulations for residential buildings. Recently, initiatives were undertaken to strongly influence political developments to come to a broad energy transition. By the name of “the Netherlands get new energy” (Anonymous, 2010) and “Energy provision of the Netherlands; today (and tomorrow?)” (Hellinga, 2010) multiple politicians and engineers try to address the urge to make the energy provision more sustainable.

Legal developments

In the time period 1998-2010 the national Building Code of 1992 and 2003 applied for new buildings. Regarding the energy use of office buildings are required: a minimum insulation value of 2.5 $(m^2 \cdot K)/W$, a minimum value for ventilation of 1.0 $dm^3/(s \cdot m^2)$, a maximum value for air infiltration of 0.2 dm^3/s per area with one and the same function and an Energy Performance Coefficient (EPC) of 1.1 at maximum. This EPC expresses a theoretical

construction and installation related energy performance of a building under certain standard conditions regarding usage, indoor temperature preferences and outdoor climate. The EPC is namely based on an equation that relates forecasted and permissible building related energy use, incorporating the installed systems for heat production, heat resistance of the building shell and the size of the house, etc. The EPC for office buildings was introduced in 1995, stating a value of 1.9 at maximum. By January 2000 this value was lowered to 1.6. In 2003 a value of 1.5 was issued and in 2008 the current value of 1.1 was introduced. Due to personal preferences, deviant outdoor conditions, and the adoption of non-building related appliances, the actual energy use of a building during usage can strongly differ from the forecasted or hypothetic building related EPC computed during the design phase.

Economic developments
Due to the economic crisis in recent years much office space came available in the last years and few new building projects were initiated. The total service costs of office space increased from $ 363,- /m^2 in January 2001 to $ 542,- /m^2 in May 2010. From November 2007 to November 2009 the costs per square meter were higher than in May 2010 (CBS, 2011). According to DTZ Zadelhoff (2011) the annual rent per square meter was € 146,- in 2009; 2.7 % less compared to 2008. In 2009 almost forty million square meter of office space was in use in the Netherlands to accommodate almost 2.3 million so called office jobs. These two values were 1 and 1.4 % respectively lower compared to 2008. A staggering 13.3 % of the total office space was not in use (DTZ, 2011). Besides these relative bad economic conditions, energy prices are increasing.

State of technology
Technical developments are highly important in the field of energy saving techniques and the authors would like to address that for every building project the current state of available energy techniques, which can be regarded by the actors involved. However, actors might attempt to rely on traditional techniques that are known to them by means of former projects. Last decade many new technologies were introduced to save energy. At this moment the high efficiency natural gas boiler, insulation packages with a heat resistance of 2.5 $m^2 \cdot K/W$ and energy saving lighting with presence detectors are common in Dutch offices.
The adoption rates of solar collectors, photovoltaic panels, and heat pumps are still rather low, although the techniques are already available for many years. The expectation is that these adoption rates will improve with the current EPC value of 1.1 or lower. New techniques recently introduced in the construction industry are Phase Change Materials and LED-lighting for example. In the nearby future the availability of techniques is likely to increase, because of growing environmental awareness and higher energy prices. Techniques that are already available will be improved and will probably become cheaper.

Project's context
The context in which offices are designed and constructed, can not easily be described in general terms. Projects with the goal to construct or renovate an office building will bring multiple actors and stakeholders together in different relations. Seldom two projects will bring together the same parties in comparable circumstances and relations. This will also become clear in the following sections.
For offices multiple environmental and energy assessment tools became available worldwide. In the Netherlands GPR Gebouw and GreenCalc$^+$ are for example available to characterize the environmental impact of office buildings. In the European Union the energy performance of new and existing buildings, including offices, can (and in the nearby future needs to) be expressed by a label. The use of assessments and performance indicators can help in

communication among the actors and stakeholders. The indicators enable them to directly have a glimpse of the energy performance. In combination with rising energy prices and banks providing financial stimuli for green or energy efficient buildings the aspect of energy receives increasing attention.

Actor's characteristics

Like already stated, multiple actors and stakeholders are brought together, when office buildings need to be constructed or renovated. Different to designing and constructing houses in private ownership, the design and construction process of offices often show different parties regarding the role of financial investor, project developer, principal, user of the building and warden in regards of maintaining the constructed office. Furthermore, multiple organizations are linked these projects to give advice about for example cost management, constructional issues and the mechanical and technical systems. These different organizations all have their own commercial drive to join the project. An office can be constructed from the point of view that it will be rent or that it will be bought by a party that is joining the construction or not. In the last case the object needs to be developed without having one specific user or customer in mind.

RESULTS OF THE CASE STUDY RESEARCH

The cases consider the actors involved in the design, construction and usage of four new office buildings in the Netherlands. Table 4 shows the basic specifications of the studied office buildings. These office buildings were chosen based on their energy performance that goes beyond regulation, the fact that the building processes were finished, enabling us to make an inventory of applied techniques, and the fact that the building processes took place rather recently. Data was collected regarding the different roles of the stakeholders by conducting 22 interviews in total.

Table 4: *Basic specifications of the four case objects being Dutch office building.*

	Case 1	**Case 2**	**Case 3**	**Case 4**
Name office building	Communal Waterworks Amsterdam	De IJsseltoren	QX & QY	De Eempolis
Location	Amsterdam	Zwolle	Best	Amersfoort
Floor area	10.855 m^2	34.000 m^2	14.700 m^2	36.750 m^2
Start design	2000	2003	2003	2000
Start construction	2001	2004	2006	2003
End construction	2003	2005	2007	2004
Energy performance	Q/Q = 0.680 EPC ≈ 1.09	Q/Q = 0.807 EPC ≈ 1.21	EPC_{QX} = 1.44 EPC_{QY} = 1.40	Q/Q = 0.829 EPC ≈ 1.32
Applied energy techniques	$R_{cons,}$= 3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pumps CHS Heat exchanger Enclosed outdoor area Open thermal ceilings T5 lighting	$R_{cons,}$= 3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump CHS Heat wheel Occupancy sensors	$R_{cons,}$= 1.6-3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump CHS Heat exchanger Occupancy sensors Ventilated armatures Shading	R_{cons}= 2.0-3.5 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump Twin coil Ventilated armatures Shading

Case 1: Communal Waterworks Amsterdam (CWA)

The central office of Waternet is located at the west side of Amsterdam. Waternet is the new name for what was before known as Gemeente Waterleidingen Amsterdam (Communal Waterworks Amsterdam; CWA), which was the formal principal and the first user of the

building. The architecture and project leadership were in hands of Van Tilburg & Partners. Seven interviews among the actors in this building process gave insights in the adoption process of the ambitious EPC and the specific energy techniques.
The building has a gross floor area of 10.855 m^2. The construction activities started in 2001 and finished in 2003. The energy performance is stated as an Q/Q of 0.68, which means the EPC is 32% below the by law requested value. This energy performance was achieved by working with the principle of the Trias Energetica. Firstly, the energy demand of the building was reduced by applying among others a highly insulated shell of 3.0 m^2·K/W. Secondly, it was possible for the remaining energy demand to make use of a thermal storage system. Two electric heat pumps provide thermal energy to cool or to heat the building. These heat pumps use green electric energy. Therefore, it seems no carbon dioxide emissions occur by maintaining a comfortable indoor climate in this building.
The owner of the office building was the municipality Amsterdam (expressed as Client (Cl)), that was willing to support the CWA director (expressed as Customer (CU)) in setting an example in sustainability. The ambition was to design an object with a 25% improved energy performance. The technical consultants (DGMR and Techniplan) were asked by the customer and later by the client and architect to specify measures which would reduce the energy consumption.
In principal every measure having a payback period of less than fifteen years was within this project acceptable. The relative advantage of specific energy measures was assessed based on energy analyses, employee's interest, and environmental impact. Photovoltaic panels were mentioned as a technique by the actors that did not fit in the necessary payback period. A green roof was suggested by the architect. Due to limited budgets only that part of the roof that is visible to employees and guests has been covered by sedum instead of the whole roof. Observability was an important issue for still partially applying this specific measure.

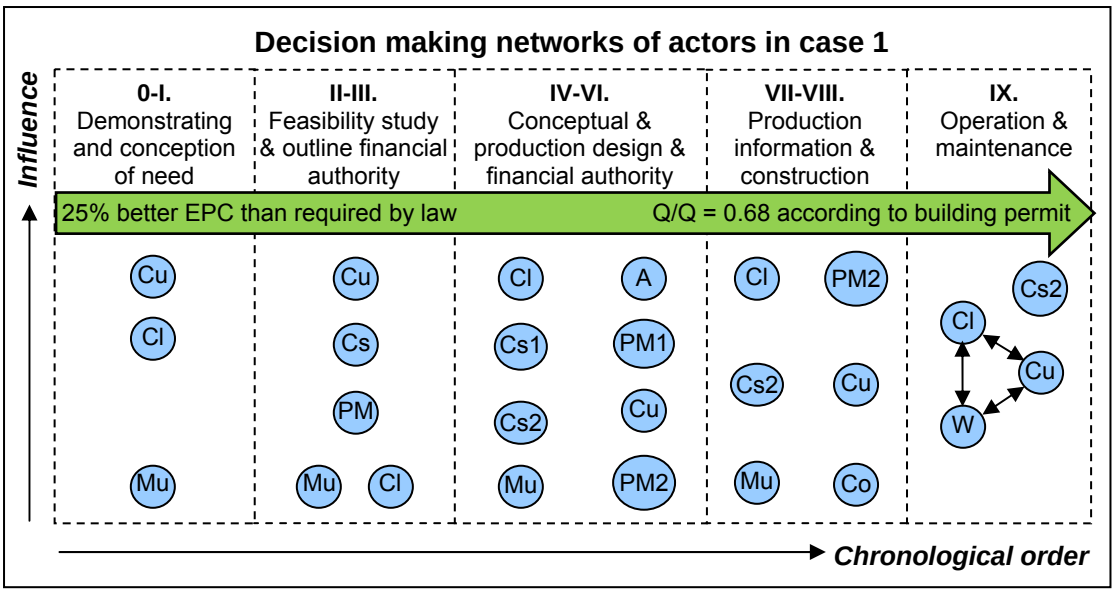


***Figure 2**: Stakeholders involved in the design and construction process of Case 1.*

Case 2: De IJsseltoren
In 2004 the building activities started to come to "De IJsseltoren" complex in Zwolle. The complex consists of three constructions and was designed by René Steevensz of PPKS Architects. The development was initiated by MAB Development. The gross floor area of approximately 34,000 m^2 is largely being used by ABN AMRO. The tower, consisting of nineteen floors, reaches up to almost 96 meters. Directly to the east the two lower buildings

of four and six floors are placed on columns. Because of agreements with the national government, which were already initiated in 1996, ABN AMRO committed itself to use timber produced in a sustainable by means of the Forest Stewardship Council (FSC) trademark and to reduce energy consumption.
The buildings encompass for example a proper insulation package, daylight responsive lighting, presence detection for lighting, timed lighting sweep, and automated shut down options for computers. In this case also a thermal storage system and a heat recovery system for air ventilation have been applied. The additional investments to make the building more environmental friendly and to give it a better energy performance were made financially available by ABN AMRO region Zwolle (customer (CU). Bouwfonds computed what the basic costs would be and which additional costs could be expected (project developer (Pd)). The basic costs were paid for by ABN AMRO (client (Cl)). The energy investments needed to have a payback time of seven years or less. In this case the financial relative advantage due to reduced energy costs prevails when comparing multiple techniques. Although a commitment exists to reduce energy use, the compliance with it seems only to be based on the mentioned payback time of seven years or less. In an early stage the idea of a wind mill was abandoned due to foreseen technical complications. Therefore this technique seems to have failed in the means of compatibility in a architectural and juridical context.

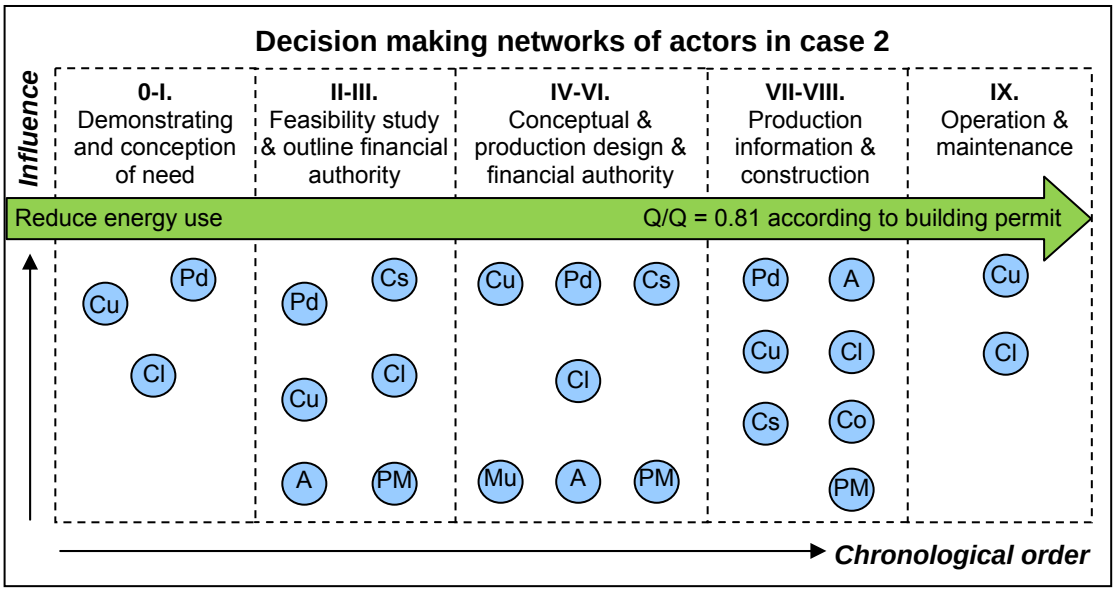


***Figure 3**: Stakeholders involved in the design and construction process of Case 2.*

Case 3: QX and QY

In Best two office buildings named "QX" and "QY" offer a combined gross floor space of 14,700 m^2. These offices form the entrance of the Philips Healthcare facilities on that location. Philips Healthcare was also the principal in this project. The architectural firm 01-10 Architecten is responsible for the design. The buildings have three floors and an additional top layer to encompass the installations. EPCs of 1.40 and 1.44 were achieved by applying a well insulated shell with a heat resistance of 3 $m^2 \cdot K/W$. The thermal storage system and a heat recovery system both had a major impact in achieving the good energy performance.
Together with some major industries, Philips has voluntarily committed itself to a governmental agreement to reduce energy use by applying all energy investments with a return on investment period of five years or less. This means that the relative advantage, in the form of cost reductions in energy use, was assessed for different energy techniques. Philips pays for the building (Client (Cl)). During the design and construction process Philips

Healthcare (customer and project developer (Cu)) was allowed to take their own decisions. In this case the insulation, thermal storage system, lightning system and heat resistant glazing were regarded. Observability and trailability were additional attributes in this case. Because Philips is famous for its lighting systems, energy saving lighting systems are by means of observability, more or less, must-haves. The thermal storage system was considered to be a proven system. Although the return on investment period was calculated to be longer than fire years (namely seven years), this techniques was applied.

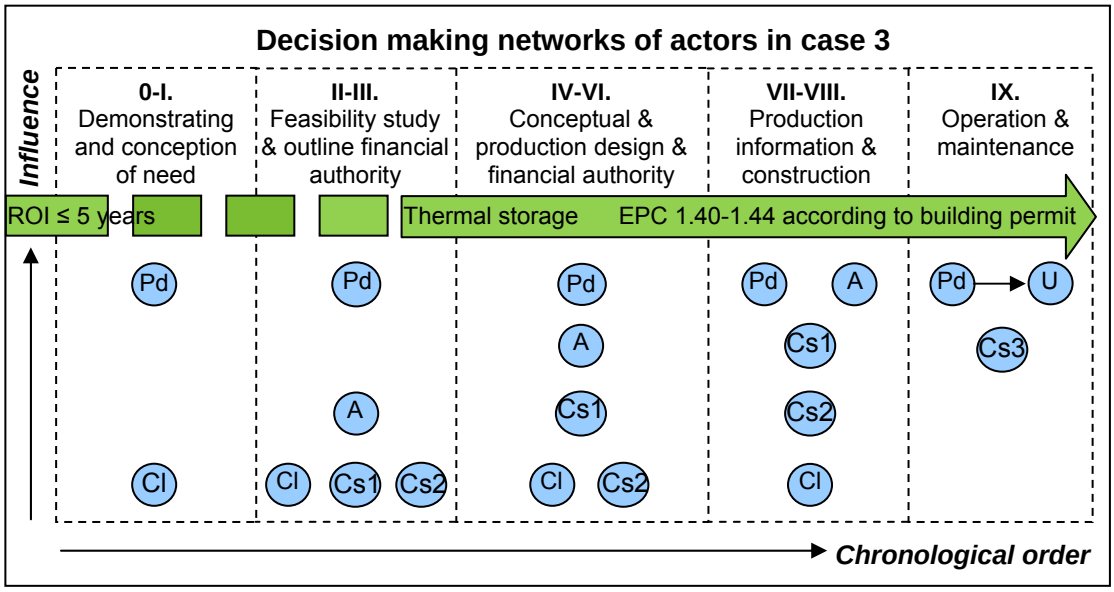


Figure 4: *Stakeholders involved in the design and construction process of Case 3.*

Case 4: De Eempolis

"De Eempolis" forms a long stretched block of office buildings along the northern side of the central railway station in Amersfoort. In this way it functions as a sound barrier. The architect of "De Eempolis" is Jan van Belkum of Arcadis and the principal is NS Poort. The total gross floor space is 36,750 m^2. The total block consists of six sections, which have three to nine floors. At ground level and around the entrance of the station some shops are located. Beneath the ground level parking places for cars and bikes are located.

The construction process started in 2003 and the building activities were finished in 2004. During the design and building process an EPC of 0.55 was mentioned. Nevertheless in the end a less ambitious EPC of ± 1.32 was mentioned in the building permit. The final energy performance was partially achieved by using thermal storage system that uses water of 120 meters below ground level in combination with a low temperature thermal transmission system in the ceilings. These systems are being used for cooling and heating purposes. Unfortunately, it took three years to let these systems operate properly. Furthermore, relatively high thermal insulation values of 3.5 $m^2 \cdot K/W$ and more are applied in the building shell.

The interviews learn that before the building process started, the principal NS Poort (project developer (Pd)) had already stated ambitions regarding the reduction of energy use in their company policy. The company policy is based on the commitment to long-range plans of the national government. These plans aim at twenty percent energy reductions in 2010 compared to the energy use in 1997. These ambitions combined with the wishes of the municipality resulted in a lower Energy Performance Coefficient than necessary to get a building license. Although the investor NS Pension fund did not stimulate energy saving, NS Real Estate being the client (Cl) requested to develop a thermal storage system using heat pumps. At that time

the actors did not have any experience with thermal storage systems. The high complexity and low trailability did not seem to be an issue compared to the supposed relative advantage by means of energy use reduction and observability by means of environmental charisma.

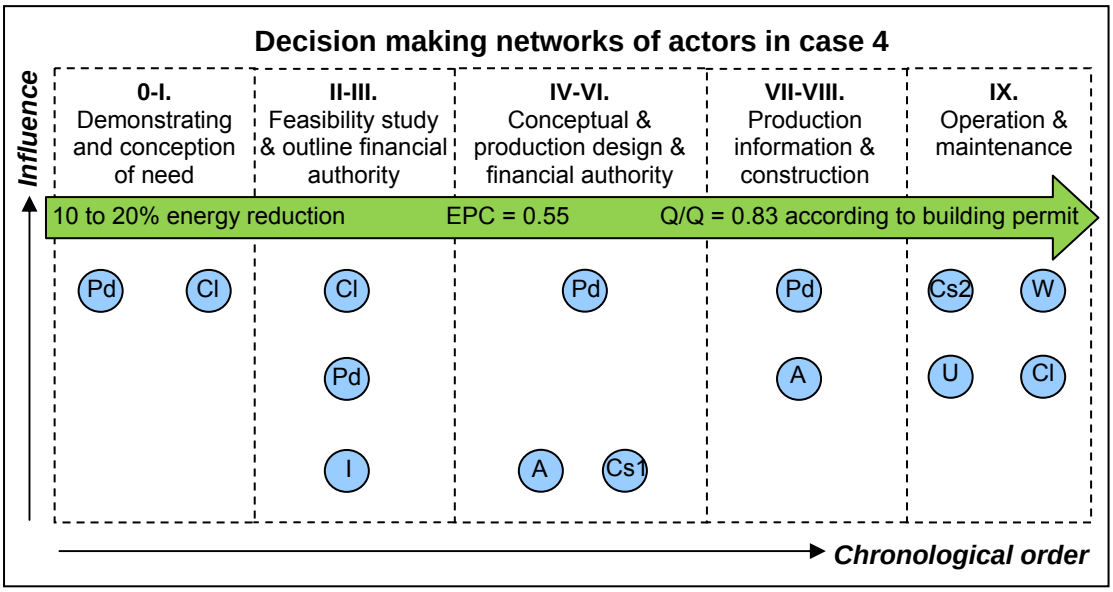


Figure 5: *Stakeholders involved in the design and construction process of Case 4.*

DISCUSSIONS AND CONCLUSIONS

The presented research aims at improving our understanding of adoption processes of energy techniques in building processes. A framework was developed to make the influence of stakeholders visible during different stages of the building process. The framework was applied on four projects. The projects and interviews show that in all cases energy was directly from the start an aspect to consider. In three out of four the need to reduce energy use existed within the organizations, namely Philips, NS Poort, and ABN AMRO. Although one might have expected that a public governmental organization, like the municipality of Amsterdam, would have additional environmental requirements regarding their own facilities in order to set an example, this does not seem to be the case.

Nevertheless, the ambition within the CWA project to reduce the energy use by 25% compared to the energy use required by law, seems to be exceeded by approximately 7%. The ambitions of ABN-AMRO were rather loosely formulated. Within case 4 De Eempolis the ambitions were not that clear either. Large shifts from 10 to 20% and an EPC of 0.55 to a final 17% energy reduction in form of a Q/Q of 0.83 can be seen, although this project had a relatively small number of stakeholders compared to the other cases.

In all cases the project developer had an important role in setting the ambitions. In case 1 CWA the customer filled in the role of project developer in the first fases (0-III) of the project. After that it became apparent that the techniques were adopted and could be implemented, the customer placed himself at the background. Only in the case of CWA the architect was able to influence the energy performance of the design in creative way. In the other projects technical advisors prepared the energy measures in such a way that the architect only needed to insert it in the design. After that, during construction, the architect functioned more or less as a project manager.

The influence of the customer became in case 2, De IJsseltoren, especially apparent when the additional investment costs were not paid for by the client. The fact that the customer was the future user of the building and not the client made it possible to finance the investment based

on the prognosis that future energy use and costs will be lower. In case 4 a higher rent was expected, when the client was able to offer the future users of the object, being the customers, a more energy efficient building.
When we take a close look at Rogers' attributes, multiple attributes are addressed when the actors address the features of adopted and rejected energy techniques in the interviews. Although in most interviews relative advantage in the form of cost and/or energy reductions is mentioned, it is striking to see that almost all considered techniques can be regarded as proven technologies. This can indicate that compatibility with past experiences or trailability (as a degree to which the innovation might be experimented with) are not attributes, but in these cases are conditions to be met first.
Finally, the case studies reveal the relevance of the availability of an energy performance indicator like the Dutch EPC. Although in these projects consultants were asked to look for and investigate possible measures and to calculate the financial and energetic impact of these measures, the ambitions and final marketing of the achieved performance are often based on the EPC and accompanying Q/Q ratio. However, it is not necessarily proven that a low EPC or Q/Q ratio will actually result in lower energy use or lower energy costs. In the case of QX and QY, where the ambition was based on a return on investment within five years instead of a target focusing on energy performance or use, relatively little advancement was made compared to the energy performance in force at that time.
When the energy use of buildings needs to be reduced by an increasing adoption of energy measures, it seems possible and wise to put a focus on disseminating knowledge to project developers, clients and customers. Furthermore, the EPC and its underlying methodology seem able to function as a design tool during the first phases of a new design and construction process.

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ARE OPEN BUILDING PRINCIPLES RELEVANT IN THE SOUTH AFRICAN HOUSING SECTOR? CSIR INVESTIGATIONS AND ANALYSIS OF HOUSING CASE STUDIES FOR SUSTAINABLE BUILDING TRANSFORMATION

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Abstract
The CSIR Housing Research Group in collaboration with a number of partners has been investigating the concepts of sustainable building transformation in the South African housing sector. These studies have relied heavily on a number of theories, including Habraken's Supports, Open Building levels as well as concepts of material/component re-use. All of these theories provide approaches with regards to the way in which materials, building components and the buildings themselves are re-used or salvaged, based on life cycle analysis. There are numerous terms used to describe this approach to the design of the built environment and these are sometimes confusingly interchanged.

Thus, this paper presents descriptions of concepts and working definitions and then proceeds to carry this investigation further by analysing housing case studies with regards to sustainable building transformation. In this process it is attempted to assess if the approaches are relevant and applicable in the South African context. While it is acknowledged that these approaches to design and delivery need to be considered for the whole housing market, there is a pressing challenge to government to deliver low-cost and affordable housing. We also saw an assessment tool for existing buildings as an important way to try and influence thinking, design and planned delivery approaches at the conceptual stages, before future projects proceed in the typical manner which we perceive to be unsustainable.

The capacity for sustainable building transformation will be rationally assessed by studying the internal planning, construction methods and material selection of the selected projects. The paper presents a tool for assessment and comparison, studies the possible changes in the existing projects and also makes some basic recommendations for new projects.

Keywords: Open building, South Africa, housing, sustainable building transformation

BACKGROUND AND AIMS OF RESEARCH

The CSIR Housing Research Group in collaboration with a number of partners has been investigating the concepts of sustainable building transformation in the South African housing sector. Documents such as Medium Density Mixed Housing: sustainable design and construction of South African Social Housing (Osman and Herthogs, 2010); Environments of change: a design solution for an informal settlement in Mamelodi (Gottsmann and Osman, 2010); "Time" as a key factor in design and technical decision-making: concepts of accessibility, affordability, participation, choice, variety and change in the South African housing sector (Osman and Sebake, 2010) are products of these investigations.

As a continuation of this process, the CSIR is currently looking at issues of quality in housing and residential neighbourhoods through developing tools for assessment of housing projects. This comprehensive tool is not only intended to assess existing housing projects, but also to guide housing processes from the outset. The intended users are developers, designers, project managers and Social Housing Institutions. The tool encompasses a diverse set of criteria including technical aspects such as the integration of housing and servicing solutions and social aspects such as social cohesion through the design of shared open space proximate to housing developments.

This process emerged from a concern that, while South Africa is successful in delivering housing numbers, the quality of the environments being achieved is questionable. The two extreme poles in the housing sector are government-subsidised housing (so-called RDP houses which are give-away houses under the government's Reconstruction and Development Programme) and very upmarket developments. Both ends of this spectrum are based on the detached house on the middle of a plot in a sub-urban style planning layout.

It is the market between these two extremes that can perhaps offer opportunities for innovative housing solutions and multi-family typologies such as medium-density, mixed housing. Therefore, for the purpose of developing a tool for building adaptation, three case studies are selected that offer alternatives to the current, unsustainable housing models that dominate the South African urban landscape.

The theoretical background for this study is firmly rooted in an approach to architecture where the design of systems and the interface between systems is given importance. This is believed to generate a richer environment that caters for different categories of users, while at the same time achieves long-term relevance by allowing buildings to adapt and transform over time with minimum waste and minimum disruption to a higher-order level of the built environment that is more permanent and gives an urban setting its identity. This is also an attempt to achieve a balance between the shared domain of an urban environment and areas of individual control. In this sense, the environmental benefits that result from the increased potential for adaptability are further supported by the achievement of higher social benefits.

By assessing existing projects, it has been possible to argue that these theories are not only relevant and applicable in the South African context, but are of high priority if long-term sustainability of residential building stock is to be achieved. This assessment also allows for the identification and ranking of existing buildings that have high potential for adaptation (Teo et al, 2010) and therefore allows for strategic targeting of buildings for upgrades in urban regeneration projects, as an example. Teo (ibid) has also argued that this allows property managers to properly maintain buildings with least impact, as opposed to traditional upgrading mechanisms. The same author explains that building stock may become obsolete

due to physical, economic, functional, technological, social and legal criteria. Many existing buildings will have to be adapted in order to enhance their sustainability performance – adaptions such as rain water collection, modification of openings or installation of solar geysers. It can therefore be seen that the concept of "change" or "adaptability" is very broad and not restricted to one or other parameter, but rather encompasses a whole range of future possibilities that the designer will not be able to determine upfront.

SOME DEFINITIONS AND DESCRIPTION OF CONCEPTS

Two main factors determine the static nature of the existing built environment: irreversible connections (e.g. welding or cement joints) and the entanglement of constructional components with different lifespans (e.g. putting services in bearing walls). Design for Disassembly (DfD) is the strategy focussing on the reversibility and disentanglement of constructional components. According to Durmisevic (2006), the degree of disassembly is determined by two component characteristics: their independence and exchangeability. The first is a measure of their entanglement, the latter determines the reversibility of the connections.

These two disassembly criteria can be evaluated using complex relational diagrams. A high number of dependencies between constructional components results in a building that is difficult to transform. Durmisevic (2006) gives the example of an assembly of five components: if all components share connections, the result is a large number of interdependent relations; on the other hand, if four components would be plugged into an intermediary fifth component, the number of relations is minimised.

There is a differentiation between "adaptability" potential of a building and "disassembly" potential. Disassembly potential implies component re-use while adaptability potential implies building re-use. Disassembly relies heavily on a deliberate and optimal sequence of assembly using reversible connections. Building adaptation relies on the "robustness" or "resilience" inherent in a designed building – the ease at which it can adapt to unbalancing changes in its context (Carmona et al. 2010). Because robustness can be introduced by using broad design guidelines, building adaptation is generally easier to achieve. On the other hand, the disassembly potential of a construction oris the key factor determining the re-use potential of the building, its components and the materials they are made of (Durmisevic, 2006). Therefore, this study tries to incorporate both aspects.

The built environment is comprised of various systems – it is the intelligent interface between these systems that allows for greater change by allowing for "disentanglement" of the various building components with minimal disruption and waste. Therefore, the sequence of construction assemblies is important to be taken into account as the process might have to be reversed to access one or other system that needs to be changed. This sequence also needs to be aligned to the higher- to lower- level configurations, implying a progression from more permanent/fixed functions at the higher levels to functions with a higher frequency of change at the lower levels.

SELECTION OF CASE STUDIES

It is important that adaptable approaches to design and delivery are considered for the whole housing market. However, due to the pressing challenge of the South African government to deliver low-cost and affordable housing, the focus of this study is on three projects built for low- to medium- income dwellers. The selected case studies are the K206 and Elangeni, both

in Johannesburg, as well as the Potters' House development in Pretoria. These projects have been selected based on the following criteria:

Typology: the architectural typologies of the projects are different in that a clustered double storey building is considered in the case of K206, allowing for interesting comparisons to be made with a double storey communal development with unique vertical access (Potters' House) and 4-storey walk up blocks with centralised vertical access in the case of Elangeni.

Use: it was also aimed to study buildings that have uses other than single-tenure residential – so the K206 was included due to the fact that it includes rental rooms adjacent to the family unit and Elangeni includes live-work units, both offering opportunities for income generation for the residents. Potter's House includes a communal facility on the ground floor to be used by the residents, who have individual rooms but share ablutions and other facilities.

Form of tenure: the aim was to look at ownership (as is the case of K206) as well as private rental (K206) and social (government-subsidised) rental (Potters' House and Elangeni).

Location: the K206 is a greenfield development in a typical South African black township setting. Elangeni and Potters' House are more centrally located, with Potters' House being an infill project as part of a larger urban regeneration scheme.

ANALYSIS OF HOUSING CASE STUDIES WITH REGARDS TO SUSTAINABLE BUILDING TRANSFORMATION

K206

The K206 project is designed by Anca Szalavicz and was developed as a low-income development in the urban township of Alexandra, Johannesburg. The project forms part of the greater Alexandra Renewal Project (ARP) development. The project aimed to increase housing densities and combines tenure of ownership and rental occupation.

Eight to ten housing units are grouped together, forming smaller clusters of communities around semi-private communal courtyards. Every unit has a 40m² double storey RDP dwelling intended for ownership as well as a 40m² two-bedroom rental unit with ablutions. The total project consists of over a thousand houses. The concept of the project is novel for the township and the inhabitants seem generally happy about the overall project.



Figure 1: *K206, Alexandra, Johannesburg.*

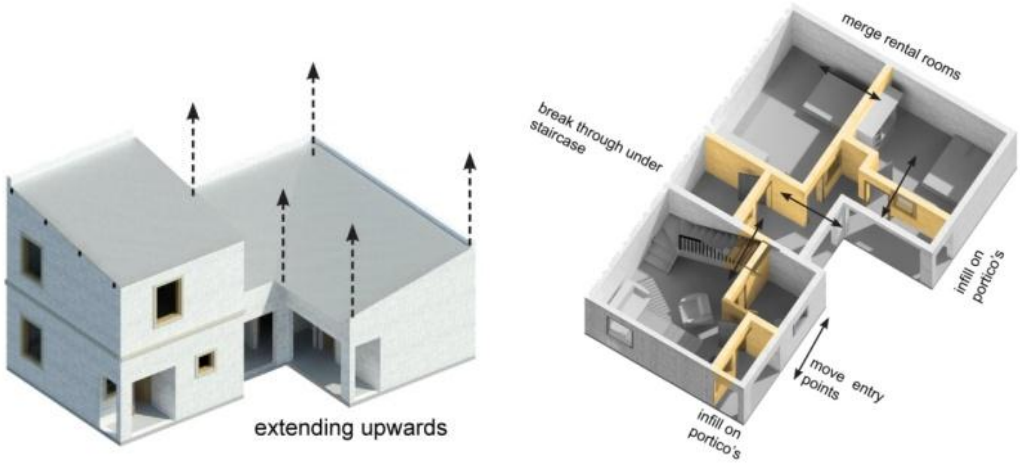
The buildings are constructed from low-cost, conventional and fairly robust materials – an earthy palette of painted and plastered concrete and fly-ash masonry walls covered by mono-pitch corrugated steel roofs with low parapets. On the exterior, the steel-frame windows and first floor concrete floor lines are highlighted with a plaster border and painted white, adding

simple decoration. The entrances to the units have small protective overhangs and the area at the entrance of the unit is intended as a semi-private garden space.

The owners/tenants are allowed to personalise and adapt the buildings within the current building lines. This restriction is imposed for a period of five years. Most residents have added simple security measures to their homes such as burglar-proofing and many have already personalised their units by painting, plastering or tiling the interior or exterior walls, floors, doors and window frames. Some gardens are being planted and some of the external steel doors have been replaced with timber doors. However, alterations to the main spaces would mean having to breakdown load-bearing masonry walls. The internal masonry staircase is robust, plastered and fitted with a simple steel railing. The railing is hinged so to allow furniture to be moved up the staircase. Otherwise, the staircase will not be able to be adapted or moved without making considerable changes to the primary unit; it can only be personalised (by tiling or by removing and changing the steel railings). The current low-cost sanitary fittings may easily be replaced and upgraded.

The simple mono-pitch roof is easy to duplicate, dismantle and re-install. The design would allow harvesting of storm water from the roof but the roof would first have to be fitted with gutters and downpipes which are not currently provided. No provision is made for refuse and washing areas. The existing roof pitches might have to be adapted if solar heaters are to be incorporated in the future – this is a perceived short-coming in the design.

If an external staircase is provided, the rental possibilities can double, or the entire ground floor area could be used as a single dwelling, and the rental tenure moved to the first floor. It would also be possible to move the point of entry to a different location on the same elevation or to a second elevation. Overall, the original structure can be manipulated to some extent but the primary unit itself has very little possibilities for change as it might be a complicated and costly exercise.



Figures2, 3: *K206 general transformation analysis – possible vertical expansion and internal layout variations in the single unit.*

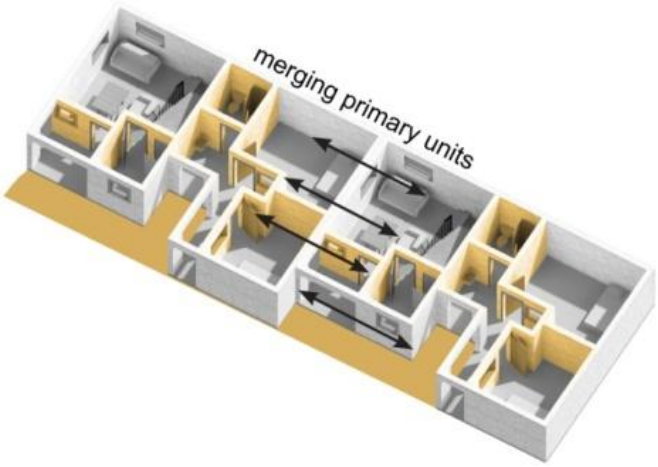


Figure 4: *K206 general transformation analysis – possible merging of primary units.*

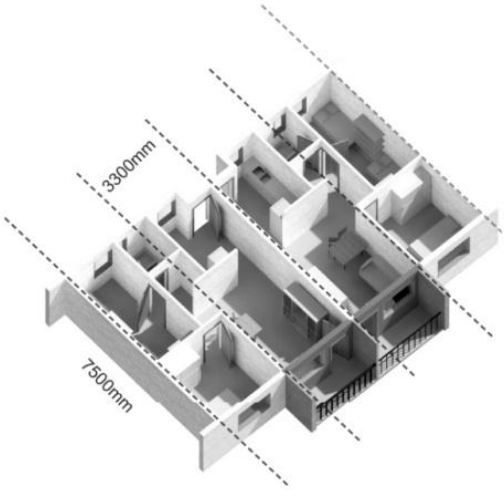
It was noticed that material choice and finishes play an important role in the overall experience of the extremely tight spaces. Therefore, by simply having a white wall finish instead of a dark wall finish internally the quality of the space is perceived to be better. The structural system restricts the replacement of the porous masonry, currently a source of great frustration to the residents because of water seepage into the unit. Inadequate divergence of stormwater around the unit, lack of insulation, lack of natural light and cross-ventilation are other shortcomings that might need increased adaptation potential of the units if remedies are to be implemented at a later date.

Elangeni

Elangeni Gardens was designed by the architecture firm Savage+Dodd. The social rental housing project is designed as a medium-rise perimeter block and is located in the heart of Johannesburg. The project is administrated by the Johannesburg Housing Company, JHC, and forms part of the City of Johannesburg's Better Buildings Programme. It was completed in 2002. The total project consists of 168 units, ranging from 35m² one-bedroom units to 59m² two-bedroom units. Other unit typologies are live-work units on the ground floor and loft units on the upper two floors. The building is divided into four main structures, linked by a concrete masonry brise-soleil on the circulation areas, and therefore reads as a single, robust, face-brick complex. The monotony is also broken by extruding shallow balconies, south-facing circulation spaces and general service shafts from the living units. These abutments are then framed with steel frames. The units are designed with stringent economy of space in mind in a typology reminiscent of row-housing – rectangular, narrow and compact.

The housing units are clustered into groups of three units per floor in an attempt to encourage a lifestyle of community living. The corner retail unit and the live-work units face a fairly busy street and filling station. The total project consists of 168 units, ranging from 35m² (one-bedroom) to 59m² (two-bedroom). Most of the rooms and units are adequate enough for either a single person in a single-bedroom unit or two people in a double-bedroom unit. Despite the small areas, young families also occupy some apartments. It is difficult to arrange furniture in the living areas according to the tenant's preferences, making for a very deterministic living arrangement within the unit, but the bedrooms are big enough for some variation. The rooms are well lit and ventilated.





Figures 5, 6: *Elangeni gardens, entrance and structural bays.*

To reduce the overall building costs and ease of maintenance, the materials used throughout the project have been kept to a simple specification. The building is structured in a modular fashion with a grid spacing of 3300mm centre to centre and the units are primarily aligned north-south. The main building structural components are uniform reinforced face-brick masonry walls at a double grid spacing (every 6600mm centre to centre). Steel beams protrude beyond the exterior masonry skins of the units to support concrete balconies, steel staircases or passageways.

There are no ceilings fitted except on the loft units. Bathrooms and kitchens are tiled and the original carpets in the living and bedroom areas are also gradually being replaced with tiles. The built-in cupboards in the bedrooms have been removed and replaced with just a rail and in some cases a small shelf. On the stair landings, behind the brise-soleil screens, there are small enclosed yards for hanging washing. There are no solar water heaters nor is there any water collection from the roof. The building does not have recycling amenities but provides a standard refuse yard for waste disposal.

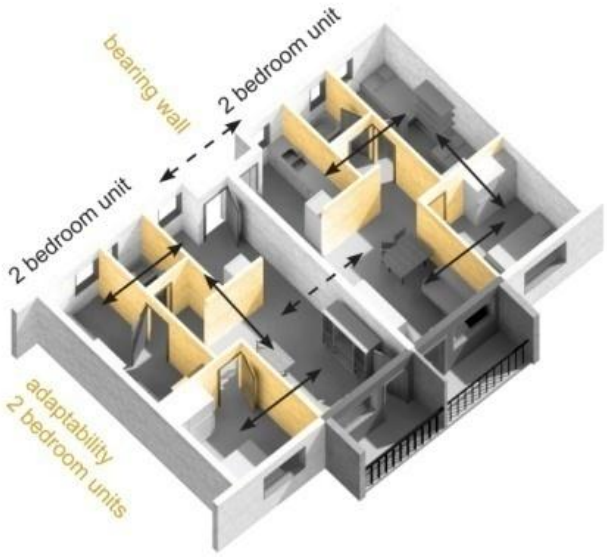
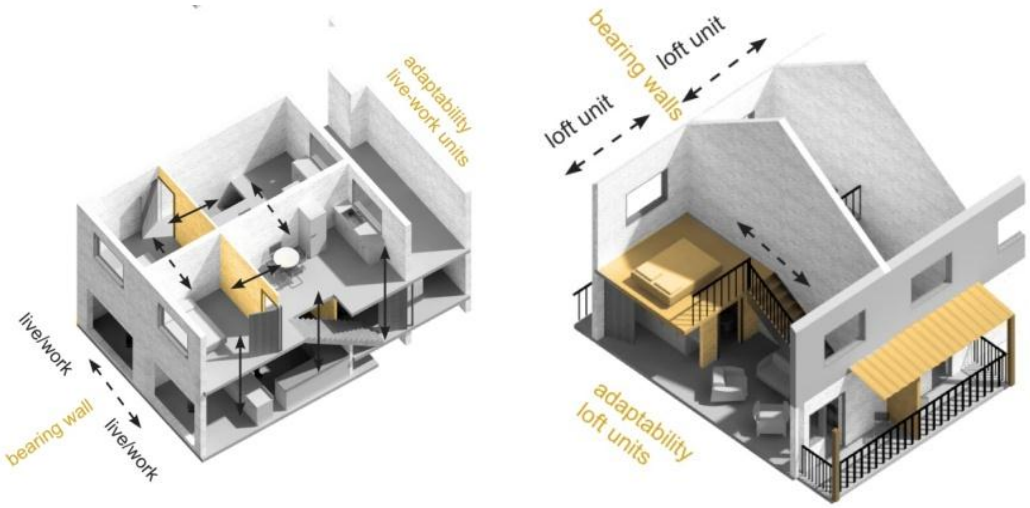


Figure 7: *Diagrammatic analysis of Elangeni Gardens*



Figures 9: *More diagrammatic analysis of Elangeni Gardens.*

The overall design and layout of the building would not allow for much adaptation or extensions beyond the current building lines. The scheme can accommodate some internal adaptations that the tenants could implement themselves, but these changes appear to be limited to the two-bedroom units. Expanding the area or merging of units requires the breakdown of bearing walls. However, it is noted that adaptability potential relates to the section of the building being considered, as some units are perceived to be easier to adapt due to differing structural and spatial features. The need to design singular units within the narrow grid spacing results in a tight fit of entrances and wet services while units that span over the double grid might offer more potential for flexibility.

In accordance with the architect's general policy to designing for efficient maintenance, the unit materials, detailing and components provide relatively low maintenance requirements to fit the economic profile of the target group.

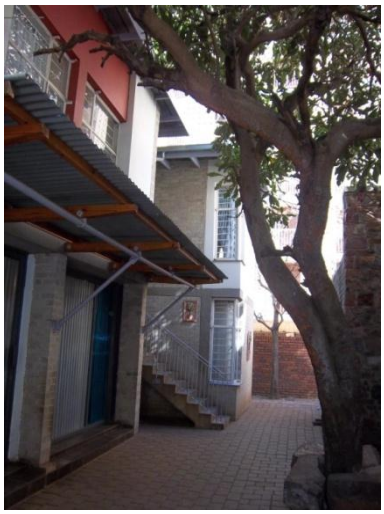
Potters' House

The Potters' House is situated in Burgers Park Lane, Pretoria city centre. The project provides various housing options mostly for people in need of shelter, social support and economic upliftment. The concept was developed by the Consortium for Urban Transformation (CUT), IDASA, the Centre for Housing and Land Development at the University of Pretoria. Burgers Park Village is conceived as an urban rejuvenation project involving the recycling of old buildings. Potters' House is a part of the Jubilee Centre mixed-use complex from which Yeast City Housing administrates the overall project. Established in 1993, the building provides rental tenure and is a transitional housing facility for women in need. It forms a part of a greater community of buildings and small courtyards and is situated behind the main office building. The exterior spaces are perceived to be relaxed, safe and calm and the interior spaces are simple and efficient. However, while the buildings are cool and protected during the summer, tenants report that the winters are very cold.

Potters' House has a symmetrical design in an H-shape formation and the ground floor has a central living-room area with large swivel doors. The ground floor units have a semi-private garden space that can be directly accessed from the northern rooms through steel-framed glass doors. This is quite a pleasant area, but the nature of the tenure means that the garden space is not well-maintained.

The building accommodates 25 bed spaces in 10 rooms. The 24m² units have simple longitudinal layouts, with one room at each end with ablutions in the middle. All the interior walls within the units have a clerestory window. The rooms are well-lit but the bathrooms are fairly dark, with the electric lights kept on most of the time. The rooms in themselves can be passively ventilated and windows are well placed for natural cross-ventilation. All the wet-service shafts are located on the exterior of the building and covered with long strips of corrugated sheets. Most entry points on the ground floor usually have a stepped threshold and entrances are covered and protected from the elements. The rooms have insulated ceilings. Every room has a simple built-in cupboard.

The two-storey building is a hybrid structure with a reinforced concrete frame on the ground floor with load-bearing concrete masonry on the upper level. The exterior surfaces are mostly covered in concrete or clay pavers. The building is robust and upkeep is low. The building has three insulated, corrugated steel sheet roofs on timber rafters, each fitted with gutters and downpipes. The building is fitted with steel-frame glass windows and primarily hollow-core doors.

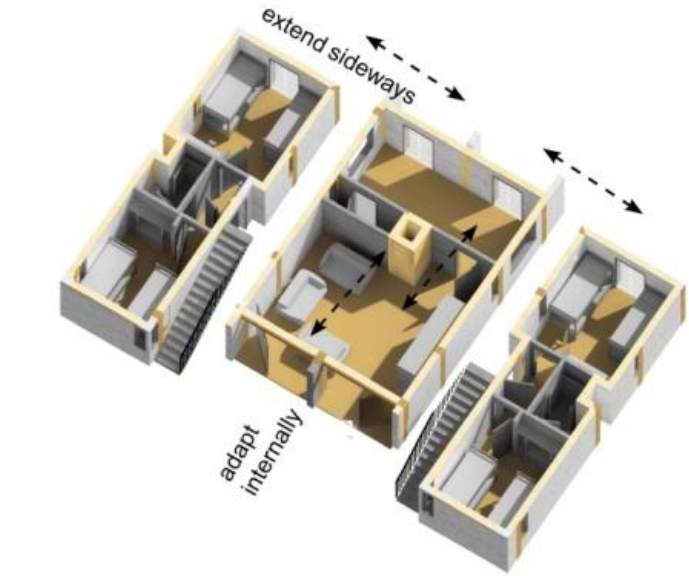




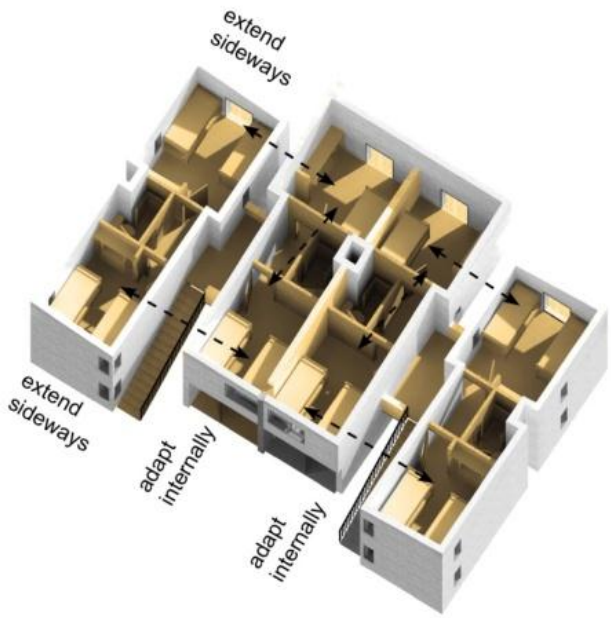
Figures 10, 11: *Views of Potters' House.*

The majority of the building exterior is unplastered, but the interior spaces are plastered, painted or tiled according to the occupation. The nature of tenure in the building mean that more significant changes, additions or extensions would have to be implemented by the Yeast City Housing company. The simple frame on the ground floor makes changes at that level relatively easy. The centrally located ablution areas might restrict adaptation to some extent. However, this same positioning of the wet-core offers various opportunities in the central block of the building. The two flanking rooms on each floor are difficult to merge, but the rooms could be adapted to change from a two bedroom unit to a self-contained one-bedroom unit on the south and a north-facing living area.

Due to the placing of passages and doorways, a room from one unit would be able to merge into the opposite unit in an L-formation, or across the entire building. By inserting an opening into a wall, it is possible to merge an entire floor completely without making significant variations to the building's appearance or structure. As a whole, it would be possible to extend the building upwards by two or three storeys, depending on the foundations provided.



ground floor
basic frame



typical floor
frame and infill

Figures 12, 13: *Analysis of Potters' House.*

General upgrading of finishes would be possible as would retro-fitting sustainability features. The ground floor area could also merge with the first floor and become a duplex or larger independent unit. It could also become one large unit with the northern portion of the building, or in contrast be divided into two smaller units as the structure would not be influenced by these adaptations. The covered exterior cast in-situ concrete staircases allows that the building can be almost decapitated from the first floor and something completely new can be built without change in the basic structure at ground floor level.

SUMMARY OF FINDINGS AND COMPILATION OF ASSESSMENT CRITERIA

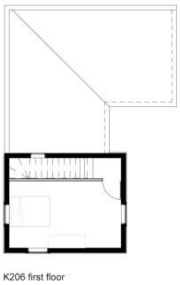
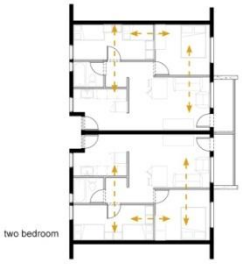
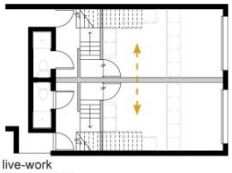
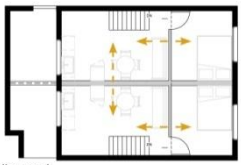
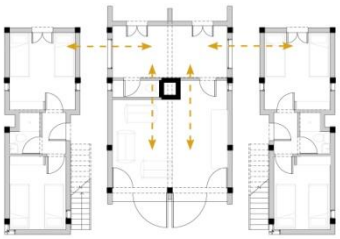
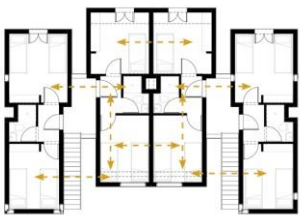
	First level	Second level	Comments on adaptability potential
K206	 K206 ground floor	 K206 first floor	-Semi-private threshold space is easily enclosed -House may be extended upwards over the two rental rooms -The two rental rooms may be merged with the primary unit – however this means losing the threshold and creating an awkward passage in one scenario or breaking down a structural wall, under the stairs, in another
Elangeni 1-bedroom	 one bedroom L-shape		-Narrow grid spacing and structural walls limit the interior alteration possibilities -However, with some effort and wastage it is possible to create an open plan in one unit or merge two units by removing a wall and adding structural support
Elangeni 2-bedrooms	 two bedroom		-This unit provides real possibilities for major changes due to the large spans and non-structural walls -The balcony spaces can be built-up adding on average 4m² of space, but this entails removal of doors and walls and does not add much value to the quality of the space
Elangeni live/work	 live-work ground floor	 live-work first floor	-The small areas limit the interior alteration possibilities of the unit but the non-structural walls allow possible merging of two units
Potters' House	 ground floor not to scale	 first floor not to scale	-Frame and infill at ground floor allows for easy changes, however the hybrid structural system poses restrictions on the adaptability potential of the structure as a whole -Central space with central wet core allows for more change and combination possibilities -While there are restrictions to extension beyond current building lines, it is not impossible to do so, especially if the building is to be linked to the surrounding buildings

Table 1: *A summary and general comparison of the plans of the selected projects. It must be noted that this information has been compiled from available drawings and documents and still needs to be verified by the architects in some cases.*

Based on the case studies, several features of the buildings are already undergoing change, by the owners or social housing institutions, with no professional input and no requirement for complex approval processes. These are therefore assessed as being easier to modify, adapt or change. These features with "easy adaptation" potential are also perceived to have high social value in some cases (such as the replacement of steel doors with timber doors in the K206) and high functional value in others (such as the incorporation of theft- and vandal- proof features in Elangeni as well as easier-to-maintain tiles as opposed to the original carpets).

While some features may have social as well as functional value, it is perceived that some features which will truly enhance functional performance are more difficult to implement as these would involve spatial alterations and the disruption of major building components which implies higher technical impact. Some high level adaptations, such as changing the facades may also have a high level of social impact, especially when a facade is considered low quality as is the case the K206. In this project a facade material change implies breaking down a structural wall.

However, it should also be remembered that the components that undergo frequent change and that are easier in a technical sense to change, may also have very high environmental impact if re-use potential, disposal options and embodied energy aspects are taken into account. "Easy adaptation" may thus encourage greater "frequency of adaptation" resulting in higher environmental costs.

From this discussion, the assessment of adaptability potential may be carried out based on features that are easier to adapt to those that pose greater difficulty and have higher impact. Frequency of adaptation is here linked to the degree of ease or difficulty of adaption:

Easy adaptation
Easy adaptations are usually short-term changes in that they deal with changing the appearance of units and (regular) maintenance work. They benefit the users (have high social value) because they could be used to increase the uniqueness of the occupied unit (use, colour, finishes). The assessment of short-term adaptability depends on architectural analysis (multi-functionality of the plan layout) and housing regulations (to what extent users are allowed to make changes). Examples are:

- changing doors (without changing the door opening) (referred to as an "independent component")
- removing carpets, paving, tiling, painting (functional- or status- linked "finishes")
- adding burglar bars ("independent component")
- add features such as solar heating or rainwater collection (general fittings also as "independent components")

Moderate adaptation
Moderate adaptations are generally medium-term frequency and generally include those changes needed to update a building to changing market demands or government requirements, e.g. replacing or upgrading finishes, increasing or decreasing unit sizes to match evolutions in demography, updating the unit layout and services according to changing societal standards, etc. The feasibility of these kinds of changes can usually be assessed by analysing the structure and construction of the building, and the degree of entanglement of constructional components and functions. Because moderate adaptation is done on the level of building components, improving the adaptable capacity on this level strongly influences the other levels. Examples:

- reconfiguring internal layouts (this implies knocking down an "internal non-structural wall")
- reconfigure internal vertical or horizontal circulation ("private circulation")

- adjust a partially-enclosed space or change a point of entry (change "building envelope" or "openings")

Intensive adaptation
These intensive changes in a building usually only happen in the long-term and only become viable when entire buildings or projects need to be refurbished. They include elaborate adaptations like vertical unit extensions (i.e. through an existing floor slab), horizontal unit extensions using new structures or cantilevers and changing the typology of outside circulation. Long-term changes require analysis and design done by architects and structural engineers. Examples:

- reconfiguring internal layouts (knocking down an "internal structural wall")

- expand vertically and horizontally (which implies adjusting various "system-dependent components" which are governed by the location of higher-order systems such as the "wet services" and "vertical service cores" as well as "communal vertical or horizontal circulation" areas which are more complex to change, not only for technical reasons but also because they are shared areas where a group decision needs to be taken as compared to "internal circulation" where individuals take the decision)

The transformational capacity of a building is, of course, largely determined by the building itself. As most aspects of adaptability come into play when trying to implement moderate/medium-term changes, it could be argued that this intermediate phase is the most important. The feasibility of medium-term changes is based on the complexity of the construction (whether components are functionally independent or interdependent) and can be assessed by the degree of professional involvement necessary to implement the changes.

ADAPTABILITY ASSESSMENT TOOL

From the above it can be seen that, while the existing housing projects do not appear to have been designed with adaptation potential as a high priority, this does not imply that they can't be adapted. An approach to assess the adaptable capacity of the existing housing projects is thus attempted.

This paper presents a broad, rather than in-depth, assessment of the selected case studies. As the projects under assessment were not designed to be adaptable, an in-depth analysis of the disassembly options of the existing construction would most likely result in low scores for all projects and would be unnecessarily time-consuming. The priority is a general assessment of the adaptability potential, rather than a detailed analysis of every aspect of disassembly or re-use of the construction and its components. This makes assessment more straight-forward, and requires a lower level of expertise.

The outcome of this process has been a list of possible adaptations and comparisons between buildings with regards to the ease with which these adaptations may be achieved. In order to be directly usable for housing practitioners, the presented tool lists possible adaptations, impact on other features/components of the building and categorises these ranging from easy to intensive adaption potential. The tool theoretically allows for scoring and computation, though this is to be done in the future and has not yet been achieved.

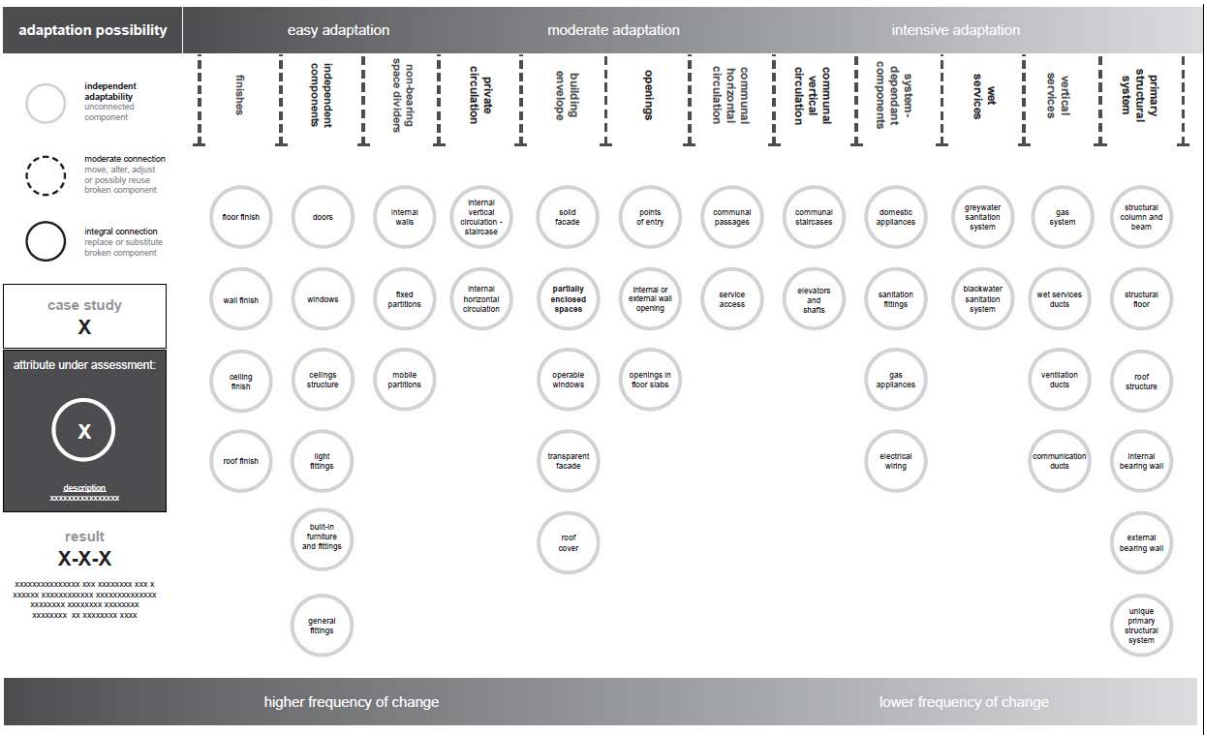
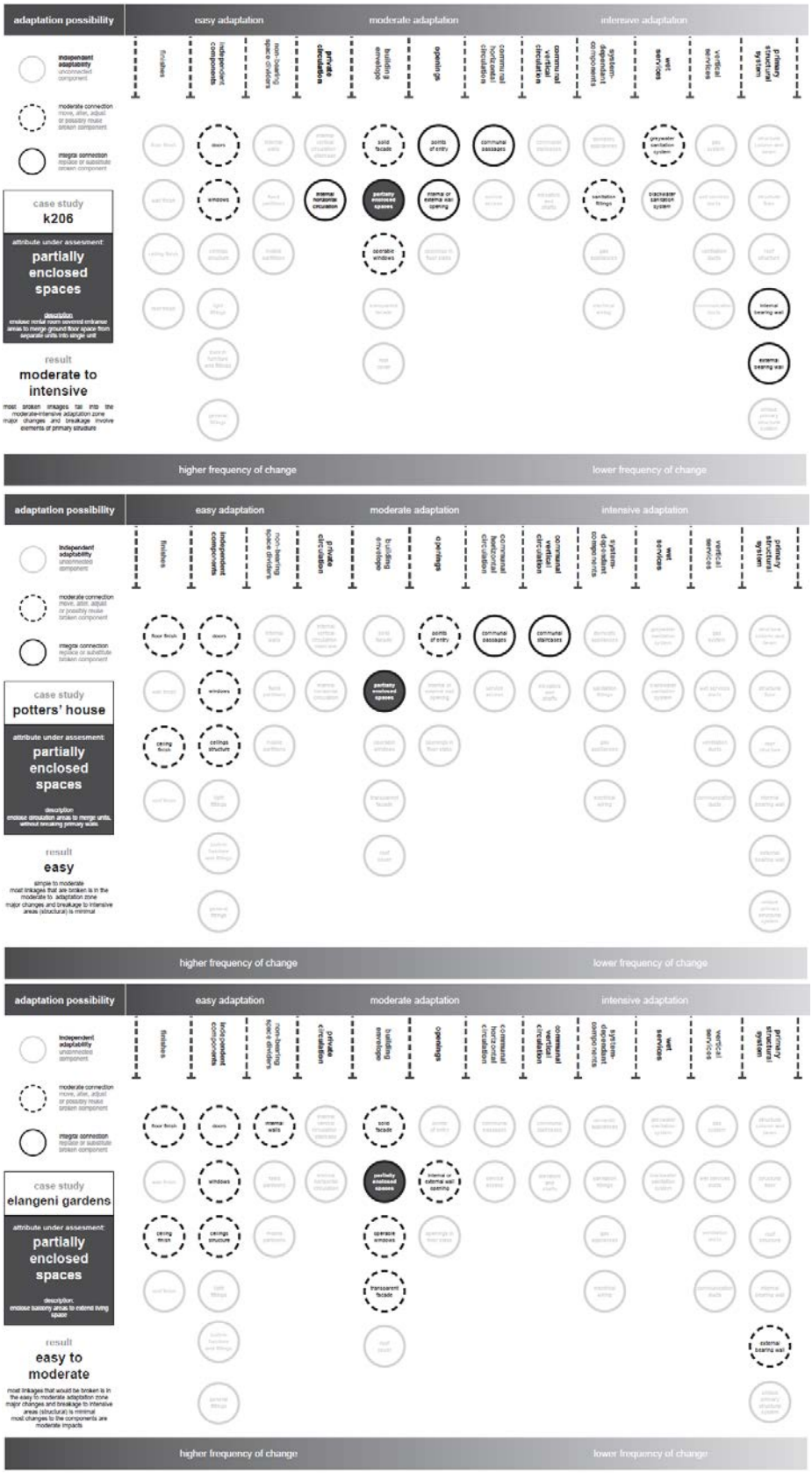


Figure 14: *The format of the assessment table.*

Currently, it is intended to simply present when change in an attribute of a building component breaks or serious alters another component/s, when there is possibility of re-using removed components, when a component can be removed and substituted without breaking anything else and when there is absolutely no impact on other components. Thus, the degree of entanglement is assessed by the number of features/components affected indicated by the number of circles on the diagram that are marked in a grey, dotted or black circle – this indicating the degree of damage to attached features/components.

A more in-depth tool might differentiate between an adaptability rating, disassembly rating or reuse of components rating and it would also incorporate aspects such as owners/users behaviour and preferences. A more complex and accurate assessment would also separate between unit adaptability and building adaptability.

Rating and comparison between projects may be achieved by assessing the number of aspects of a building affected by the same change in attributes in the buildings being compared. The number of affected circles on the table (building components/features) determines the degree of entanglement of the attribute under assessment. The more affected circles on the right side of the table, the more difficult it is to adjust that particular aspect of the building. These relations and their degree of entanglement may ultimately be scored.



Figures 15, 16, 17: *Application of assessment to the three case studies.*

DISCUSSION

The capacity for sustainable building transformation has been assessed by studying the internal planning, construction methods and material selection of some case studies. Some results of this study may be presented as follows:

- Simple column and beam structures offer more opportunity for change when compared to load-bearing masonry
- Alternative technologies (sandbag construction, adobe construction, or bamboo-reinforced concrete masonry) could be even more cost-effective and should be investigated
- If not the entire structure, perhaps only one or two walls can be considered with alternative materials to counteract some site specific issues such as drainage or heat gain or allow for a more varied potential in adaptability of the building.
- Narrow grids limit spatial manipulation, especially when the bays are separated by structural walls
- Variation in the grid may allow for a variety of spatial experiences and areas according to preferred taste and need
- Open plans allow for varied interpretations; this may also be investigated vertically with a structural system over two floors instead of per floor
- Alternative building components should be considered to demarcate spaces in the double grid units, such as adaptable composite panelling structures or the use of mobile storage units

It should be noted that this list is used as an example and is not intended to be exhaustive. It has also not considered the cost implications of this approach – however, it is believed that the long-term financial and environmental cost implications of not taking adaptability into account are is very high – especially when a building has to be completely demolished with no possibility to dismantle components for re-use.

We therefore proceeded to develop an assessment tool to study possible adaptation in more detail. While this has been described as “broad” rather than “in-depth” assessment, a preliminary conceptual tool is presented to allow for further comparisons between projects with regards to adaptability potential.

CONCLUSION

By studying existing housing projects, it has been possible to develop an approach to assessing the potential for adaptability as well as to offer some guidelines for new projects. This research intends to contribute to the debate on transformable structures and to raise awareness on the topic. The proposed assessment tool may be used by designers or project managers increase their comprehension of basic concepts of transformability and disentanglement of functional layers. Hopefully, it will show that sometimes only small changes are required to drastically increase the future options available to a project that needs to be renovated. Once the tool is further developed, the intention is to use it in the field and to get input from professionals. While the ultimate aim is to develop a design guide, this would

require a greater level of detail planned for another stage of this research project. This design guide will aim to influence thinking, design and planned delivery approaches at the conceptual stages. It is concluded that this approach to design is highly relevant to the South African context and deserves serious attention in the building of future housing projects.

NOTE

All photographs were taken by Calayde Davey or Amira Osman, all models/graphics are drawn by Calayde Davey and sources for plans were either the architects themselves or they were sourced from ASA and Yeast.

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DUTCH STRATEGIES FOR THE HISTORIC URBAN CORE, THE HISTORIC INNER CITY, FADED GLORY OR CORE BUSINESS

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Abstract
This article is about the strategies of Dutch cities for the historic urban core, based on empirical research done on the policy reports of twenty Dutch cities. In addition to the policy reports plans for spatial and functional interventions, initiated by the local government, were analyzed.
The analysis were made in the years 2006, 2007 and 2008. The years just before the start of a possibly long lasting economic recession. Apart from some reflections on this subject at the end of this article no attention is paid to this in an analytical way.
Keywords: historic urban core, strategy, transformation, identity

INTRODUCTION

Cities are more and more competing with each other in different leagues, for the favor of the high educated creative settlers, the cultural visitors, companies looking for a new location and to keep those already bound to the city (Gardiner, Martin, & Tyler, 2004; Gospodini, 2002; Greffe, 2004; Kavaratzis, 2008; van der Borg, Costa, & Gotti, 1996; Wiesand, 2005).
The historic urban core seems to have characteristics which are significant in the context of that competition. Characteristics often referred to as unique qualities and specified in terms of identity, authenticity, historic continuity, organic grown street patterns etc. (Lewicka, 2008; McCabe & Stokoe, 2004; Murtagh, Graham, & Shirlow, 2008; Murzyn-Kupisz & Gwosdz, 2011; Pendlebury, Short, & While, 2009) Zirubavel argues that the past and the present are not entirely separate entities (Zerubavel, 2003) and that people have a need to bridge the gap between the two. The physical surroundings which remain relatively stable constitute a reliable locus of memories and often serve as major foci of personal as well as group nostalgia. That underscores efforts to preserve those parts of the city that provide us with a link to the past. Lowenthal argues that in western society, because people live longer and are more mobile, they seldom remain surrounded by the things they grew up with. That is why there is an increased interest in history and why people stick to the last recognizable things (Lowenthal, 1985). The historic urban core gives the opportunity to make contact with previous generations and step in the footsteps of our ancestors.
The same message as Lowenthal, is given nearly twenty years later, in a policy document of the central government of the Netherlands. The following statement is made in that document: "The need for historical embedded identity, for slow movement in time, for distinction ability, for nuances, familiar situations and variety, can also be seen as the counter point for the dominant influence of the levelling global culture. Handling the cultural heritage with respect guarantees the historical continuity and opens up possibilities to preserve the cultural identity of a village, city, region and even the whole country" (VROM, 1999) Kotkin is explicitly referring to the historic urban core giving a sense of place and history amidst a society in which the barriers of time and space are under constant assault. "As centres of arts and culture, repositories of our past history and architecture, the core retains a powerful tug of consciousness. It reminds us not only who we are but also what we have been" (Kotkin, 1999)

The function and significance of the still present characteristics of the historic urban core has changed over the last decades and will develop further, giving support to the presentation of the city image. In order to fully equip the historic urban core for its actual and future function spatial and functional interventions are maybe needed. Or certain interventions by private parties maybe support opposing objectives and need to be prevented. Because of the delicate structure of the historic urban core interventions have to be planned and executed very carefully (Doratli, Hoskara, & Fasli, 2004). There are many parties, private as well as public, which have an interest in the historic urban core. Because of the general interest the historic urban core can be considered a common good particularly on a local level. That does impose the role of mediator, navigator and initiator on the local government for the way the historic urban core is utilized and optimized.

This project, of which this paper is about, is primarily concentrated on Dutch cities with an historic urban core, dating from around 1000 a Chr. In Gospodini‟s terms (Gospodini, 2002) Dutch cities are smaller cities. He classifies the cities in the European global system in three main categories: metropolitan cities, larger cities and smaller cities. According to Gospodini, with reference to Commission of the European Communities (CEC), 1992, smaller cities are considered to be the dynamic force of modern urban Europe and the majority of them are expected to continue growing successfully in the new competitive milieu. According to eurostat statistics concerning more than 300 European cities more than 50% of Europes population is living in cities with less than 500.000 inhabitants. For the smaller cities in Europe the maintenance, preservation and enhancement of the qualities of urban space is a dominant selling product in the context of the before mentioned competition. The historic urban core is often, for the smaller cities, their flagship project while the bigger cities have the possibility, and take the advantage, to create new ones.

In order to execute its role as guardian of the historic urban core the local government needs a long term strategy framed in possible future developments. To orientate on this subject research, about which this paper is giving account, has been done based on the leading question:

What is the future strategy, in terms of vision, objectives and means, of Dutch local governments for their historic urban core?

In this paper first attention is paid to what is supposed to be the content of a long term local government policy strategy. Then the selection of 20 cities is explained. The strategies of the 20 cities appeared to be very “look alike”. Therefore the choice is made to present them in the form of an average, being the strategy for the theoretical reference of Dutchtown. In the end conclusions are drawn concerning the main characteristics, focus points and shortcomings of the strategy. This article is illustrated with examples of interventions in the historic urban core in three of the twenty cities.

GOVERNING CHANGE OF THE HISTORIC URBAN CORE, LOCAL GOVERNMENT STRATEGY

What is a strategy? The concept was adopted as a management tool taken from the area of competence of the military generals. In that context the concept is as old as mankind. In the field of management the concept is given various meanings by scholars and managers in the field.

Porter stressed the competitive character and defined a strategy as “a broad formula for how a business is going to compete, what its goals should be, and what policies will be needed to carry out those goals.” (Porter, 1980/1998)

Henry Mintzberg indicated that strategy is a *plan*, a *pattern*, a *position*, a *perspective* and he indicated that it can also be a *ploy*, a maneuver intended to outwit a competitor. (Mintzberg, 1994)

Private corporations were the first to use the strategy concept in their management activities. Public institutions and authorities followed in their footsteps. Also in the field of urban management and the management of specific urban areas, like the historic urban core, local government strategies are used as a guideline for management activities.
A set of local government decisions concerning spatial and functional management activities framed in objectives which are paving the way to a future vision or future brand are forming a strategy. (Figure 1)
The historic urban core is very differentiated with regard to ownership of property. This means that many different parties are involved in the changing process of this area. A process that is, historically seen, a continuum of small scale interventions. The municipality has the abilities to govern that process using a range of management tools or means that can be categorised in regulation, incentives (financial support with public money), initiate and participation in interventions (Figure 2)
Related to real estate and spatial planning a strategy is always covering a long time. Real estate and spatial patterns have a very long life cycle, sometimes ages. Decisions in that context have therefore long term effects. Those effects should be taken into account as important considerations for decisions to make and for the strategy to develop. Qualification and quantification of long term effects is only possible if a strategy is placed in the context of future developments not being part of the strategy but often highly detirmend for the strategy success. Future developments forming the context for a strategy cannot be influenced or predicted. Therefore a strategy is placed in the context of different possible futures or scenarios in order to specify its possible effects and also to test its „strategic response capability". That is the capability to respond adequate on changes in the context, which cannot be influenced, by flexibility and robustness of the strategy. (Bettis & Hitt, 1995; Lindgren & Bandhold, 2009)
The policy reports of the 20 municipalities were analyzed taking the scenario/strategy approach as a basic principle and taking the framework given by figure 1 and 2 as a structure.

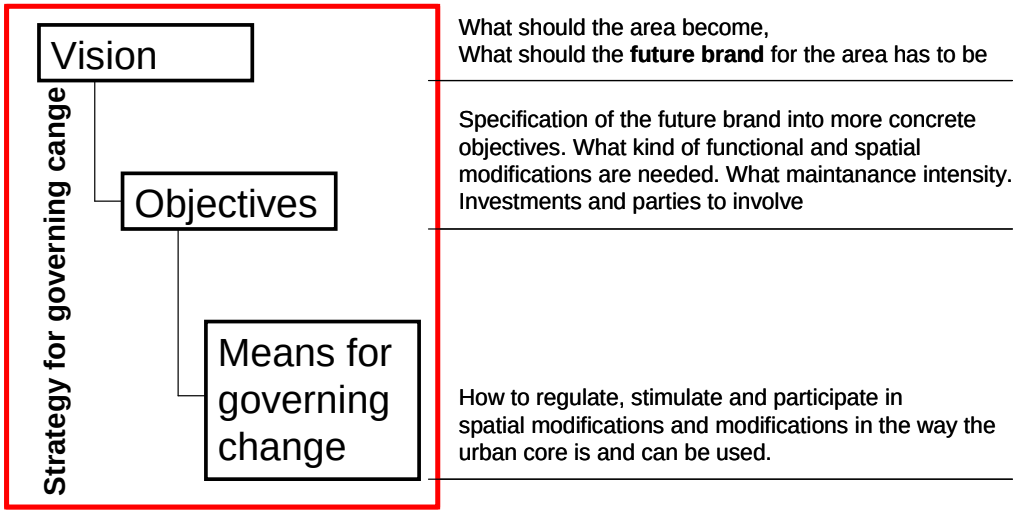


Figure 1 *The strategy components*

Below an explanation is given for the means that can be used as part of a local government strategy.

Governing change

The management means of the local council can be classified in the following main groups:
1. Regulation

2. Incentives
3. Participation in execution

Regulation

Regulation implies the contextualisation of spatial changes of buildings and urban structures through rules. These rules are laid down in legal frameworks, such as:

- Zoning plans
- Registration of conservation areas
- Registration of monuments
- Procedures for applying for planning permission

Regulation implies laying down what is permitted and what is not permitted with regard to spatial and functional interventions.

Regulation also concerns the contextualisation of possible uses. For example, a traffic circulation plan sets rules for how the road system is used.

Incentives

Within the scope of what is permissible, a distinction can be made between what is possible and what is deemed desirable. Incentives can be used to put the focus on what is desirable. Subsidy schemes clearly belong to the category of incentives. One example of an incentive is advice and subsidy for the promotion of the use of authentic colours. However, incentives can also take the form of active cooperation from private initiatives through official municipal bodies, which can lead to quicker and more streamlined procedures.

Participation

The municipality is responsible for the spatial planning and management of public spaces. The municipality also owns a considerable share of the property in the historic urban core. The initiative for interventions in the historic urban core, therefore, often lies with the municipality. The participation of private parties is also necessary, in order to produce an intervention that is qualitatively well-balanced and financially feasible. There are no set norms for the division of roles within local councils.

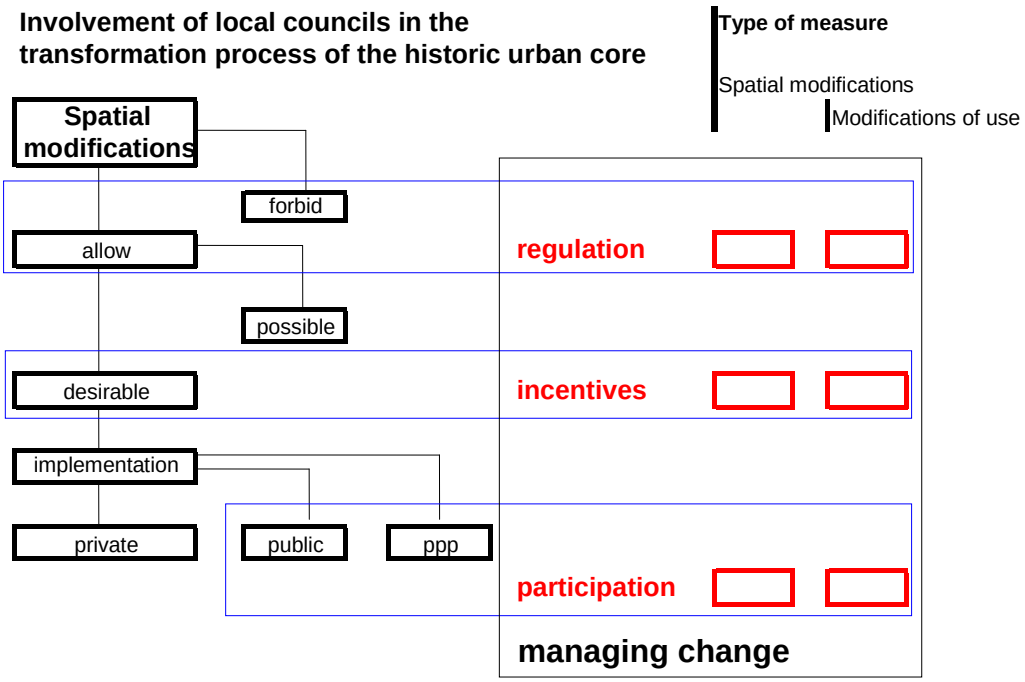


Figure 2 *Managing change*

Traditionally, regulation is the main working area of local councils. To a limited extent, incentives are an extension of this. Risk-bearing initiatives and participation in large-scale transformation investments are less obvious areas of involvement.

THE EMPERICAL FUNDAMENT, THE POLICY OF 20 DUTCH CITIES

In order to gain insight into the strategies applied by Dutch local governments, an analysis is made on the policy reports of 20 municipalities. First an explanation is given on how the 20 municipalities were selected. After that some general characteristics of the local policy reports and strategies involved are presented. Finally an average of the strategies of the 20 cities is worked out.

The strategies of the 20 municipalities involved in the analysis turned out to correspond on many points. This made it feasible to embed the policies of the 20 municipalities within the framework of a theoretical reference municipality, without detracting from the differentiation in policy. We called the theoretical reference municipality „Dutchtown". The focus in the analysis is laid primarily on the way in which the local policy documents described the positioning and the future prospects of the historic urban core. A note was also made of the measures proposed in the policy documents for providing spatial and functional support to the future profile of the historic urban core. Finally, the measures noted were sorted according to the principles outlined in figure 3.

Selection of the cities

Of the 50 largest municipalities in the Netherlands, those municipalities were selected with a historic urban core that still exists for a considerable part (number of listed buildings in the historic urban core/inhabitants of the total city =>2). Fig. 3 and 4 shows an overview of the 20 municipalities thus selected. Some characteristics of the selected municipalities are:

- By far the greater part of the selected cities were granted city charters around 1250. The exceptions to this are Deventer (956) and The Hague (1806).
- Around 20% of the population of the Netherlands live in the 20 selected municipalities (89% of the Dutch population live in urban areas).
- In the area of the historic urban core, there are generally less than 10% of the number of dwellings in the whole city. Exceptions to this are Amsterdam, Leiden, Delft and Bergen op Zoom.
- On average, the Dutch Real Estate Appraisal Act (WOZ) values of the dwellings in the historic urban core are 6% higher than the average WOZ value of the dwellings in the city as a whole. In 14 of the 20 municipalities, the WOZ value of the dwellings in the historic urban core are considerably higher than the average value of the city as a whole.

Letters were sent to all the municipalities in the selection in 2006 and 2007, asking them to provide policy documents relevant to the area of the historic urban core. Information was also sought through the municipalities" websites. The analysis includes a total of 91 policy documents from 20 municipalities.

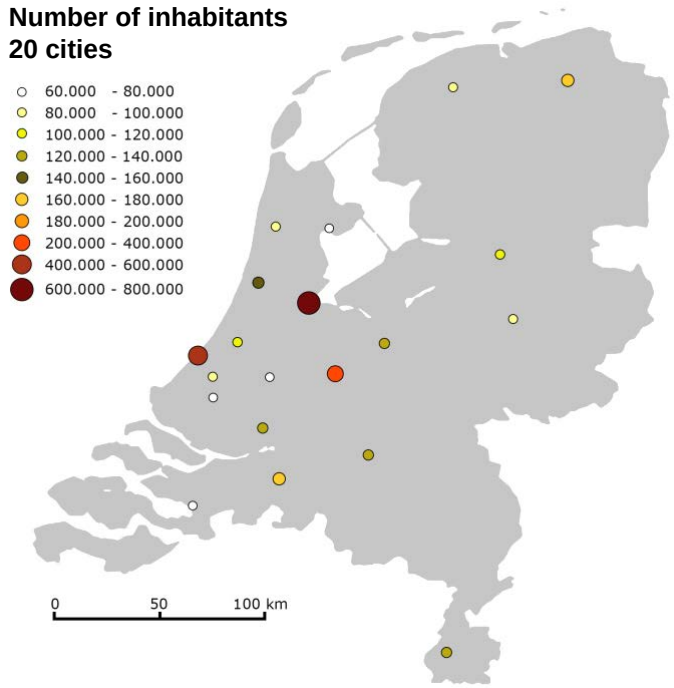


Figure 3 *Selection of Dutch cities*

the 20cities	city inhabitants	monuments/ inhabitants x 1000	number of dwellings	dwellings inner city	year of city legimization
Amsterdam	735.526	9,5	374.952	45.960	1306
Den Haag	457.726	2,3	221.966	10.370	1806
Utrecht	260.625	5,0	114.116	6.030	1122
Groningen	175.569	3,6	81.997	6.340	1040
Breda	163.427	2,3	71.053	5.140	1252
Haarlem	147.831	7,5	66.964	6.250	1245
Den Bosch	131.697	3,7	55.940	5.070	1195
Amersfoort	129.720	2,8	53.612	2.530	1259
Maastricht	122.005	13,0	54.333	940	1204
Dordrecht	120.222	7,0	52.331	4.070	1220
Leiden	117.170	10,2	50.271	8.341	1266
Zwolle	109.000	3,8	46.311	1.510	1230
Delft	96.936	6,2	42.694	8.770	1246
Alkmaar	92.992	3,6	40.185	2.430	1254
Leeuwarden	90.516	6,0	43.323	2.620	1285
Deventer	86.072	6,4	36.507	2.700	956
Schiedam	76.576	2,3	35.453	1.730	1275
Gouda	71.688	4,6	29.920	2.730	1272
Hoorn	66.458	5,5	28.007	2.050	1357
Bergen op Zoom	65.793	3,4	27.734	3.940	1213

source: Nyfer atlas voor gemeenten 2003 (gegevens hebben betrekking op 2002)

Figure 4 *Some figures of the selection of Dutch cities*

DUTCHTOWN STRATEGY

As a consequence of the credit crunch also municipal budgets are cut down and priorities are reconsidered. Related to that there is a tendency towards more involvement of market parties and more restrictions in order to exclude financial not profitable investments.
The Dutchtown strategy, being an average detected from 91 policy reports and presented hereafter was formulated before the credit crunch. Therefore it is likely that, on the short term, there will appear some modification in the strategy to adjourn the investments needed.

Characteristics and significance of Dutchtown core

The Dutchtown urban core has been created over many centuries and is characterised by a great degree of diversity. This development process is illustrated by new and old buildings. The current urban development situation has grown slowly, as the buildings have been replaced and changed over the centuries. The presence of different building periods also means a variety of construction techniques and methods and differences in architectural styles.

The buildings in the urban core are characterised by „unity in diversity". This unity is formed by a common idiom, in which the building height, the vertical character, the classic façades, the roof directions, the parcelling, the use of materials and the small scale are characteristic features. The greater part of the buildings were built in accordance with the traditional means and possibilities of the times. Afterwards, in more recent periods, many buildings were changed in both appearance and function. The diversity of the architectural picture is expressed (within the common characteristics described above) in a rich architectural variety of façade lay-outs, gable ends, ornamentation and numerous small differences in guttering heights, ridge heights and use of materials.

Seen against the background of increasing globalisation of society, competition between the municipalities and the regions will play an ever larger role. It will be increasingly important that the municipality of Dutchtown, too, assumes its own identity and tries to distinguish itself from others, with the goal of creating a positive image by promoting the municipality through its unique selling points. The historic heart is that, or at least a very important selling points of Dutchtown. It is not only of great importance for the urban economy, but also largely determines the character of Dutchtown, and thus functions as a magnet for visitors from the city itself and from elsewhere.

Future Objectives for the urban core

Cultural tourism

In the coming years, cultural history will occupy a central place in ideas about the identity and image of the city. In the new municipal policy on the conservation of monuments and archaeology, links are made with city marketing, cultural tourism and the city"s economy. The heritage of Dutchtown – both below and above ground – will be utilised in order to profit optimally from all the potential in these areas. Sometimes cities formulate something like a „Cultural Profile" master plan, in which the strategic opportunities of the heart of the city are specified.

Readability of history

The objective of keeping the city"s history readable and reinforcing it where possible is a front runner in policy. In meeting this objective, attention is paid not only to the conservation of monuments, but also to the conservation of the structure of urban planning over the whole terrain of the city. The relationship of cultural history to urban modernisation is addressed as well.

Preference for conservation and restoration
Conservation and restoration takes precedence over modernisation. The historic building materials, structures and methods of construction represent an important monumental and historical value. This value must be respected as much as possible, so that the history and development of traditional building, and the daily use of a monument are readable. Replacement would entail this readability being lost forever.
Cultural historical identity must be more decisive in spatial planning. In order to maintain its distinctness from other historic cities, Dutchtown must retain its original image and reinforce it in a modern way, rather than immediately searching for a totally new image or other identity factors.
The pedestrian tourist
The implementation policies that focus on restricting traffic in the urban core will benefit its character and attractiveness to guests. The same applies to the construction of parking garages. It is expected that tourism will occupy an increasingly important place, and this is part of the reason why retaining a small-scale character is extremely important.
Expand the urban core domain
Dutchtown wants to intensify the use of the urban core with permanent and temporary public attractions and to modernise the character of the city as reflected in the architecture and activities. This is possible by reinforcing the working function and urban housing, as well as expanding recreational and shopping facilities. Further reinforcement of such a multicultural urban core requires space, but this space is only available to a limited extent within the current urban core borders. It is therefore important to expand the urban core domain to include some neighbouring areas.

Local government measures

Regulation
Regulation requires good information about matters to which the regulation applies. This explains why attention is paid in many policy documents to the documentation of everything that is situated within the historic urban core. This includes:

- Drawing up a map of areas of historical architectural interest and charting historical architectural values in the urban core
- Charting archaeological values and designating areas of archaeological interest
- Developing digital charts of cultural historical values
- Historical architectural research and formulating historical morphological reports
- Formulating cultural historical investigation and effect reports

Designating and protecting valuable inner areas, on the basis of inventory charts.

Implementing stringent visual quality policy for the urban core, focusing on architecture, use of colour and material, street and façade advertising, spatial planning for public spaces, street signs and street furniture. New buildings in the urban core must fit the historic image of the city, with regard to size, scale and character. Spatial planning for public spaces must be matched to the character of the historic image of the city (important factors include the design of street signs and street furniture). Restoring architectural coherence, so that the shop front and the rest of the façade (which is often historic) is seen as a whole once more.

Spatial extension of the urban core: the case of ’s-Hertogenbosch

The historical background

‟s-Hertogenbosch is an average-sized Dutch city, dating from the 13th century. At present, it has a population of 132,000. The mediaeval structure of the historic part of the city, with its ramparts and pattern of narrow streets, has been largely preserved. The old city is situated on a sandbar, surrounded by marshy land. Because of this, urban expansion was very problematic in the past. Furthermore, ‟s-Hertogenbosch was a fortified city with impressive, sturdy ramparts. The city plan of 1652, shown in fig. 1, is still very recognisable in the present city plan. In the 19th century, the city was forced to find solutions to the growing need for space by opting for a high concentration of buildings within the city walls. It was only in 1874, when a law was passed stating that the fortifications of Dutch towns and cities were no longer functional, that creative solutions were sought for making the surrounding marshy land suitable for building. The railway and the station were built on the periphery of the historic urban core, where 590 national and municipal monuments are situated. These buildings strongly determine its authenticity and historical character, and therefore its attractiveness. The area has therefore been given protected status, making it difficult to realise any spatial and functional interventions. The urban core also plays an important role in the economic functioning of the city, because more than a third of employment is situated here. Though ‟s-Hertogenbosch has maintained and reinforced its past role as an urban centre, this has been accompanied by a growing need to extend it.



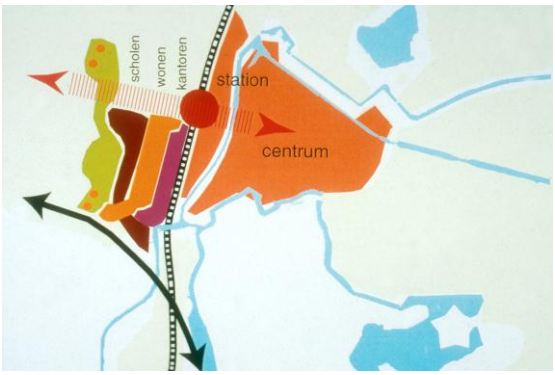


Fig. b *A historical map of the city of ’s-Hertogenbosch Source: Blaeu's Toonneel der Steden (1652).*

Plan of the city and the extension to the west

The need to extend the city centre

The economic growth of ‟s-Hertogenbosch put ever greater pressure on the urban core to accommodate offices, shops and housing. From the eighties onwards, the municipality searched for possibilities to extend the urban core.

At the end of the eighties, the decision was taken to extend the urban core in a westerly direction. The challenging title given to this risky undertaking was the „leap over the railway‟. On the western side of the railway was an industrial site that had been developed around the war years. Many of the businesses that had originally occupied this site had moved in the meantime to locations that offered more space and were more accessible, and where carrying out the business was less of a nuisance for those in the immediate surroundings. Existing buildings started to become empty in the eighties, which offered perspectives for large-scale redevelopment. Fig. 1 gives a schematic view of the extension.

The main specification for redeveloping the area around the railway was to „lift‟ the inner city over the railway to create a place in the western section of that zone for city centre functions that could not be accommodated in the historic urban core due to lack of space. The location was one that offered possibilities for creating a new, high-quality urban environment, with new, high-density architecture and modern solutions. An additional specification was to create space for the new „spatial claimants‟ on the market - large-scale organisations in education, the service industries and banking - which had resulted from mergers. The functions of these organisations, as far as scale level was concerned, no longer fitted into the finely meshed parcelling of the historic urban core.

Developments in the urban core are based on such points as finely meshed parcelling, human size and scale, individual buildings, historic parcelling and street patterns. The stone size of individual buildings in the urban core forms the basis for the degree of combining different functions and joining parcels. Paying attention to appropriate use of colour and material, moulding, scale and human size, in order to maintain the desired small-scale intimacy.
Retaining a building as the base unit for a function (instead of a pre-determined maximum floor area, for example). Opposing the joining of historic buildings, so that there is sufficient differentiation between larger and smaller buildings. In principle, it is not permitted to unite two buildings into one. The unit must remain intact as far as possible.

Stimulation

Historic colours
The historic image of the streets is strongly influenced by the colours of the façades. Consistently using historic colours on woodwork, such as doors, window sills and frames ensures a recognisable character of Dutchtown colours. Owners of monuments and buildings that determine the image can be offered assistance by compiling a palette of historic colours. The historic colouring of façades of dwellings in the Protected City Image (Beschermd Stadsgezicht) is being researched and translated into a colour fan (following the example of the Dordrecht municipality). Research into the colouring (which has now disappeared or faded) of the façades of these buildings, particularly the original coloured reliefs, is being translated into concrete colour restoration projects – where possible and desirable.
Parking rates
Parking problems are an important point for attention in the policy of many cities. The steady rise in car ownership gives a temporary character to every solution that has been thought up in the past. The historic urban core can offer no more space for cars in combination with a policy that focuses on increasing the attractiveness of the area. The raise of parking rates will discourage visitors to come by car. The Amsterdam historic urban core has the highest parking rates in the world.
Restoration financial support
Many private owners of property in the historic urban core do not have sufficient financial means to renovate their property to a high standard. With regard to this, the creation of a Dutchtown Revolving Fund as a financial instrument for restoration will be investigated. Investigation will be carried out into the possibilities of an integral, more area-oriented subsidy system, besides subsidies for individual monuments and complexes. The formulation of Long-term Maintenance Programmes may be made obligatory for restorations to be subsidised. A variety of initiatives will be undertaken for this, ranging from distributing informative leaflets and expanding the website and publications to talks with owners/residents, interest groups, restoration institutions and housing associations about cultural history.
Establishing a depot for old building materials for repair work to monuments.
Empty storeys above shops
During the day, the shopping streets in the historic urban core present a lively picture, but when the shops shut their blinds at night, the street image changes starkly, with negative consequences for the quality of life and the attractiveness of the area. Reinforcing the residential function in the urban core can contribute to combating these consequences. One way of doing so is to put now empty storeys above shops to good use again. This will involve technically complex and financially difficult interventions, particularly in relation to

Public space intervention: the Breda Harbour restored

In Breda, a city of 163.500 inhabitants, plans were developed in the nineties to restore the filled-in inner harbour. Since the very beginnings of Breda, the harbour had fulfilled a function that helped determine the city‟s right to existence. 700 years after Breda was granted its city charter, it was decided in 1964 to fill in this „monument‟ in order to make the city more car-friendly.
Meeting accessibility demands in order to support the economic interests of the historic urban core was a decision that fitted the spirit of the times. However, forty years after the decision to fill in the harbour, it has been decided – once again on the grounds of economic interests – to restore the buried monument. The plans for restoring the harbour in Breda are combined with modernisation interventions. The Belvedere Memorandum refers to this type of plan as follows: „In essence, current shared opinion is that cultural history is not only worth saving, but that it also offers exciting opportunities for development whenever and wherever a synthesis can be found between the retention of existing historic values and the creation of new spatial values‟.
The **Belevedere Memorandum** is a Dutch policy document on the relationship between cultural history and spatial planning. The memorandum was published in the summer of 1999 and signed by four ministries: the ministries of Education, Culture and Science, Public Housing, Spatial Planning and the Environment, Agriculture, Nature Management and Fisheries, and Transport, Public Works and Water Management. The development plans for Breda form an illustration of the synthesis referred to in the quotation above, in a set-up where public and private parties work together.



Figure a The original harbour, transformed into a four lane road, the new 21 th century harbour and real estate development along the water

In Breda, there was agreement on:
-The importance of restoring the city‟s oldest monument
- The significance of this for the city‟s identity and competitive position
- The significance for the increase in value of land and property in the direct vicinity of the harbour.
The municipality took on by far the largest share of the costs of this intervention in the public space. The project, which was completed in 2006, needed an investment of EUR 29.5 million. During the development of plans for the restoration of the historic urban waterway, there were many discussions about authenticity. Far-reaching concessions were made in this area, particularly under pressure of financial feasibility. Identity needs were apparently satisfied to a sufficient extent through something that evokes associations with the current, socially upheld view of history. In Breda, the choice was made to return the water (the harbour as the source of Breda‟s origins) to the city – but then to the city of the 21st century.

accessibility. The municipality provides incentives for initiatives in this area, including subsidies and procedural and organisational support.

Communication/education

Intensifying education about surroundings and heritage. Knowledge about the past and the surroundings of Dutchtown will contribute to pupils‟ appreciation of their city. Central cultural historical information point for architects, urban planners, building contractors and clients. Presentation of results of archaeological and construction history research in an open depot set-up. Incidental exhibitions (construction history, archaeology or conservation of historic buildings). Publication of cultural historical magazine. Giving on-the-spot information about the location of the archaeological and construction history research. Accessible information about subsidy regulations for monuments. Giving lectures and guided tours. Permanent and semi-permanent public presentations about the results of archaeological and construction history research and conservation of historic buildings. Listing and describing spatial characteristics, valuable cultural historic elements and valuable historic green elements. Coordinating and organising an Open Monument Day. Putting Dutchtown on the map through publications.

Participation

Re design public space

Reducing „searching‟ traffic, e.g. through better street signs and better access to information about compartmentalisation and traffic flows. Making it easier to load and unload. Realising delivery routes for freight traffic to the urban core. Traffic light systems that give priority in the urban core to bikes and public transport instead of cars. Expanding the low-traffic area of the urban core. Introducing one-way traffic. Constructing attended bike sheds in the urban core. Realising a system of signs to parking garages and promoting parking garages.

Erecting urinals, creating taxi stands near entertainment areas, and ensuring socially safe lighting. Creating historic street lighting in the urban core. Existing fences, posts and basement grilles, etc. must be protected. Coherence of street furniture, in keeping with the historic image. The Urban Core Tree Preservation Society (Behoud Bomen Binnenstad) ensures an approach to planting and preserving trees that is in line with policy. Protecting city gardens, trees with preservation orders and ecologically valuable structures.

The green in the urban core does not often consist of continuous stretches of green, as is the case, for example, in post-war districts. In the urban core, there is much less grass and low greenery than elsewhere. Nevertheless, many urban cores give a green impression, which is due to the distribution of many trees over public spaces and along canals, etc.

Refurbishing squares, streets and avenues, paying attention to historic building lines, use of sustainable materials and research into historic predecessors. Choice of materials, structure and colour for road surfaces and pavements are essential for setting off monuments.

Underground refuse collection. Centrally organised graffiti control. Discouraging dog dirt, graffiti and illegal bill posting, and controlling weeds.

Attending to and maintaining the structure of canals, streets and alleyways, vacant areas (inner courtyards), building and parcel borders and premises.

Management and marketing cultural tourism
In many cities, centre management is a joint initiative by the municipality and companies in the urban core. Within that collaboration, agreements are made about management, maintenance of the public space, lighting historic buildings, street signs, advertising, character of shopping streets and promotion.
Using the characteristics of the urban core as a unique selling point and keeping in line with the municipal promotion policy to highlight the possibilities of Dutchtown.
The tourist function of the historic urban core can be reinforced by building conference facilities and expanding hotel capacity. Making space for large-scale events and festivals in and around the historic urban core. Creating new developments that link up to the cultural historical tradition. Combining the forces of cultural organisations, tourist organisations, the marketing and information branch, the municipality, and residents and (cultural) entrepreneurs, in order to strengthen cultural historical tourism. The cultural historical centre of the urban core forms the setting within which cultural tourist attractiveness is reinforced.

Out of site parking
The aim is to exchange the parking areas on public roads for parking space in constructed facilities.
The constructed facilities are often realised in the form of multi storey underground car parks just on the edge of, but outside the historic urban core.

Extend the urban core domain
Realising „overspill" locations. Here, space can be offered to functions that are too big, or have grown too big, for the historic heart of the city. In these outskirts, there is also space for high-density new buildings. In this type of initiative, the municipality can restrict itself to creating incentives for initiatives by private parties. The municipality can also choose for a more active approach. Den Bosch is a good example of this.

Strengthen the cultural function
Cultural and recreational functions will be given incentives. Cultural facilities in the urban core that focus on ethnic and cultural minorities will be promoted.
Concentrating the accommodation of cultural institutions in monumental buildings in the urban core, in order to safeguard this compact cultural experience and promote cooperation. The monuments in possession of the municipality are destined with precedence for cultural functions.

The municipality as owner and custodian of cultural heritage
Renovation of Utrecht Town Hall



Fig.c The old and new townhall in one

The town hall in Utrecht has a long history dating back several centuries. It was over 650 years ago that the government of the city of Utrecht took up residence on this spot.

In 1997, the Spanish architect Enric Miralles (1955-2000) was commissioned to create an open, transparent and accessible building. Miralles was chosen for the job mainly because of his respect for history, combined with his innovative and daring architecture. Miralles was particularly renowned for the way in which he interwove the old and the new. “The main thing is to make history readable”, he wrote himself.

Miralles created a new entrance at the back of the town hall, which gives the building two faces, as it were. The town hall has an exciting but logical structure, so that visitors and users can find their way around almost automatically. The entrance building of concrete, steel and glass spatially integrates the square behind the town hall with the town hall itself.

The public space around the town hall has been redeveloped in accordance with the architect‟s plans. Miralles‟ design has transformed the square into an outdoor space with trees and a water feature. In the road surfacing, bluestone outlines indicate where houses stood in the (distant) past. Cars are excluded as far as possible. The new wing rises up above a couple of small listed buildings, and is linked and interwoven with them. Part of the façade of the demolished part of the old town hall has been retained, and it is incorporated in the new wing. The council chamber is situated on the first floor and stretches to the ridge of the building. Here, it is clearly visible how Miralles has linked the old and the new. Open-work beamed ceilings give a view of the wooden roof boarding, and the exposed mediaeval beams, which are staggered halfway along, show that two buildings with storeys of different heights have been joined together. The inner wall of the council chamber displays a palette of materials and styles that have been used throughout the centuries: cast-iron profiles, arched windows, plasterwork sections and windows with a view onto the staircase or the new corridors.

In the building, components of constructional historical value have been re-exposed or re-used. Parts of the existing complex that were „just nice‟ have also been retained and often given a new function. For instance, old ceilings are visible in several places, as well as joists, strips of brick, old staircases, mediaeval gutters, doors and windows, and gables, etc., which have all been exposed in surprising ways.

The budget made available for the commission by the local council was EUR 13 million. In the end, the intervention cost almost EUR 20 million. An intervention that paid less attention to historical details would have been considerably cheaper.

CONCLUSIONS

- In most policy reports there is no clear distinction between what generally is seen as the historic urban core and what generally is seen as the city centre. In almost all the policy reports the focus is on the city centre, which covers a bigger area then the historic urban core.
- The time scope municipalities use in their policy reports to specify their future vision is very different, most of the times very short and sometimes they cover several decennia and everything in between. Most of the reports have a time scope of about ten years. That is short regarding the time that is involved in making functional and spatial changes in the core.
- The visions are not formulated in terms of the future function of the historic urban core within the context of the city as a whole, referring to the interaction between the different areas that together form the city. However the urban core is seen by all the cities involved in this analysis as their flag ship, especially aiming for the interest of the pedestrian cultural tourist.
- The characteristics and significance of the historic urban core are described in "soft specifications" like for example "unity in diversity". That kind of specification cannot be used as operational assessment criterion for interventions in the historic urban core.
- The same problem occurs when taking a closer look at the objectives. For example the objective of "Keeping the city"s history readable and reinforcing it where possible" will awake a large number of different meanings given by different people. Most people can read a book but only a few learned how to read a cities history.
- In many municipal policy documents, there is a lack of specification of measures that would give a concrete dimension to the strategies. The measures are still often formulated in terms of goals and good intentions.
- Most municipalities use a one track strategy. There are not alternative strategies presented as taken into consideration. There are no future scenarios, describing the scope of the possible future context for the strategies, taken into account. What we see is a single strategy approach placed in the context of a single scenario future. It is evident that taking a time scope of about ten years the approach with future scenarios does not fit with the objectives. The future developments used as a context for the strategy can be seen as a projection of trends that characterize the actual situation. Big changes in the future context, like the credit crunch or something likewise, have not been taking into account. What we see is a single strategy approach placed in the context of a single short term scenario future. Because of that approach the strategy (s) are not tested on their „strategic response capability"
- The focus of the municipality is on modifications in the public space and on marketing, aiming for the attention of the on culture oriented tourist.
- The financial feasibility is always a major criteria. Despite this decisive importance strategies very seldom have a financial paragraph in which is worked out what figure there is on the bill to pay and who is paying which part of that bill. In specifying the policy set out in the memoranda for the future of the historic urban core, local councils do not immediately take on long-term financial obligations that go further than what comes under regular expenses. Specific project-related investments are included separately in the political decisions.
- Investments by local councils for specific projects in the historic urban core are implicitly legitimised from the point of view of common interest. Participation by the local government in these projects is in most cases not financial profitable for the municipality. Local politicians use arguments related to the common interest for the city to legitimize

the input of tax payers money. That implicates that there needs to be a positive social attitude for giving priority to investments that support the quality and attractiveness of the historic urban core.

Based on the analysis and conclusions drawn from that, a need can be detected for an adequate theoretical framework for local government future strategies for the (Dutch) historic urban core

Following the ingredients from which a strategy is build up, being also the ingeredients for the theoretical framework:

1. A vision in which the future social economic function of the historic urban core in the context of the city as a whole is stipulated
2. The objectives, which make the rather abstract vision more concrete.
3. The means, which describe the kind of activities the local government will initiate in order to meet their own objectives.
4. Criteria. The characteristics and significance of the historic urban core and the objectives for the future of the historic urban core are often described in "soft specifications" . That kind of specification cannot be used as operational criteria in which a strategy can be formulated and assessed on forehand and tested on its effects later on.
5. Strategic response capability in the context of different future scenarios. Most municipalities use a one track strategy. There are not alternative strategies presented as taken into consideration. There are no future scenarios, describing the scope of the possible future context for the strategies, taken into account. What we see is a single strategy approach placed in the context of a single scenario future.
6. Cost and benefit. The financial feasibility is always a major criteria. Related to the social economic function of the historic urban core and related to the content of the proposed strategy a cost benefit analysis should be part of the framework.

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BALANCING BETWEEN FEASIBILITY AND RELATIONSHIP. INTERVENTIONS TO PREVENT DYSFUNCTIONALITY OF CONFLICT IN PUBLIC PRIVATE PARTNERSHIP PROJECTS.

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Abstract

Research shows that there are many bottle-necks in Public Private Partnership (PPP) Projects in Dutch spatial development. Due to the specific properties of Public Private Partnerships, these bottle-necks can lead to dysfunctional conflicts which are damaging the project. Hence the question is: how to prevent these conflicts?
Literature doesn't answer this question on an operational level in the context of a PPP project in spatial development. So ten cases of PPP in spatial development are selected in which a conflict escalated in a way that the existence of the project was on the edge. The research strategy is to compare cases in a cooperative climate with cases in a competitive climate. Data are collected by interviewing representatives of the public side as well of the private side. Analyzing the data, several interventions are found. Analysis shows that in a cooperative climate a rich variety of interventions is used, while in a competitive climate the interventions are limited. The analysis also shows that in a competitive climate interventions are more focused on the relationship between the partners than on feasibility, while in a cooperative climate both aspects are equally attended.
Regardless of a cooperative or a competitive climate, the interventions found are concerning the feasibility of the project or the relation between actors. One moment it proves to be necessary to emphasize feasibility and the other moment the relationship. Therefore it is concluded that in spatial development dysfunctional conflicts in PPP projects can be prevented by balancing between feasibility and relationship. As such this research contributes to organizing collaboration.

Keywords: interventions, dysfunctionality, conflict, public private partnership, spatial development.

INTRODUCTION

Public Private Partnership in The Netherlands started a long time ago. „The Verenigde Oost-Indische Compagnie (VOC), founded in march 1602, was already an example of Public Private Partnership in The Netherlands. The city of Amsterdam participated for more than 50 % in the risk-bearing capital of the VOC at the time of its foundation and the VOC was involved directly in the lay-out of the city.“ (Bult Spiering 2003: 8). Since then Public Private Partnership in The Netherlands has had from time to time many applications, e.g. in rebuilding the country after World War II, but it became regular after the use of the concept in the coalition agreement of the Dutch government in 1986. Two kinds of PPP in the

building industry evolved: projects with or without shared risk-bearing investments. An example of the first kind is an area development in which the price of the land to be paid to the public side is made dependent of the price of the real estate on it, to be paid by the market. An example of the second kind is in which the public side as a client drafts a contract with a private party about the Designing Building Financing Maintaining and sometimes also Operating, in short DBFM-O contracts, of e.g. a high way or a school building. Different from other countries as the UK, Germany, France or the USA, PPP projects with a shared risk-bearing investment has become a regularity in the Netherlands. The cause of this sometimes is located in institutional constraints. In the UK for example the public side is only by special allowance permitted to take part in Public Private Partnerships when it is possible that market-risks will be within the public realm and in the United States there is a stringent separation between Public and Private (Hobma, 2008: 7). Yet, still PPP projects with a shared financial risk appear in the UK as well is the USA, e.g. in joint venture projects as the Docklands in the UK and Baltimore or Portland in the USA (Bult-Spiering, 2008: 134-172). This article is only concerning PPP projects with shared risk-bearing investments; PPP projects in spatial development, where spatial development projects encloses projects in area development, infra structural projects and real estate projects. Because bottle neck research shows that the most and most intense bottle necks appear in the phases prior to the realization or construction contract (De Vries et al, 2003 en Dol et al, 2005, 2007), the case research at hand is limited to these phases.

FROM BOTTLE NECKS TO DYSFUNCTIONAL CONFLICTS

Research shows that many bottle-necks do occur in PPP projects in Dutch spatial development (Lousberg, 2009). Examples of these bottle-necks are:
- conflict of interest: public interest of quality versus private interest of profit (Spiering et al, 2001: 18);
- public decision making & procedures (Blanken et al, 2004: 41);
- in some practices, policy rhetoric instead of policy urgency is at hand (Van Rooy, 2009: 104-126, comp. Flyvbjerg et al, 2003).

A question is whether these bottle-necks can lead to dysfunctional conflicts.

What a conflict is or what a dysfunctional conflict is, is normative. It depends on what is considered as a problem. In this article a dysfunctional conflict is defined as a conflict in which, although parties involved want otherwise:
- no result is achieved that is shared and desired by all (compare Duke et al, 2004: 169);
- winning or losing becomes the key question (De Dreu, 2005: 77, 48);
- an unwanted delay or breaking up of the relationship occurs that is detrimental to the project.

Four indications of a relationship between bottle-necks and dysfunctional conflicts are found in literature.

First, due to sharing market risks, one of the most important properties of PPP projects in spatial development is uncertainty. In uncertain situations assumptions, defined as fact and values, play an important role and are affiliated closely with a belief that is emotionally

charged (Weick, 1995: 114). In an uncertain situation compared to a stabile context there it is more likely that a conflict becomes social-emotional (Schruijer, 2007: 208, De Dreu, 2005:71, 72). Second, PPP projects in spatial development are ambiguous (Teisman, 2004: 14). By lack of objective criteria in ambiguous situations players with a different orientation on values rely on more personal or professional values while making sense of the situation. The clash of the different values often charges the situation politically and emotionally (Weick, 1995: 93).
Third, PPP-projects in spatial development are characterized by social diversity of public and private parties (Van der Meij et al, 2000:39, Bult-Spiering, 2003: 260, Karré et al, 2007: 192). Social diversity, defined as different in social terms: demographic properties, value systems determined by culture, religious convictions etc. enhance the possibility of social emotional conflict (De Dreu, 2005: 112, Pinto, 2004: 208).
Finally, in a business context social-emotional conflicts are dysfunctional (Robbins et al, 2010: 263).

These indications suggest that in the context of Public Private Partnerships in spatial development, bottle-necks can lead to dysfunctional conflicts which damage the project. Hence the question is: which interventions are used in practice to prevent dysfunctional conflict in PPP projects in spatial development?

IN SEARCH FOR INTERVENTIONS

Intervening is defined as one or a series of planned activities for change that are directed on increasing the effectiveness of an organization (De Caluwé et al, 2009); in this research interventions are defined as one or a series of planned activities on an operational level that in the interest of the project try to prevent a conflict becoming dysfunctional. In search for such interventions a rigorous and comprehensive literature study was conducted (Lousberg, 2009). Covering ground that has been covered many times before was expected. It did only partly. What was missing was a description of the interventions on an operational level specific in the context of a PPP project in spatial development. Time for a case study.

SELECTION OF THE CASES

The case study was conducted in 2009. Because of their expertise, more than 20 professionals were asked if they knew PPP cases in spatial development in which a conflict on feasibility escalated in such a way that the very existence of the project had been on the edge.

The earlier mentioned literature study indicated that in studying negotiations and conflict it is important to make a distinction between a competitive climate (group A) and a cooperative climate (group B) (compare Tjosvold, 1998). Comparing interventions in opposed conditions holds research findings more robust as far as a finding in one condition is not found in the other one (comp. Yin, 2003: 47). So the goal was to select cases with a cooperative climate as well as cases with a competitive climate.
A minimum of two to three cases in each group was required (Yin, 2003: 47) in order to make comparison between cases within a group possible (Yin, 2003: 51).

Twelve cases were recommended by experts after an extensive exploration, even after contacting relations of these experts no further cases were found. Out of these twelve, two cases were rejected; they didn‟t match the requested profile. So ten cases were left. Using the criterion that the respondent from the public side should agree on the qualification of the climate with the respondent on the private side, one case was undefined, one appeared to have an average climate, two cases appeared to have a competitive climate and six a cooperative climate.

RESEARCH PHASES

The case study consists of three phases: Setting up the list of questions, Field work and Analysis.

Phase 1: Setting up the list of questions

The list of questions is structured in three parts:

- The first intended to check whether it is a suitable case;
- In the second part questions are as open as possible and broadly oriented in order to get the picture as complete as possible;
- The third part is directed in detail and made of closed questions.

Phase 2: Field work

In phase two the cases are examined by interviewing key role players:

- First in a number of telephone calls it was figured out who these key role players were;
- Next two, or in a single case three, interviews were conducted in order to gain insight in the circumstances under which the conflict threatened to become dysfunctional and to gain insight in what was done to prevent an escalation;
- Finally transcripts of the interviews were made. On the base of that case descriptions were made. These descriptions were send to the participants for approval.

Phase 3: Analysis

The analysis of the response to the control questions consisted of checking the response on the requirement that this was a case of PPP in spatial development in which a conflict on feasibility escalated in a way that the existence of the project was on the edge.

Analysis of the response to the open questions was focused on essences and not on patterns in or relations between concepts that were used in the answer. Therefore a method was used that consisted of tracing the essences in the answers by underlining text fragments, summarize these and interpret this summary on used interventions. As indicated before an intervention is defined as one or a series of activities on an operational level that in the interest of the project try to prevent a conflict becoming dysfunctional.

The analysis of the response to the closed questions consisted of qualification in terms of Yes, No, +, +/- and -.

The research strategy was to compare cases, so a cross case analysis was conducted. This cross case analysis was based on the data of a single case analysis. The single case analysis is described first.

Because of the limited number of pages of this article, only two out of the ten cases are presented here. They represent two extremes in the spectrum of possible climates: one case in a competitive climate and one case in a cooperative climate.

SINGLE CASE ANALYSIS

The response to the control questions in the first part of the interviews confirms that the cases match the requested profile. The response to the second part of the interviews is presented below. The answers to the third part of the interviews, the closed questions, will be attended in the cross case analysis next to this single case analysis.

The case in a competitive climate

Project and Public Private Partnership
A mid-sized municipality in the Netherlands decides in the nineties to transform the existing center into a modern center attractive to inhabitants of the city and the region. Goal is to unite two areas that are divided by urban barriers. The municipality organizes a competition that is won by a project developer. The first phase of the project requires 150 million euro‟s on investment. The case is restricted to the period prior to the moment of the actual development agreement, early 2000.
Together with relevant parties, including the developer and the investor, the municipality commissioned an architect to design a plan. This plan not only included urban, financial and legal affairs but also the way in which all parties cooperate. At the end of the project the bill will be settled with money left over from subtracting costs from revenues paid by the market. No PPP legal entity is at hand, but a PPP wherein public revenues on land are dependent of private revenues on selling real estate on this land.

Heart of the conflict and escalation
The municipality: „It went wrong in the phase that we had to agree based on a base amount. And we didn‟t agree on this base amount(-). Originally it were some millions, but in the end it was two hundred thousand euro‟s.‟ The developer noticed: „Two hundred thousand euro‟s, you can call that no conflict. But it was a kind of escalation of a long lasting mutual irritation‟.

De developer continues on how the conflict escalated: ‟It was a kind of escalation of a very long process in which we felt: “Guys, this is the limit, it‟s not possible any more, the project won‟t last any longer”. And a municipality that continued to say: “And this has to be added, and that has to be added, and those have also to be added”, anyway that was our perspective. So finally we visited that restaurant, were it escalated. I‟ve never been so angry in my career! A special moment anyway…‟.
The municipality: „We went with a complete delegation from here to eat elsewhere and that didn‟t work: we didn‟t succeeded in any way. Of course we had informed our alderman extensively, but he interpreted it all much to literally. His stake was: “They won‟t get these

two hundred thousand euro‟s!" and he really went to sit on it; he said: "You are really delivering these two hundred thousand, or the cooperation is over!" Yeah, really, it almost went out of control. Finally it was "If you don‟t call me tomorrow morning before half past eight and agree, you will be kicked out!".‟

Analysis of the response to the open questions
Besides general questions about the project and the conflict, four open questions were asked:

1. What was the climate for cooperation over time and how was this created?
2. What actions took place in the realm of feasibility?
3. What actions took place in the realm of the relationship?
4. What actions were taken in order to proceed succesfully?

In the tables below in the first column it is indicated whether a response is given by the Municipality (M) or the Developer (D). In the second column the response to the questions is presented, the essences are shown in italics. In the third column these essences are summarized and, if possible, interpreted as interventions. Interventions are defined as one or a series of activities on an operational level that in the interest of the project try to prevent a dysfunctional conflict (compare De Caluwé et al, 2009).
To make the summary retraceable, it is placed directly beside the essences in italics. In the summary interventions are shown in bold.

The table with the response on the open questions is followed by a table with the response on the closed questions.

	Question 1: What was the climate for cooperation over time and how was this created?	Summarized and interpreted
M	„*Difficult*‟(-) It‟s totally not, it‟s not filled with hatred. But it is sometimes like "Come on, *it really annoys me now*. I‟ve given you all the arguments *that I can think of why I am right and so why you are really wrong", well at that moment sometimes you get irritations".* And on how this was created: „With some developers you agree within a couple of months and that means that you don‟t diverge much of what you have estimated. With other developers it‟s not the same. My lifelong experience with this developer, also from my earlier period, is quite simple: *it goes on and on and on*. According to me it has to do something with the instructions the project staff receives: *"Get the most out of it".*	Tending to competitive by endless efforts to get the utmost out of it
D	„We had, as we experienced it, *a difficult relationship with the municipality.* We *never had a real ambition together* for the plan (-). No, it wasn‟t easy.‟ And on how this was created: „We came closer and closer to that 26 [the deficit]. Always in very tiny steps. And that gave me with this boss very much the feeling of "how can I turn the ship". Sometimes one has also a feeling of lack of power, of not performing well. *We didn"t have something in common, in a sense of: "Let"s do a project together".‟*	Doubtful by a lack of shared ambition

Question 2: What actions took place in the realm of feasibility?		Summarized and interpreted
M	„We always start with a land development sheet. There we fill in the numbers on the revenue side. We then thus hear that this is way too high. All the parameters that are in there, they are *all subject of negotiation.* But then *in the end* on the base of the design, *the cost side dominates*.“	Factors that determine the revenues are negotiable. Discussion finally focuses on the cost side.
O	„It went very much into *detail*. It went along with a large mutual *distrust*. We often said: "This cost about this and this cost about that and then it"s ok" but the municipality they went to sort it out, all details. This fed also a little bit the *distrust* of the municipality as a kind of *"They take it all too easy"*.“	Mutual distrust fed by nonchalance on costs.

Question 3: What actions took place in the realm of the relationship?		Summarized and interpreted
M	„I"ve always learned one thing: (-) if you just talk on a relaxed level, things really go well. And that needs *organizing a climat* and that, also with this alderman, and that absolutely doesn"t always has to be a negotiation. It"s much more fun to get together once in a while. *There must evolve a certain relation and trust between people* and hence everyone that"s sitting there has a certain responsibility to arrange things in a way that what we do agree on. *Only, what you see with developers is that this level between the operational and policy or management part, that it"s unbelievable how far these levels do diverge.* On a certain level *beautiful deals are made and the people that are under it, it"s their cup of tea to execute it. But they get targets…you"ll get sick of* . That"s something that"s never discussed up there, really, but anyhow, it"s not possible to exclude that a war is going on here. *It"s really always the interaction between people that determines whether it"s going to work or it is damned to die.*“	**Informal contact** is needed to generate trust The level of trust differs per level of position due to targets. Working together as a critical factor of success
D	*„Not"*	Not

Question 4. What actions were taken in order to proceed succesfully?		Summarized and interpreted
M	„Meeting off side. In the official meeting it"s tough, and then you think: "this is not getting us anywhere". Next you just take them apart and try to give the other party insight in: "If we stay as stubborn as we are now, the cooperation will be over".“ And specifically on the conflict: „So what happens the next day [after the conflict in the restaurant] before half past eight, or around half past eight, the developer called: "Ok, we do agree".“	In general: **Informal contact** During the conflict: **Give in**
D	„Honestly I think that we didn"t manage the relationship with the municipality at all. *We have more looked outside the municipality* in order to get things right, than to improve the relationship with the municipality. I might admit.“	Geen

The case in a cooperative climate

Project and Public Private Partnership
The case is the development of an area of a big city in the Netherlands. It‟s about 650 houses with an estimated investment of 200 million euro‟s. The private parties were involved through an European tender during the nineties. Finally two developers joined together, an investor and a housing association represented by one project executive: the Developer. The public side is also represented by a project executive; in the following indicated as the Municipality. The case itself is around 2005/2006, in the final stage of contract negotiations.

How risks were divided among themselves is reflected in the following quote: „It‟s rather simple, normally we say: we deliver the prepared land, we equip the public area and take care of the legal and urban procedures. And they take care of the realization of the houses according to specifications that we agreed on. You design an urban plan, we made it together, but it is up to him to really meet the urban profiles of the that we agreed on. Also the number and the categories of houses that we agreed on. These are mainly houses, so normally a municipality has a certain system that means that the price for the land is what is left in the end after selling the houses and other buildings. Here it is different, we did it normatively. We say, yes, of course you can pump up the building costs as much as you want, but this is the price we need for the land. Because we know what happens, otherwise calculations will be so expensive that no price for the land is left.‟ Just as in the former case, in this PPP there is no legal entity for the project wherein risks and revenues are taken public as well as private, but there is a PPP in which public revenues finally are dependent on private revenues.

Escalation and heart of the conflict
The municipality on how the conflict almost escalated: „The first phase was when the developer was just indoors and immediately started about the price for the land. He immediately started a discussion about the senselessness of the way that we calculate this price for the land. I said “we do it in our own way” and he said “that‟s nonsense, you really have to do it non-normative, you really don‟t understand how it works”...well, that‟s not a sensible remark in the beginning.‟

According to the developer the heart of the conflict was in: „We were stuck. We say we are waiting for the non-normative price, they say normative. They say the revenues must be that much, we say it‟s impossible. They say it has to be like this, we say it has to be different.‟ And according to the municipality: „Well, the heart of the conflict was that we estimated their possibility for profit much higher than they did and that they on the other side of course estimated our costs far too low.‟

Analysis of the response to the open questions

Question 1: What was the climate for cooperation over time and how was this created?		Summarized and interpreted
M	„It was *cooperative* (-) There are a few things you can‟t exactly describe, it‟s about *chemistry between people*, that was part of it. Once I had to attend a meeting somewhere in Rotterdam en the developer,	Cooperative by chemistry between people and by

	he lived in Rotterdam. When he heard that I had to go to Rotterdam and that I had my return trip arranged, but not getting there…well, he said "we drive together then and eat something en route". *Than the conversation is about other things…you don"t talk immediately about your work.* That was a very important moment, *…if you only talk to them during meetings, things go wrong.* (-) On the other hand…the municipality is under magnifying glasses; it"s of course *not possible to make hole-and-corner arrangements.* That"s the other side, but what I sometimes observe is that people keep distance out of fear, that occurs. I"m not going to eat with a developer, that"s nonsense. The only thing I can do is to pay my own bill. It"s that simple".	cautious informal contact
D	„*Well, very nice*(-) We"ve had our moments, if I"m honest, but finally it proves to be *that the will to do it together, that settles it.* The climate was influenced at that time by the will of both sides to be successful and after that moment the climate was also very cooperative. A very positive mutual respect evolved and understanding of each other interests (-) The representative of the municipality had of course his political bosses and I had my bosses; that gave a strong relation, as in: "*I'll get by to drink a cup of coffee or when we had a meeting. I"llget by half an hour earlier, is that possible…"* and then also say "but when I do this I"m in that much trouble…that I won"t do", but the representative of the municipality also said: "Yes, I"m stuck here with politics and I do understand that we can"t go any faster, but what can we do next?" What matters is that you *create understanding with the other party* for the problems that you have and vice versa."	Cooperative by the will to cooperate and by informal contact create understanding

Question 2: What actions took place in the realm of feasibility?		Summarized and interpreted
M	„Working on feasibility was making transparent the *cost* side to the municipality and to *give the other party insight* into that and offering them the opportunity to do it cheaper as a matter of fact."	Discussion focuses on the cost side and the back grounds of it
D	„We *negotiated the price of the land* of course. I went through calculations again and again and I thought…the municipality is *exaggerating immensely"*	During conflict negotiating on the price of the land

Question 3: What actions took place in the realm of the relationship?		Summarized and interpreted
M	„You can"t sincerely work *together if the personal relationship is poor.* What is convenient for later negotiations, is that *the business side is connected with the personal side.* So *the art is to do this business side as sharp as possible without a nasty way of talking getting the upper hand*. So you build a relationship in order to make a shared plan. That"s what I mean with the social side…practical things…*you have to visit together things, preparation of the project*...when you	A good relationship as pre condition for cooperation, connecting the business side with the personal, negotiate on the edge in a friendly way and work together on a shared plan. Building a relationship by **Co operation**

	have done all this you can negotiate on the edge. ‟	
O	„By talking, *by understanding what their problem is e*n what we can do…so by creating a common ground…by *creating a shared problem.* So we have searched very consciously in order to find a solution. What we have orientated on is *to keep our relationship balanced,* it‟s also a part of peoples characters, I suppose. As a matter of fact we *appreciated each other* very much in the role we had, so we did *understand* each other.	By understanding the problem of the other party as **Creating a shared problem and solve it**. Next keeping relationship balanced. Appreciation of each other‟s role as pre condition for understanding

Question 4. What actions were taken in order to proceed successfully?		Summarized and interpreted
M	„If you have a difference in price as large as we had….with a difference of 10 million on a sum of 37, that‟s rather dramatic…what you do once again is to *explore things* in a total different way…you investigate *what else you can come up* with…because these 37 million that we asked as the price for the land, were equal to our costs in his case. So my proposition was…as a municipality *we are not going to lose on this one,* as simple as that…this is the end. And in a way this was reasonable. They didn‟t think so and a discussion emerged: "Yes, but we have *done also some calculations* and we think that 37 million is an awful lot of money". Municipalities usually don‟t give any insight in their calculations. We said "*If you can do it for less*…it‟s negotiable". Then they recalculated everything and said: "we think that we can do it for 27 million and then we are even".‟	During conflict: **Confrontation** and **Exploration** **BAWA** - Best Alternative Without an Agreement (Fisher et al, 2004: 123) **Offering an alternative**
D	„I said to my colleague: "If it‟s up to me we are going to tell them tomorrow that we take over, that we take the risk. We have looked very well into it and we want to help you by taking over the risk of developing the land".‟	During conflict: **Taking over the risk of the other party**

CROSS CASE ANALYSIS

Above, two examples were given of how the ten cases were analyzed. In analyzing the ten cases several interventions were traced. Cross case analysis started with making an inventory of the interventions that took place in a cooperative climate next to interventions in a competitive climate and labeling the interventions as concerning feasibility or the relationship, see figure 1.

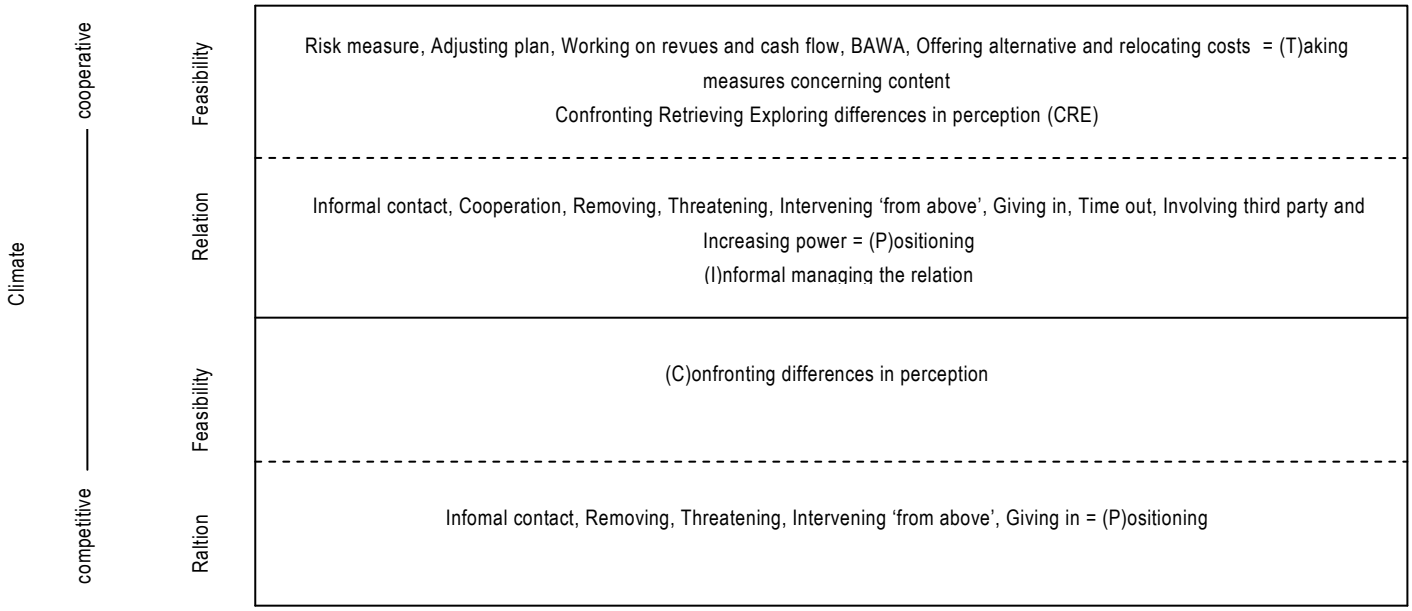


Figure 1: *aced in the case study.*

The figure shows that in a cooperative climate a rich variety of interventions is used, while in a competitive climate the interventions are limited.
It is remarkable that, contrary to a cooperative climate, in the competitive climate only one intervention is found concerning feasibility, namely Confrontation of differences in perception, and several concerning the relationship, namely Informal contact and Threatening, Giving in, Intervening „from above" and Removing. In a competitive climate attention seems to be more directed towards relationship than feasibility.

So, analysis shows that in a competitive climate interventions are more focused on the relationship between the partners than on feasibility, while in a cooperative climate both aspects are equally attended.

Next, the interventions will be described by examples as found in the case study.

Interventions in a cooperative climate
The figure shows that in a cooperative climate intervening in feasibility contributes to preventing a dysfunctional conflict by:

- Taking risk measures such as converting an investment that is depending on revenues to a guaranteed investment or by taking over the risk from the other party;
- Adjustment of the quality or quantity of the plan such as transforming it to other functions or adjusting the number of houses;
- Working on the revenues and the cash flow such as increasing the quality of the houses in favor of the revenues or speeding up the cash flow because of reduction of the cost of interest;
- Prior to the negotiations determining a Best Alternative Without an Agreement (BAWA) (Fisher, 2004: 123) such as cancelling the project if no agreement is

reached;
- Offering alternatives as taking over preparing the land from the other party;
- Relocating costs as cut backs or increasing the price of the land.

In short: by (T)aking measures concerning content (see the figure).

Further Confronting Retrieving and Exploring of differences in perception on feasibility (CRE) proves to be contributing to the prevention of a dysfunctional conflict.

Intervening in the relationship also proves to be contributing to the prevention of a dysfunctional conflict in a cooperative climate by:

- Having informal contact prior to a meeting in order to elaborate on political back grounds of points of view or to brain storm about possible solutions;
- Cooperation such as making a shared problem statement or sketching a plan together;
- If it appears to be necessary: removing a party that undermines the cooperation by reasoning solely from his own interest;
- Threatening such as threatening with the possibility that if negotiations fail the whole project will be taken over or threatening with negative publicity.
- Intervening „from above" such as convincing a minister to make a telephone call to the CEO of the other party;
- Giving in as a way of investing in the continuance of the relationship in the future;
- Taking a Time out in order to give the parties involved a chance to reconsider;
- Involving a third party when negotiations have reached a deadlock such as a mediator or not deciding by yourself but letting your backing decide;
- In case of an unbalance in power giving one of the parties more or less power in order to restore the balance.

In short: by (P)ositioning.

Finally in a cooperative climate it proves to be that preventing a dysfunctional conflict coincides with private conversations, calling at the end of the day in order to coordinate and tune fine, prior to negotiations meet informal, call sometimes in between hours to test ideas, sitting apart for a minute or celebrating mile stones together; in short: by managing the relationship (I)nformal.

Interventions in a competitive climate

In a competitive climate regarding the intervention Confronting Retrieving and Exploring of differences in perception on feasibility (CRE) only the (C)onfrontation of differences in perception takes place, no Retrieving of back grounds or Exploration.

Concerning the relation in a competitive climate partly the same interventions as in a cooperative climate occur, namely Informal contact, Threatening, Giving in and Intervening „from above", all part of (P)ositioning.

CONCLUSION

The research question for this case study was: which interventions are used in practice to prevent dysfunctional conflict in PPP projects in spatial development?

Analysis shows that in practice the interventions (T)aking measures concerning content, Confronting Retrieving and Exploring of differences in perception of feasibility (CRE), (P)ositioning and managing the relationship (I)nformal contribute to the prevention of dysfunctional conflicts. Further, the prevention of a dysfunctional conflict cannot exclusively be related to a cooperative climate, but in a competitive climate the interventions (C)onfronting differences in perception on feasibility and (P)ositioning can also prevent dysfunctional conflicts.

Regardless of a cooperative or a competitive climate, the interventions found are concerning the feasibility of the project or the relation between actors. One moment it proves to be necessary to emphasize feasibility and the other moment the relationship. Therefore it is concluded that in spatial development dysfunctional conflicts in PPP projects can be prevented by balancing between feasibility and relationship. As such it contributes to organizing collaboration.

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FOSTERING AN ENVIRONMENTALLY RESPONSIVE INDUSTRY – A PUBLIC SECTOR CASE STUDY FROM HONG KONG

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Abstract

Well meaning high-level construction industry reviews, and recommendations from those reviews, usually lead to many industry development initiatives. Promoting a safer work place and environmentally responsible industry was one of the seven themes under which recommendations were made in Construction Industry Review Committee (CIRC) Report of 2001 of Hong Kong. These were followed with many related initiatives for industry development by industry stakeholders. The findings reported here are part (limited in focus to environmental responsiveness of construction industry) of a wider research project titled 'Construction Industry Development Comparison and Acceleration' (CIDCA) designed to track implementation programmes against the original objectives in the CIRC report and some changing priorities thereafter, actual achievements, drivers, enablers and barriers, residual issues and concerns; in comparison with UK and Singapore scenarios in interlocking studies.

The original CIRC recommendations laid the responsibility of promoting an environmentally responsible industry on public sector agencies with an assumption that the private sector would follow suit. In this regard, a case study of a proactive public sector client was conducted. The data from the case study was supplemented with interviews with key personnel from other stakeholder organisations. The findings reported here identify environmentally responsive initiatives from the case study and isolate high impact initiatives among them. Their implementation is tracked and their impact on the rest of the industry is analysed. Also, key challenges and enablers/ barriers are identified in terms of achieving (i) desired results within the organisation and (ii) desired impact on the industry. Lessons learnt are then discussed with an emphasis on transforming innovative initiatives into acceptable industry norms. The reported findings though specific to the Hong Kong Construction Industry should provide pointers on implementing public sector led initiatives for other countries.

Keywords: Environmentally Responsible Construction Industry, Industry Development Initiatives, Public Sector

BACKGROUND

Despite the recent surge in international focus and universal aspirations, „reduced environmental impact" and „sustainability" are phrases that still trigger apprehensions in many construction contractors, as these are still associated with added and non-reimbursable costs. This is especially true in the private sector where project schedule acceleration and profit generation remain the primary drivers. An effective solution to this problem, as well as a way to gradually change the mindset and culture of the industry, is to have a sufficiently influential public client leading the new initiatives, as a catalyst and test-bed.

Triggered by some ethical and quality control related issues in the Hong Kong construction industry in the late 1990's, a government directed, comprehensive industry review was conducted by Construction Industry Review Committee (CIRC). The review report (CIRC, 2001) made 109 recommendations under seven themes, one of which was promoting a „safer workplace and an environmentally responsible industry". Under this theme, many recommendations advocated a more environmentally responsible industry, with specific recommendations tailored for public sector clients, whom it was expected would become a leading example and catalyze the industry in general.

In this regard, this paper presents interim findings from a case study which targeted one of the leading public sector clients entrusted with championing environmental initiatives in Hong Kong for the construction industry. This case study was part (being limited to environmental responsiveness of construction industry) of a wider research project titled „Construction Industry Development Comparison and Acceleration" (CIDCA) designed to track implementation programmes against the original objectives in the CIRC report and some changing priorities thereafter, actual achievements, drivers, enablers and barriers, residual issues and concerns; in comparison with UK and Singapore scenarios in interlocking studies.

INTRODUCTION TO CASE STUDY

The CIRC report advocated championing of select themes by select public sector clients as mentioned earlier. The case study presented here is of one such public sector client (termed as PSC hereafter). The strategies suggested in the report for championing the themes were to incentivise the adoption of initiatives as well as to link the procurement (tendering opportunities) to adoption and performance of these initiatives by contractors. It has to be noted here that environmental responsiveness initiatives are long term objectives and hence need to be championed for a longer term to demonstrate their impact. Also, they are often not in the commercial interests of the contractor if they are cost intensive and non-reimbursable. From partnering experiences in construction industry (Bennet & Jayes 1995, 1998; Barlow et. al. 1997), it has been demonstrated that in aligning long term adversarial goals, sustainable workload (continuity of work) is the key, along with economy of scale. In this regard, the selected PSC appropriately fits the bill as it is mandated to provide housing for the economically weaker sections of the society, hence a continuous and steady work flow in their domain.

CASE STUDY METHODOLOGY

The methodology followed for this case study was the same as for the other case studies for the wider research project mentioned above. The target institution for the case was identified first, following which the case study was conducted in three stages as described below:

Stage 1: Setting up the Case Study Agenda - This stage consisted of an initial meeting with a few key representatives of the target institution. For this meeting, a list of initiatives that that the research team was aware of as having been implemented and were directly/ indirectly linked to the HK construction industry self improvement initiatives was sent in advance. Target institutions representatives were asked to supplement the items on our list if required, and help us identify a few (3 or 4) initiatives that were perceived as having achieved high degrees of positive impact. In addition, other key personnel from the institution who were involved in implementing these high impact initiatives were identified as possible interviewees for the next stage.

Stage 2: Series of individual interviews on identified high impact initiatives - This was to delve deeper into these initiatives. A series of interviews with personnel identified in the first meeting were set up at convenient times for them, to track how the initiatives were implemented, identify barriers to implementing them and strategies used to overcome these etc. In this stage, access to relevant data in the form of documents, statistics etc was also requested.

Stage 3: Case Study Report Preparation - In this stage data collected from above was analyzed and a report prepared.

The following sections describe the key initiatives identified in the case study, their implementation process and impact on the general industry and discuss the key challenges and drivers in implementing them.

KEY INITIATIVES IMPLEMENTED

Life Cycle Strategies

The CIRC report recommends that PSC‟s are to take a lead in practicing life-cycle costing strategies. Following the CIRC report, the PSC published its very own Environmental Procurement Policies in the same year, seeking to minimize the use of natural resources in main building components and materials. A consultancy study on life cycle costing (LCC) and life cycle analysis (LCA) of various building materials (as well as their respective alternative materials) frequently used in housing projects was completed in 2004. As a result, an in-house database and technical guidelines of the major building materials for the PSC‟s projects was established. A procurement strategy and specifications for more environmentally friendly materials, which are technically and economically viable was also developed (HKHA 2010a).

Based on the study, a software tool for selecting construction materials in terms of LCC/LCA, waste generation, energy consumption as well as environmental impact was made available free of charge to the industry in 2005. Several other public sector bodies have made use of this tool in the design stages of four pilot projects to examine its effectiveness and practicality,

which are currently being reviewed by the industry. The adoption of the LCC/LCA scheme not only aids the designers in project planning stage, but will also offer value for occupants especially in the Hong Kong housing market. The PSC is also responsible for maintenance of its assets. Thus the long term economical values and durability are decisive factors from its perspective. The finished products which utilized LCC/LCA material selection tool have also played an educational role in advising the general public about the environmental and economical benefits from adopting selected building materials. It was hoped that this demonstrated the advantages of adopting this approach to the private sector developers and that they would follow similar LCC/LCA strategies to attract buyer‟s who are concerned with quality products, and long term value for money.

However, the existing database does not fully address the long term strategic directives of the PSC in terms of having a comprehensive performance and economic appraisal/ assessment for many alternative building materials. Such a database requires a full life cycle monitoring and assessment (both financially and environmentally) of the material performance, in which case it must span long periods of time before the result can be obtained. As construction materials vary greatly in substance, function, sophistication and method of construction, an universal LCA assessment methodology has been difficult to establish. Internationally, although countries have developed their own LCA tools, very few of them have linked LCC module (with updated cost information). The highly fluctuating construction material costs require any particular LCC software tool to be updated actively at least monthly to the most current market prices of materials, which again can be difficult (HKHA, 2005).

Recycling and Waste Minimisation

The CIRC report recommends the public sector clients to take a lead in promoting wider use of recycled materials for new construction projects. In recent years, a greater amount of building waste from redevelopment projects is being recycled in construction. The specifications for public works and public housing projects have also been updated accordingly to facilitate the use of recycled materials in building foundation, sub-base in road construction and in concrete that requires less structural strength such as concrete paving blocks (CIC, 2009).

In an attempt to maximize recycled content in new construction, recycled steel from demolished hoardings and recycled concrete are put together to produce furniture for its new projects. In the new Kai Tak development where the old Hong Kong airport was situated, marine mud is being used, after strengthening and stabilizing conditionings, for backfilling at the project site itself. Being one of the largest consumers for concrete and related materials, there is huge potential for the PSC to use recycled aggregate concrete (RAC) in its projects. The PSC, therefore proactively invested in numerous studies before RAC was used in real projects. These studies unveiled RAC‟s structural and chemical properties as well as its suitability in various building applications (HKHA 2010b). With local experiences apparently lacking in the long term properties of RAC in new construction, the PSC explored international experiences and found that RAC, when used appropriately, is comparable in quality to ordinary concrete. With the confidence gained from the review, the PSC is examining the possibility of extending the use of RA in structural concrete as a sustainable building material.

On specific projects, according to the PSC statistics, 1700 tonnes of RA from the demolition of Wong Chuk Hang Estate were used as backfill at Tung Tau Estate Phase 9, and 180 cubic meters of rock core was used in the outdoor areas of Choi Wan Estate (HKHA 2010a). In

total, until 2009, about 3,100 tonnes of RA have been used in the PSC‟s projects in Hong Kong (CIC 2009). Cement replacement materials such as pulverised fuel ash and ground granulated blast furnace slag are also put into the concrete mix to partially substitute cement content in pre-fabricated façades (HKHA 2010b). From the cost perspective, contrary to common public perceptions, the cost of preparing RAC such as setting up and operating crushing facilities to produce RA is in fact comparable with that of transporting and disposing demolition wastes to landfill facilities (HKHA 2010b), while limited landfill capacities pose a related problem.

This demonstration coupled with the rapidly increasing construction material cost, maximizing use of recycled content has become a popular practice in the construction industry in Hong Kong. The apparent and significant cost saving gained, drives its usage to increasingly higher levels. In addition, the levy of landfill charge scheme implemented by the HKSAR government will further incentivize developers and contractors to turn construction and demolition wastes to their respective recycled usages. However, the perceived high cost of crushing RA and the limited sources (government is the only supplier of RA for the time being) of purchasing RA are two main obstacles in its propagated implementation. Due to the latter, contractors may be exposed to higher liability as they are unable to control the source of RA and subsequently the performance of RAC. Therefore, a fully commercialized and regulated supplier of RA is needed.

Prefabrication

Prefabrication in construction has a number of advantages in terms of environmental responsiveness such as reduce (i) noise, (ii) construction waste and (iv) pollution. Greater use of pre-fabricated components was also called for in the CIRC report. In response to that and in addition to the conventional precast elements that were already in use, the PSC piloted the use of other non-conventional building elements such as volumetric precast bathrooms, and precast lift core as a holistic unit in such a way that things like waterproofing, M&E semi-fittings are all completed off-site. Aside from its sustainability benefits, volumetric precasting offers easy and fast assembly procedure, better quality control, and cost saving in the long term if implemented in large quantities. In addition, prefabricated facades are already used extensively in the PSC‟s projects.

However, the initial investment in product development has hindered the popularity of prefabrication. In addition, the absence of a local manufacturing industry adds additional transportation costs for the precast elements to be transported from factories in Mainland China. Therefore, unless proven long term cost saving is observed which requires economy of scale, it may be difficult for many private clients and contractors to adopt more prefabrication. In this case, having an influential public sector client to take a pioneering role becomes especially critical, while a long term and strategic commitment from such client for its promotion, testing and use is essential.

Green Design

The CIRC report specifically called for wider use of green designs in the PSC‟s projects. The PSC introduced its first departmental environmental objectives in 1999, and subsequently updated it to reflect rapidly developing environmental perspectives as soon as the needs arose. These objectives are the guidelines and also drivers of many initiatives implemented by the PSC. Some of these are described below.

Micro-climate study has been introduced since 2001 on all the PSC‟s projects to refine design to ensure optimized use of natural features at that particular location, and to implement appropriate sustainability measures. The design initiatives are then measured at the completion of the project to check against its projected effectiveness. These have hitherto shown positive results.

The PSC places strong focus on maximizing the comfort level and well-being of residents. In achieving it, new standards of greening have been put in place. The current guideline specifies that for every 15 domestic housing units built, at least one tree has to be planted; and for every housing development project, a greening ratio of no less than 20% to 30% is to be followed (HKHA 2010a). In addition to greened rooftop planted with self-maintainable vegetations in newly built low-rise estates, vertical green panels are also being installed to increase the greening areas. Vertical green panels not only provide increased areas of greening, but also help to reduce the heat of the concrete wall behind it by up to 16 degrees Celsius and thus lower the interior temperature (HKHA 2010a). These greening initiatives reduce heat island effect and energy consumption, and also enhance noise absorption to abate noise pollution in the estates.

Other green measures that the PSC has adopted in pilot projects include installation of photovoltaic systems, solar water heating systems, wind and solar hybrid powered street lighting. As these initiatives are still in their early testing stage, the high initial investment as well as the intangible and uncertain ROI (Return on Investment) is a key challenge for them to be extensively adopted.

Procurement

A large part in the above mentioned relevant section of the CIRC report was devoted to the suggestion to give weight to environmental performance in assessing tenders and performance of contractors. In response, the PSC has incorporated environmental aspects into its procurement process starting right from the tender stage. An „Environmental Management Plan‟ from contractors is now mandatory for demolition, piling, building and civil contracts. In the tendering process, additional credits are given to those with environmental proposal that exceed the basic contractual requirements. More weights are inserted into the Performance Assessment Scoring System (PASS) which was developed by the PSC to maintain the standard of works for its new building works projects in 1990. Its main functions are for work performance monitoring, registered contractor list management, and for streamlining tender process (Tao 2009).

Of the eight assessment categories in the PASS criteria, section F measures contractor‟s performance in terms of environmental, health and other related provisions. Assessed on a quarterly basis, the scores of a particular contractor performing work in a project are then totalled and calculated (Tao 2009). The score, together with other past performance scores, will then become part of the assessment criteria in subsequent project tenders submitted by this particular contractor. The PASS system is updated and improved from time to time to reflect the concurrent needs and focus areas of the industry. With the implementation of “pay for environment” scheme mentioned in the next section, the PASS score is more of a reflection of the contractor‟s obligated efforts in optimizing the environmental performance of the their respective construction discipline. In the private sector, some clients, although may not be as aggressive, are following the public sector in terms of placing a strong focus in environmental aspect of the construction in the tendering and contractor assessment processes.

A new procurement method which may potentially place more focus on sustainable design and construction was developed and implemented by the PSC in a pilot project. The PSC calls this new approach the "three envelope system". This is distinct from the now common "two envelops system" by adding a third envelope which proposes innovative ideas and technologies with the associated costs (Fung 2010). The new system opens the door for more environmentally innovative designs and building technologies. The majority of the accepted innovations in the pilot project contributed towards improved sustainability. However, concerns have been expressed over this new approach by designers and contractors that they may lose a competitive edge by disclosing their technologies in this system, especially in the case of a losing tender.

Construction Nuisance Mitigation

A number of initiatives derived from construction nuisance mitigation objective outlined in the CIRC report were implemented by the PSC in recent years with an encouraging response from the industry. One of these is the integrated "pay for safety, environment and hygiene" scheme introduced in 2003. Aside from encouraging better safety and site hygiene initiatives, the program incentivized contractors to translate adequate measures under the project‟s Environmental Management Plan into responsible actions without having to sacrifice profits. Such Environmental Management Plans address various issues such as noise control, water pollution control, dust control and protection of existing facilities, depending on the nature and location of the particular project. While meeting these main objectives, the scheme indirectly promotes a healthy tender process in a way that contractors bidding for the project would not need to cut corners to meet environmental requirements during the construction process, as may be later set by the clients.

With positive responses from the industry, particularly contractors, similar schemes have also been adapted by some progressive private sector clients. The Construction Industry Council (CIC) of Hong Kong has published guidelines in this regard (CIC 2008), hoping that the rest of private sector clients will soon catch up and thus transform it to become a norm in the industry.

Promotion of Public Awareness

New initiatives need to be accepted and appreciated by the people who are using and benefiting from them. The CIRC report recommended promoting public awareness of energy efficiency and wider adoption of energy efficient designs a priority. In this regard, the PSC works closely with other government departments, district councils and institutions to facilitate exchanges with the communities. Forums and workshops are also conducted at the design stage of its projects to encourage public engagements. Also, post completion review workshops are held with the residents and contractors, as a way of understanding the performance of green technologies and materials – and assessing whether they have achieved design objectives and expectations (HKHA 2010a).

Tenant‟s involvement in greening their own estates not only can contribute to fostering a better environmental community, but also plays an effective role in promoting environmental concepts in the community at large. Launched in 2007, the Action Seedling program provides tenants the opportunities to nurture and raise plants until they are mature enough to be transplanted as part of the greening in the estates. In the past year, over 15,000 seedlings have been nourished and eventually moved to community gardens in various estates (HKHA 2010a).

KEY CHALLENGES AND DRIVERS

The impact of championing the above initiatives on the industry as a whole has been mixed, as described under individual initiatives. Cost intensive initiatives have been slow to be cross pollinated to the private sector. This is probably because many of these initiatives involve new technologies which require investments and the fact that the benefits of some of these initiatives are yet to be demonstrated as they can only be proven in the long run. Therefore, the initial costs are considered as a barrier. Suggested remedies include subsidies to the industry until the initiatives are widely propagated and become the norm.

Within the public sector, it was felt that commitment to environmental initiatives is the key driver to promote them. The PSC is ready to bear additional costs in demonstrating them in pilot projects but foresees that it can only sustain them if they can show cost advantages in the longer run. It was also felt that the contribution of these initiatives to the society has to be clear and acceptable to the general public if they are to be sustained. The success of many of the initiatives has been attributed to linking procurement (tender opportunities) to performance scores. Another key driver that is important to the extensive implementation of environmental initiatives adopted by the PSC is the support from CIC, the industry"s coordinating body, which needs to effectively educate the industry by disseminating information about the initiatives, their advantages and successes.

CONCLUDING OBSERVATIONS

This case study analysis indicates that in general, it is observed that industry wide implementation of many environmental friendly initiatives in the construction industry is step-by-step "work in progress". Most of the initiatives are at the initial stage, with benefits of some being still to be demonstrated. Initiatives such as "pay for safety, environment and hygiene" experience less obstacles to be employed by contractors, because costs are borne by committed clients and have been highly successful. Since nearly all the public projects are now exercising this scheme where applicable, it is hopeful that with the catalyst of CIC"s published guidelines, it is likely to be transformed into an industry norm in the near future.

The PSC has taken an important step forward by pioneering and investing in practicing LCC/LCA exercises which provide a solid foundation and material database for future use. Fostering an environmentally responsible culture is further enhanced by periodically updating procurement and tender systems in such a way that environmental requirements reflect the needs of the developing market. Objectives, inputs and outputs of the most current R&D programs should be geared accordingly. However, the barriers and challenges in driving environmentally responsible industry forward need to be noted and addressed. Although due to the inherent characteristics of each environmental initiative, the challenges are different, what they share in common is that it requires a persistently long term commitment from the investing client. Therefore the industry needs such proactive clients with a responsible vision of the future and a willingness to "test the water" and invest money and efforts to foster an environmentally conscious industry.

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ABBREVIATIONS

CIC	The Construction Industry Council
CIDCA	Construction Industry Development: Comparison and Acceleration
CIRC	Construction Industry Review Committee
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
HKHA	The Hong Kong Housing Authority
HKSAR	The Hong Kong Special Administrative Region
M&E	Mechanical and Electrical
PASS	Performance Assessment Scoring System
PSC	Public Sector Client
RA	Recycled Aggregates
RAC	Recycled Aggregate Concrete

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FOURTEEN PROCESSES DEFINING COMPETITIVE ADVANTAGE OF BRAZILIAN TRADE CONTRACTORS

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Abstract
Brazilian Trade Contractors (TC), or Subcontractors and Specialty Contractors, are main players in the Brazilian Building Industry competitiveness. They are part of a highly fragmentized and informal chain, with a great diversity in their value propositions and in their organizational forms. Nonetheless, despite their heterogeneity, most of them are SMEs lacking resources, capabilities, and other assets. This lack of assets and a competition led by the lowest bid offering produces the bankruptcy of 50% of them in their fourth year of operation, with negative consequences in the competitiveness of the whole Industry. Hence, understanding the causes of that performance is an important issue to improve TC management practices and, consequently, their performance. This paper focuses on internal factors, specifically, on the internal processes that allow Trade Contractors to achieve a good performance in their specific competitions. For this purpose, data were gathered from a qualitative research in 24 Trade Contractors with good performance and in 7 other agents that hire them, mainly in Sao Paulo - Brazil. Two are the main results: First, fourteen processes conducted by TC were identified. Second, those processes are performed in different configurations in accordance with different value propositions and size of the TC.

Keywords: Trade contractors, subcontractors, competitiveness, process, Brazil.

INTRODUCTION

The Construction Industry is a fundamental sector of the Brazilian economy. It is composed of agents that perform construction activities, industrial activities associated with it (suppliers of raw materials and equipment for the construction process) and support services (CBIC, 2001). In it, the construction activity accounts for 61.2% of the GDP in the industry - or US$ 76 billion - and 69.3% of its workforce (Abramat, 2010). The main agents that perform the activity are the construction companies and Trade contractors (TC), known as subcontractors and specialty contractors (Oviedo Haito, 2010).

Between these two agents, TC is very important for its systemic impact on the sector performance. This importance can be illustrated by the fact that they have a significant

participation in the sector with over 350,000 companies operating in it (Cardoso et al., 2007), which are mostly micro, small and medium businesses - SME, 93% have less than 29 workers (Cardoso et al., 2007). Their participation is paramount in the production process of the 'building product'; besides, TC are important to projects success (Haltenhoff, 1995; Love, 1997) and also increase the sector competitiveness requires to update TC technological and managerial capacity (Cardoso, 2003).

Despite this importance, in Brazil, 50% of TC go bankrupt in their fourth year of operation (SEBRAE-SP, 2008), due to deficiencies in internal and external factors.

Oviedo Haito (2010) summarized the deficiencies related to internal factors of TC. The lack of resources and competences or even the the lack of strategic assets (Amit and Schoemaker, 1993); understanding them as "a firm-level factor that has the potential to contribute economic benefits [to the company]" (Galbreath, 2004, p. 106). One of such assets is the Organizational Capital, and also the processes performed by the firm.

In a related research, as an external factor, Oviedo Haito (2010) found that a general perception in TC is that the agents that hire them impose predatory conditions for their survival in the market, being the relationship with its contractors antagonistic (Hinze and Tracey, 1994; Kumaraswamy and Matthews, 2000) and paradoxical, since their contractors impose high requirements, but hire TC at the lowest price (Pereira, 2003), and the poor conditions provided for many prime contractors at the construction site prevent TC from achieving the desired results.

In this context, those requirements are expressed in terms of quality, scope, time and cost (Kale and Ardity, 2003; Kormaz and Messner, 2003), while the adverse working conditions in construction sites refer mainly to the physical space for production, the means and space to transport materials and workers, the unfinished products of other trades, and changes in technical sequences of site works (Oviedo Haito, 2010).

In this Brazilian TC context, how do they organize in order to achieve a good performance in their specific competitions?
The aim is to contribute to fill the gap of TC's organizational knowledge and to discuss which processes TC of good performance deploy in Brazil. Due to the importance of this matter, other organizational dimensions are out of scope.

THE PROCESS APPROACH OF A FIRM PERFORMANCE

Mastering the factors that determine a firm's success is every manager's dream. Activity-based view as in Porter's 5 forces (Porter, 1980) and Barney's resource-based view (Barney, 1991), are the main conceptual theorizations of how firms attain success in the market (Ramos-Rodriguez, Ruiz-Navarro, 2004). In those theories, a superior performance, the so-called competitive advantage (Porter, 1985) or the Sustainable competitive advantage (Hoffman, 2000) results from different sources, such as the activities they conduct, or from what the firm have to do to reach their results.

On the other hand, as it occurs also in Brazil (SEBRAE-SP, 2008), Schaufelberger (2003) argue that the Construction Industry has the third highest rate of bankruptcy among all industries in the United States. Moreover, Thornhill and Amit (2003) outlined the value of

studying businesses failures as a source of knowledge about firms performance, and not only from studying their success. In this sense, among others, works by Schleifer (1987), Russel (1991), Kale and Arditi (1998) and Schaufelberger (2003) converged on some internal and external factors related to the failure of the Construction Industry firms, specially Main contractors and Trade contractors.

Based on those works, among the internal factors, Oviedo Haito and Cardoso (2009) pointed out as weaknesses in their business and production management, lack of resources, oversight relationship with customers and other agents involved in their external environment, and limited bargaining power caused by the large number of TC and their lack of associative forms, as in unions. Among the external factors, Oviedo Haito (2010) outlined the conditions of construction sites and the conditions of competition imposed on TC. Also, Kale and Arditi (1998) discussed that organizations are open systems with the mission of transforming inputs into outputs in an efficient and effective manner. Those authors highlighted two factors, or key processes to the firm survival: 1) to receive enough inputs from their environment (external processes) and 2) to have the capacity to transform those inputs into outputs (internal process).

But TC compete in building different trades and, thus, in different competitions. Based on Porter's work (Porter 1980), Kale and Arditi (2003), and Kormaz and Messner (2003) described that the competitive positioning of the firms of the Construction Industry is determined by mode (cost, time, quality and innovation) and by the scope of their specific competition (segment, mix of products and clients, etc.). Hence, different factors are required for different competitive positioning.

In addition, Oviedo Haito (2010) discussed that TC are service firms. To Vargo and Lusch (2008), service firms reach the value of the service with the co-production of their clients. This is applicable to TC, because their performance in cost, time, quality or innovation depends on adequate conditions such as: well finished previous trades, adequate information about the work done, an adequate supply of materials, and so on; provided by other agents involved in the production process.

Because of that, TC can only propose a potential performance, a promise that the firm makes to clients to deliver a particular outcome (Bititci et al., 2004). That promise is the value proposition of the firm. Oviedo Haito (2010) discussed that, to TC, that value proposition is composed of several factors such as resources, competences, activities and performances that are part of the firm and that can be delivered to their customers for the production of their specific trades.

Therefore, what factors must be considered to analyze TC performance? Porter´s (1985) activities or Barney's (1991) resources? Alternatively, Ray, Barney e Muhanna (2004, p.35) stated: "*Activities, routines, and business processes are the mechanisms through which resources and capabilities get exposed to market processes where their ultimate value and ability to generate competitive advantages are realized*".

Hence, a process approach to studying firms, such as TC, is useful to investigate TC performance. It also has another advantage; the analysis of firms on a process-based view (Gruchman, 2009) allows linking other factors such as resources, competences and activities for each process identified.

For a Main contractor, Lu, Shen and Yam (2008) concluded that a good performance is related to mastering factors such as Project Management, Organizational Structure, Organization Resources, Competitive Strategy, Relationships, Bidding Techniques, Marketing and Technology.

For Parung and Bititci (2006) and to Galbreath (2004), factors such physical assets, financial assets, organizational capital, relationship capital, human capital and reputational assets, are factors generating value to the firm. By developing a model to understand construction firms performance, productivity specifically, Thomas et al. (1990) analyzed construction firms as open conversion systems, relating factors such as labor, capital, material, equipment, organizational structure, products and projects, among others, with three generic stages: input factors (e.g. physical resources), internal environment factors (e.g. organizational competences), and output factors (e.g. performance, reputation).

One can thus say that factors such as physical assets, financial assets, organizational capital, relationship capital, human capital and reputational assets can be used to represent that a firm has to reach a certain performance and, from this, to represent their value proposition.

Specifically, based on works by Shimitzu (2003) and Pereira (2003), Cardoso (2003) found nine processes performed by Brazilian TC, namely: Planning and Management, Commercial, Design, Production Planning, Human Resources, Occupational Safety and Technical Assistance.

Nevertheless, according to the works by Schleifer (1987), Russel (1991), Kale and Arditi (1998), Stewart et al. (2003), Schaufelberger (2003), Lu, Shen and Yam (2008), and Maneschi and Melhado (2010) - in Construction Industry - and the works by Amit and Schoemaker (1993), Eisenhardt and Martin (2000), Thornhill and Amit (2003), and Flamholtz e Hua (2003) - in management science-, firms success depends on how firms can capture more resources from their external environment and, in an efficient and effective manner, transform them into outputs to meet the requirements of their specific competitions.

For that, as a way of improve their performance, Oviedo Haito (2010) discussed the importance of TC to execute functions such as: Information Technology (Stewart et al., 2003), Financial and Accounting, Research and Development (R&D), Marketing (Slack et al., 1996), and to divide the design process into Product Design and Design for Production (Maneschi and Melhado, 2010).

Consequently, Oviedo Haito (2010) outlined the importance of managing 13 processes, namely: Planning and Management, Commercial, Information Technology, Technical Assistance, Marketing, Financial and Accounting, Procurement, Product Design, Design for Production, Production Planning, Human Resources, Occupational Safety, and Production Process. Table 1 shows a summarized description of these processes. It is important to mention that processes such as legal, R&D, among others, are important. Nevertheless, they are not always feasible for Brazilian TC, specially for SMEs, as discussed by Oviedo Haito (2010).

Process	Description
Planning and Management	Management of strategy, objectives, division of labor and bussines management indicators (physical and financial)
Commercial	Management of contracts life cycle of building trades, from bidding,

	formalization, execution and closing.
Information Technology	Management of a support system for decision-making and management of the documentation of their information
Technical Assistance	Management of customers´ satisfaction related to the product built and its performance
Marketing	Management of the relationships of TC with their external environment (e.g. customers, suppliers, etc.) as to assets development
Financial and Accounting	Management of financial transactions, accounting and tax issues related to TC business and operation
Procurement	Management of internal and external logistic efforts (acquisition of goods and services, transport and distribution of materials on site, etc.)
Product Design	Management of the design defining physical attributes for the trade to be built
Design for Production	Management of the design defining the main characteristics and conditions of what the trade will build
Production Planning	Management of the strategy for the execution of trades and management of its requirements in terms of resources and competences
Human Resources	Management of people in the firm
Occupational Safety	Management of safety and health at work and its suitability with existing regulations in force
Production	Management of the conditions and of the organization for the execution of the trade, as well as its conservation and the preservation of other existing trades

Table 1: *Identified Processes for Brazilian Trade Contractors (OVIEDO HAITO, 2010)*

Therefore, assets composing value proposition and processes performed by TC are used to understand some TC sources of competitive advantage.

RESEARCH METHOD

For this research, we had a main question: how is good performance in TC are? In order to approach it, we studied what processes TC perform and their relationship with a number of factors. The research method used was a qualitative research involving twenty four TC and seven other agents that hire TC. All of them were selected by purposeful sampling (Coyne, 1997), specifically, by Intensity sampling (Patton, 1990) from good performance TC. Data was collected in open and in semi-structured questionnaires.

The research has two main stages. First, we inquired seven agents who hire TC, being one Construction Project Manager, two Construction Quality Managers, a Construction Technical Manager –all of them from top Brazilian Main Contractors–, a consultant on SME issues, a Product Manager from a Construction Mortar manufacturer, and a representative of an association of laminated flooring manufacturers. They were questioned on: 1) What good performance characteristics do TC have? and 2) What building trades are best performed in São Paulo?

Analyzing their answers, we got a list of 18 building trades, and we understand that there is not a convergence about what characteristics define good performance for a TC. Even more, we understand that the factors they use to evaluate good performance are primarily related to cost, time, quality and scope, and on what assets TC have to build their trades, case by case.

In the second stage, we associated those assets to what Parung and Bititci (2006) and Galbreath (2004) considered as strategic assets and, in order to choose what TC to research, we sought acknowledged TC for their good performance in their specific trade. Then, TC were questioned about what processes they deploy to perform their specific trades. We interviewed TC representatives from company directory, such as the owner or a representative who knows how the firm works. As not all of the TC representatives interviewed had higher education, they were not asked directly about what processes they deploy. Instead, they were questioned about some activities related to some of the processes studied. For example, for the production planning process, they were questioned about what kind of preparations they have before the execution of their specific trades.

Interviewed TC were asked about the identified factors: assets that compose their value proposition (Parung and Bititci, 2006; Galbreath, 2004; Bititci et al., 2004), the age of the firm (Kale and Arditi, 1998), the size of the firm, the time they spend in producing their building trades; and asked about the processes they deploy (Oviedo Haito, 2010).

Data gathered were tabulated, and the identified factors were compared against the 13 processes proposed by Oviedo Haito (2010).

As a result, we interviewed 24 TC that build trades included in the 18 building trades recommended by the agents that hire them. Table 2 shows the data collected.

RESEARCH ANALYSIS AND RESULTS

Firm	Building Trade	Firm Age (years)	Number of employees	Production Time (month of 22 days)	Firm Size	Physical Assets	Financial Assets	Organizational Assets	Human Capital	Relational Capital	Reputational Assets	Quantity of assets	Procurement	Human Resources	Production	Commercial	Technical Assistance	Financial and Accounting	Production Planning	Occupational Safety	Planning and Management	Marketing	Design for Production	Information Technology	Product Design
TC_09	External coating and Concrete structures	20	1250	16	BIG	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1	1	
TC_23	Masonry, internal and external coating, and subfloor	15	500	6	BIG	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1	1		1
TC_07	Foundations	75	400	2.5	BIG	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1	1	1
TC_05	Masonry	4	376	4	BIG	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1	1		
TC_24	Masonry	11	350	8	BIG	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1	1	1	1
TC_02	Masonry, internal and external coating, and subfloor	12	295	15	BIG	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1		1	
TC_01	Masonry, internal and external coating, and subfloor	15	200	16	BIG		B	C	D			3	1	1	1	1	1	1	1	1	1		1		
TC_08	Water proofing systems	26	200	6	BIG	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1	1	1
TC_10	Water proofing systems	17	180	8	BIG	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1	1	1
TC_22	Dry Wall	1	100	5	BIG	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1	1		
TC_03	Masonry, internal and external coating, and subfloor	3.5	96	16	MED	A	B		D		F	4	1	1	1	1	1	1		1		1			
TC_04	Fenestration, doors, frames and hardware	2	46	8	MED	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1		1
TC_15	Laminate flooring	5	41	0.045	MED		B		D		F	3	1	1	1	1	1	1	1		1	1			
TC_16	Dry Wall	4	37	8	SMALL	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1			
TC_17	Dry Wall	2.5	30	7	SMALL	A	B		D	E	F	5	1	1	1	1	1	1	1	1	1	1	1	1	
TC_19	Fenestration, doors, frames and hardware, glazing, and metal panels	7	29	12	SMALL		B	C	D	E	F	5	1	1	1	1	1	1	1	1	1	1			
TC_21	Fenestration, doors, frames and hardware, glazing, and metal panels	37	24	10	SMALL	A	B	C	D	E	F	6	1	1	1	1	1		1	1	1	1	1		1
TC_14	Gypsum Plaster	16	22	3	SMALL	A	B		D		F	4	1	1	1	1	1	1	1	1	1	1			
TC_11	Laminate flooring	13	17	0.045	SMALL	A	B	C	D		F	5	1	1	1	1	1	1	1	1	1	1	1		
TC_13	Laminate flooring	18	12	0.09	SMALL	A		C	D		F	4	1	1	1	1	1	1	1	1			1		
TC_12	Masonry, internal and external coating, and subfloor	6	12	4.5	SMALL				D			1	1	1	1	1	1	1	1	1	1	1			
TC_06	Electrical wiring and communications	17	10	1.59	SMALL	A	B	C	D	E	F	6	1	1	1	1	1	1	1	1	1	1	1		
TC_20	Laminate flooring	8	6	0.045	MICRO			C	D		F	3	1	1	1	1	1	1	1	1	1				
TC_18	Electrical maintenance	3	2	0.23	MICRO		B		D		F	3	1	1	1	1	1	1	1	1	1				
						18	21	18	24	9	22		24	24	24	24	24	23	23	23	22	20	15	7	7

Note: SEBRAE-SP (2008) criteria for firm size: Large (> 100 employees and turnover > US$ 1.33 million), Medium (99 < employees < 50 and turnover < US$ 1.33 million), Small (49 < employees < 10 and turnover < US$ 133.333), Micro Small (employees < 10)

Table 2: *Characteristics of 24 TC studied (Adapted from Oviedo Haito, 2010)*

By analyzing data from Table 2, we found:
a) Even for TC that perform the same building trade, the factors investigated (firm age, firm size, firm assets / value propositions and firm production time) vary without an identified pattern, showing the heterogeneity of TC in what do they do and the heterogeneity in their proposal of assets to build their trades. Despite this disparateness, we found that TC perform different configurations of the 13 processes investigated.

b) Regardless of the different factors studied, we only found that there is some relationship between the 13 processes and the size of the TC, identifying a tendency that the more employees the firm has, the more processes they perform.

Another issue we found is that the frequency of the processes identified varies, and we can classify the sample studied into four categories:

1) Processes always performed by TC (Procurement, Human Resources, Production, Commercial, Technical Assistance); related to the core of the production capacity of TC, from gain a bid, procure the people and resources, produce it, and to the warranty of the building trade.

2) Processes almost always performed by TC (Financial and Accounting, Production, Planning, Occupational Safety); associated to a major concern of TC with regard to the consequences to the people of the company and their performance to their external environment. Those processes are strongly linked to the production process.

3) Processes frequently performed by TC (Planning and Management, Marketing, Design for Production); related to a major concern about the firm organization, about the relationship of the TC with their competitive environment, and to the improvement of their results through implementing support activities.

4) Processes not often performed by TC (Information Technology, Product Design); being other support activities, and their practice is not generalized among TC. They are related to the necessity of formalize the communication across the organization and, mainly, with the production team through more detailed specifications.

So, we can say that Brazilian TC have four organizational stages: 1) oriented to control their production capacity; 2) oriented to control the impacts of their production on their interested parties; 3) oriented to control the impacts of their production in front the performance expected by their external environment; and 4) oriented to control the firm organization and, mainly, to control the quality of the information across the organization.

Therefore, despite this heterogeneity in TC characteristics, one can say that there is a core of processes performed by TC (Procurement, Human Resources, Production, Commercial, and Technical Assistance) and, from them; the TC deploy others in order to meet their competitive environmental demands.

Now, by analyzing supply of strategic assets, we understood:

There is no relationship between the firm size and the scope traded, or the age and scope of the company marketed. It depends on the strategic positioning of TC.

Despite the difference between the assets they offer, all the studied TC offer the manpower to produce their building trades. The second scope, reputational capital, was the most supplied, which indicates that most of TC are hired by references to their good performance in previous services. The third element commercialized corresponds to the financial asset, which indicates that the TC prepare their bids based on their ability to finance their own production.

Fourthly, we have the organizational capital and physical assets. This lower amount of the supply of those assets can mean that many TC are hired just to perform their building trades, and the contractor provides the physical means necessary for production. In the case of organizational capital, one of the reasons identified for the TC not providing such capital was that the Main Contractor assumes all production management, subcontracting only the provision of means of production that will be managed directly by them. An example is TC12, which expressed that he only recruits and provides manpower to perform masonry walls

The asset less provided by these companies is the relationship capital. Some causes were identified as the lack of bargaining power, lack of collaboration in networks or trade unions, and lack of support obtained from external agents.

Thus, by analyzing the variation of assets and processes owned by TC, we understood that those elements are not randomly configured, but they are established to meet the requirements of their competitions. That response can be delivered or undelivered, and we also understood that the configuration of value proposition in TC is a response that can be managed within another process. Hence, the core of the response given by TC to their environment (in terms of what assets they offer to build their trades) is defined in the 14th process, the Strategic Process.

CONCLUSION

Researching organizational issues, especially TC, is a major challenge. This is mainly due to the heterogeneity of the trades built by TC and because of the diversity in the set of resources and competences needed by TC to build their trades. Nevertheless, 14 processes defining TC performance are found, specifically: Strategic Process, Planning and Management, Commercial, Information Technology, Technical Assistance, Marketing, Financial and Accounting, Procurement, Product Design, Design for Production, Production Planning, Human Resources, Occupational Safety, and Production Process.

Also, the process approach used to analyze different types of TC was useful to identify some patterns. In this sense, despite the TC specific trades built, our approach allowed finding:

- What TC do, in terms of processes deployed, to build their trades;
- What kind of TC their clients want, as a function of what do they do;

Thus, by studying the TC processes, four processes profiles were found, essentially related to the size of the TC analyzed.

Different sets of processes were understood to be related to different value propositions and that the value proposition of TC is defined, in a manner delivered or not, by a Strategic process. In addition, it was understood that TC are heterogeneous. Hence, the fact of their

developing more processes or of offering more assets in their value proposition, does not mean that they are more capable, but more adequate to compete in their specific competitions.

As in other countries, Brazilian TC are mostly SME and face similar challenges to its worldwide peers. One of them is the challenge of growing. Consequently, we can say that issues as the organizational development is a similar one. By analyzing the set of processes a TC deploys is a way to approach this issue.

So, in order to improve their results and their competitiveness as a consequence, TC must set a determinate set of processes, in order to equilibrate their organizational development stage with the requirements of the specific competitions they participate. That equilibrium can be reduced to two aspects: 1) to produce, and 2) guarantee the adequate quality of their (larger) production scale.

This paper limited the discussion to the processes performed by TC. Related issues such as the resources, competences and specific activities identified in the TC studied are out of the scope of this paper. In spite of that, we encourage the development of that kind of research, mainly because those elements allow TC to deploy their processes, in a competitive manner. Another limitation is the scale of our research, which affects the consolidation of the profiles of processes deployed by TC.

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DEVELOPING INTERACTIONS, DISENTANGLING CONTRADICTIONS: EXAMINING PARADOXES OF INTER-ORGANISATIONAL RELATIONS IN CONSTRUCTING COLLABORATIONS

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Abstract
The positive nature of partnering to resolve adversarial relationships in the construction industry is well-rehearsed. However, critics have argued that espoused benefits of partnering have not materialised because business-as-usual prevails. Furthermore, some scholars insist that more needs to be done to analyse the practices of partnering by scrutinising more deeply the emergence of inter-organisational collaboration. This study examines a contemporary, emerging collaboration, which initially sought to investigate effective knowledge sharing during the early stages of a real-life collaborative venture between three infrastructure companies. The case study was based on participant observations and interviews with key people involved in forming this collaborative venture. Findings reveal a number of paradoxes that are perplexing on the one hand, yet generative in terms of actions on the other. These paradoxes relate to the three areas of sensemaking, formal methods and time synchronicity.

Keywords: collaboration, paradox, observations, sensemaking, time synchronicity.

INTRODUCTION

Advocates of partnering have often claimed that effective collaboration reaps benefits of improved productivity, waste reduction and better client satisfaction (see e.g. Loraine, 1993; Bennett and Jayes, 1998; Construction Industry Institute, 1998; Black *et al.*, 2000; Proverbs *et al.*, 2000; Naoum, 2003; and Wood and Ellis, 2005). At the same time, partnering promises the possibilities of bridging the age-old gap between the key social actors (i.e. clients, designers and contractors), as well as integrating ever more complex supply chains, in construction (see e.g. Latham, 1994; Egan, 1998; Akintoye *et al.*, 2000; Vrijhoef and Koskela, 2000; and Saad *et al.*, 2002). Despite the somewhat intuitive claims of the wonders of partnering, and repeated exhortations of how partnering can arrest the problems associated with fragmented relations in construction, there are still gaps in understanding how inter-organisational collaboration in construction really works (see e.g. Wood and Ellis, 2005;

Bresnen, 2007; Gadde and Dubois, 2010; and Bresnen, 2010). Critical scholars have highlighted how the realities of collaborative working are often detached from rhetorical claims of its positive nature (see e.g. Bresnen and Marshall, 2001; and Nyström, 2008); some question whether benefits can really be delivered to all stakeholders involved (e.g. Green, 1999; and Dainty *et al.*, 2001), whilst others argue that the status quo of adversarial working relationships persists (e.g. Briscoe and Dainty, 2005). There is also greater acknowledgement of the limits of prescriptive notions of partnering (e.g. Beach *et al.*, 2005; Phua, 2006; and Chan *et al.*, 2006), and growing acceptance that partnering in construction is simply elusive (e.g. Bresnen, 2009).

Nonetheless, supporters and critics of partnering in construction share one common feature. That is, the arguments rallied for and against the use of partnering have implicitly focussed on the essence of partnering (i.e. *being*), and rarely examined the process of how partnering comes into being (i.e. *becoming*). So, on the one hand, partnering is treated as a desired concept fiercely defended by its proponents, such that explaining the pre-requisites, components and performative goals (see Nyström, 2005) appears to be their central mission. On the other hand, opponents tended to question the validity of the concept of partnering by emphasising the failure by advocates to demonstrate the existence of partnering arrangements and associated benefits in construction. Both camps have thus taken the concept of „partnering" for granted, and neglected a deeper understanding of how the concept – incoherent and shifting as it is – comes into being. To put simply, how does partnering practice emerge to become „partnering" as we know it in these debates?

This article draws on the analysis of participant observations in a single case study. The study sought to make sense of emerging practices (see Bresnen, 2009) entailed in the formation of a new partnership through participant observations. The main objective of the article is to provide a better understanding of the processes of how inter-organisational collaborations come about (see Cousins, 2002; Bresnen, 2007; Bresnen and Marshall, 2010). In this article, perspectives of collaborative working are initially outlined, which traces the key debates of disconnections between the rhetoric and reality of partnering in construction. The review highlights the need to refocus the attention on the process, rather than the essence of, partnering. Thereafter, the background to the case study and details of the participant observations are presented. Finally, findings from the analysis of the observations are discussed, which reveal three main paradoxes that are noteworthy, including the paradox of sensemaking, the paradox of formal methods, and the paradox of time synchronicity.

Perspectives of partnering: two sides of the same coin

Calls for reform of the construction industry have become, certainly in the Western world, a regular feature since the post-WWII era (see Murray and Langford, 2003). Such restructuring consistently points towards the need to move away from adversarial working relationships towards developing more effective forms of collaboration, encapsulated in the contemporary agenda of partnering (e.g. Latham, 1994; and Egan, 1998). In this section, the literature on partnering in construction is reviewed under two main streams. The first deals with the *aspirations and mechanics* of partnering since it is hailed as a universal panacea to cure the ills of the industry. Critically, the second stream serves as a counterbalance to highlight *problems with the desired state* of partnering. Through a review of the salient points of the construction partnering literature, an argument is put forward to shift the attention away from essentialist views of partnering to examine the *practices* of how the partnering process comes into being.

Aspirations and mechanics of partnering

The introduction of the language of partnering seeks to invoke the reshaping of working relationships in the construction industry, primarily in terms of the relationship between the client and contractor (Alderman and Ivory, 2007). Partnering is considered to offer a plausible improvement strategy to mend the adversarial relationships that have long troubled the industry. It promises a paradigm shift towards longer-term commitment between partner organisations, sharing of often-scarce resources, and enhanced cooperation to deliver a set of mutually-agreed objectives (e.g. Construction Industry Institute, 1989; and Bennett and Jayes, 1998). Such aspirations have meant that considerable research effort have gone into explaining the nature, conditions and mechanics associated with partnering, as well as to demonstrate the realisation of the intended benefits.

So, Bennett and Jayes (1998) comprehensively articulated seven fundamentals of partnering. These serve to consider in great detail the strategy for enhancing commitment and improvement, adequate and appropriate membership of partner organisations, equity arrangements, social and structural integration, formal project processes, continuous improvement and feedback. Barlow and Jashapara (1998) suggested a need to distinguish between partnering that happens at a strategic (longer-term) level and more tactical project level. Many have sought to identify critical success factors and benefits of partnering, often through self-perception questionnaire surveys (e.g. Black *et al.*, 2000), or small-scale case studies (e.g. Beach *et al.*, 2005). There are also studies dedicated to examining project processes in great depth (e.g. Cooper *et al.*, 2004) to encourage development of the partnering ethos among stakeholders as early on in the project life cycle as possible (e.g. Matthews *et al.*, 1996). Formal tools and procedures (e.g. Loraine, 1993) are also frequently emphasised, alongside investigations into such social dimensions as trust (e.g. Wood *et al.*, 2002) and chemistry (e.g. Nicolini, 2002), with a view to encourage seamless integration of working practices across partner organisations. The use of information technology is also highlighted to encourage information and knowledge sharing (e.g. Tan *et al.*, 2007). Research into partnering has also evolved to consider the role of suppliers (e.g. Jones and Saad, 1998; and Saad *et al.*, 2002). Partnering in construction has also attracted international interest, even though a majority of studies are rooted in an Anglo-American perspective (see e.g. Cheng and Li, 2002; Cheung *et al.*, 2003; Chan *et al.*, 2004; and Tang *et al.*, 2006).

Problems with the desired state of partnering

Despite much research endeavour to promote the ideals of partnering in construction, difficulties of implementation and problems of unified understanding persist (e.g. Gadde and Dubois, 2010). Several commentators have argued that the empirical basis for claiming benefits of partnering remains weak (e.g. Naoum, 2003; Alderman and Ivory, 2007; and Nyström, 2008), because methods used to highlight performative outcomes of partnering simply fail to consider the contingent and localised nature of construction work (Bresnen, 2007). Furthermore, tracing the causality of better performance to the introduction of partnering practices remains a challenge (e.g. Beach *et al.*, 2005). Others are more critical to suggest that the language of partnering does little to help eradicate adversarial business-as-usual practices that encourage a corporatist agenda, which subverts the possibility of developing genuine, collaborative working relationships (e.g. Green, 1999; and Alderman and Ivory, 2007). One such example often cited in the literature is the absence of material benefits accrued to partner organisations further down the supply chain because of the perpetuation of cost-reduction strategies (e.g. Dainty *et al.*, 2001; Wood and Ellis, 2005; and

Briscoe and Dainty, 2005). Formal methods and procedures aimed at systematically introducing partnering practices have also been charged for being too prescriptive and over-engineered, and thus unworkable in reality (e.g. Phua, 2006; and Chan *et al.*, 2006).

Emphasising the „practice-turn" of partnering: a need to scrutinise paradoxes in the process of forming partnerships

By reviewing the two streams above, it is observed that the essentialist view of partnering in construction predominates in the literature. So, the term „partnering" is taken at face value by supporters and critics alike. Enthusiasts amass evidence (often uncritically) to demonstrate the existence of „best practice" approaches and positive outcomes, whereas contenders see the absence of „partnering" in reality and challenge its orthodoxy. In order to understand how collaboration can be a good thing for all involved, there is a requirement to shift the perspective of partnering in construction away from an essentialist view to one that is based on the *ontology of becoming* (see Chia, 1995). As Cousins (2002) assert, partnerships do not exist, and certainly not as cosy constructs. According to him, it is critical to refocus on the process of partnerships rather than its static, idealised form. Indeed, as Bresnen and Marshall (2001; 2010) argue, there is still a lot of scope to study the emerging practices of partnering in construction to understand how the process of partnering becomes accepted and applied in reality.

In the heat of the battle between proponents and opponents of partnering in construction, one critical dimension that has hitherto been given scant attention is the resolution of paradoxes and contradictions in the early stages of forming partnerships. Whilst studies have been undertaken to explain the general nature of organisational paradoxes (see Smith and Berg, 1987) and tactics for dealing with these (e.g. Poole and van de Ven, 1989; Clegg *et al.*, 2002; Beech *et al.*, 2004; and Smith and Tushman, 2005), the exposition of paradoxes in the construction industry is much rarer (see exceptions on strategy in construction by Langford and Male, 2001; Price and Newson, 2003; Chan and Cooper, 2010). Yet, there are inherent contradictions associated with inter-firm collaborations that need to be scrutinised, so that problems arising from these paradoxes can be dealt with when constructing partnerships in construction. For example, London and Kenley (2001) highlighted the tensions created by simultaneously maintaining competition and cooperation in integrating supply chains. Bresnen (2007) also deconstructed seven paradoxical effects of partnering vis-à-vis Bennett and Jayes" (1998) recommendations, including wishful strategic thinking and unrealistic targets, the dangers of fostering exclusive relationships, exploitation, reinforcing a false sense of control and over-engineering of processes, and failure to encourage organisational learning.

Notwithstanding the identification of these paradoxes in partnering, the dynamics of how these paradoxes emerge, and how these might usefully be tackled when developing the process of partnering in construction, remain relatively under-explored. Thus, the present article seeks to contribute in two main areas. Firstly, the study reported in this article adopts a practice-based approach to explain the process of early formation of partnering in a single ethnographic case study. In so doing, a number of paradoxes have been identified, and their manifestations observed. And so, the second contribution of this article is an analysis of the dynamics these paradoxes, which would help shed light on how tackling these paradoxes might go some way in affording better collaborations in practice. The next section will describe the observational context and method.

Case Study Observations: Context and method

This case study arose out of the involvement of one of us – the last author – who was working as a project management support officer to a railway company known as RailCo1. RailCo1 is a local client organisation, governed as a quasi-public sector organisation, with a long history of providing railway infrastructure in London. As a client organisation, it is responsible for providing capacity enhancement to the railway infrastructure managed under its authority, which includes upgrading of existing stations. At the time of the research (between March and November 2009), an opportunity emerged that permitted her to engage in ethnographic research. She was involved in a project to build a new station facility (named as the „Project"). This facility was to be constructed by RailCo3, a newly set-up railway client, also governed as a quasi-public sector organisation, charged with building new railway infrastructure in London. However, the „Project" meant that infrastructure owned by RailCo2, a national railway client wholly owned and regulated by the government that is responsible for the ownership of the national railway infrastructure, had to be relocated to another part of the station. The relocated part of the station is to be built and owned by RailCo2 and operated by RailCo3.To complicate matters further, the relocated facility would then become adjacent to infrastructure owned by RailCo1, which in turn restricted RailCo1"s ability to implement its strategy to enhance capacity. Concomitantly, RailCo1 had within the previous 12 months of the commencement of this research completed a long process of subsuming a loss-making public-private-partnership responsible for upgrading stations within its network boundary.

To coordinate the project across the three companies, it was decided that an integrated project team (named here as RailPro) involving members from each company was set up. This decision was also driven by senior officials at the governing authority of Greater London as a way to rationalise resources. One senior representative from each of the three companies – each were accountable to the board of directors of their respective companies – also formed a Liaison Group (named here as RailLG) to facilitate strategic discussions around the formation of RailPro. As discussed above, it is critical to study how the process of partnering comes into being. Moreover, it is important to understand this in the context of the early phase of a project (Kolltveit and Grønhaug, 2004). Hence, this case study presented a unique opportunity to get rich and deep insights into the formation of a new partnership that happened during the early stage (i.e. concept design stage) of the „Project". Data sources used for this research included interviews with key participants involved in the „Project" and „RailPro" (see Table 1 below), observational data, and documentary evidence.

Table 1. Profile of project participants interviewed for the research.

Interviewee	Role	Organisation
A	Senior project manager *(operational)*	RailCo1
B	Sponsor and representative on RailLG *(strategic)*	RailCo1
C	Project management support *(operational)*	RailCo1
D	Sponsor and representative on RailLG *(strategic)*	RailCo2
E	Project engineer *(operational)*	RailCo2
F	Sponsor and representative on RailLG *(strategic)*	RailCo3
G	Building services engineer *(operational)*	These were design consultants involved in delivering the concept design for the 'project'.
H	Design lead for architecture *(operational)*	
J	Design lead for engineering *(operational)*	

The research questions informing the data collection were initially concerned with identifying critical issues, enablers and barriers that contribute to effective knowledge sharing at the outset of the „Project". So interview questions included the role of the participant and their perspectives of notable events encountered in the „Project". Observations were recorded in the researcher's diary to make sense of the (visible and audible) social dynamics of participants during meetings and review workshops at the concept design stage of the „Project". Where appropriate, cross-references were made to minutes of meetings. The interviews were recorded and transcribed for analysis. The findings will be discussed in the next section, including the detour made during the research to focus on emerging paradoxes that surfaced in the formation of the partnership RailPro.

Discussion of Findings

As mentioned in the preceding section, the initial inquiry sought to explain knowledge sharing behaviours of participants in this case study. The motivation came from previous *"show stopping"* experiences between the three RailCos when undertaking site acquisitions and negotiations on land use. There was then an observable absence of effective knowledge sharing within and across each of the three companies, which led to the pursuit of this research project in the first instance. At the start of this research, high-level meetings that occurred at the RailLG level and „Project" review meetings were concerned with two key issues, namely geographic and systematic integration of operations across the three RailCos into the formation of RailPro. Questions were raised about the possibility of co-location of staff and setting up of operating procedures for RailPro. Put simply, the procedural form and scope of the partnership were being developed (Loraine, 1993). It was also clear to the participant observer and interviewees that the formation of RailPro meant that resources were not only being shared, but rationalised as well since there were clearly duplicity in terms of roles and responsibilities. It is worth noting that there were redundancies that actually took place soon after the research. Given this backdrop and the chequered past of difficult working relations in the past, participants had expected that the sharing of information would not be forthcoming. Surprisingly, this was not what the researcher observed at the initial stages of the formation of RailPro. Participants exceeded expectations in that they appeared to be very keen about sharing the information they had about the „Project". The observations also yielded another interesting finding; that is, as procedures were increasingly formalised, the openness observed at the outset of the research started to dwindle. This led us to take a detour to explore the dynamics of this paradox, explained in terms of sensemaking, formal methods, and time synchronicity.

Paradox of sensemaking

It is widely known that as projects progress in time, participants travel from a phase of relative uncertainty towards producing outcomes that are more certain. Therefore, sensemaking (Weick, 1995) plays a significant role in this process. The need for participants across the three companies to make sense of what this „Project" was about and what setting up RailPro means for their work accounted for the relative openness observed in the initial stage of the research. Yet, this was not so straightforward. Rather, the keenness shown in terms of sharing information about their thoughts of the „Project" was a means for participants to assert one's authority in framing the scope of what the „Project" was seeking to do. As Participant A suggests, when people were introduced to RailPro from each of the three companies, some still needed persuading as to why RailPro was necessary. He added that they clearly *"had their own objectives and goals"* to articulate. In some respects, the sharing

of their perspectives of what the foundations of the cooperation should look like is more of a *sensegiving* (see Gioia and Chittipeddi, 1991), rather than a simple, emergent *sensemaking*, process. Thus, as Cousins (2002) aptly pointed out, the process of forming partnerships is often rooted in a hard-nosed reality than many enthusiasts would concede. As the shape of the collaboration takes a more structured form, participants tend to shift their positions to make statements like *"this is not how we would do things in [our respective companies]"*, indicating dissatisfaction with how the partnership arrangements are being articulated, and creating an impression of *sense-hiding* (see Maitlis and Lawrence, 2007) instead.

Paradox of formal methods

Proponents of partnering in construction place much emphasis on formal tools and procedures. Yet, when RailPro was first conceived, participants at both strategic and operational levels were „doing" collaboration designing the „Project". Formal contracts were only signed and agreed between the design consultants (Participants G, H and J) and RailCo1. Yet, discussions were observed to continue fairly openly between the consultants and members of RailCo2 and RailCo3 as well. It would seem that delivering the „Project" mattered more than the formal rights and responsibilities articulated in the contract document, even though the „Project" – at least for RailPro – was still being reified (see Hodgson and Cicmil, 2006). Contracts have been known to invoke communicative acts and social interactions in projects (e.g. Marshall, 2006; and Bresnen and Harty, 2010). It would seem that the absence of contracts also have the power to stimulate, in this case, information sharing between participants. As a typical comment suggests, the *"lack of contractual arrangements did make for more openness."* Paradoxically, for Participant E, the finalising of contracts did prohibit him from *"getting pally"* with some of the other participants, and he stressed that *"informal arrangements definitely broke down the barriers normally found in communications between the two organisations."*

Paradox of time synchronicity

Time is an important dimension in projects. Yet, the partnering literature has ignored this critical aspect. In prescribing often-linear stages of the partnering life cycle, time is often treated as synchronous, and that partners necessarily know where and when they fit in within such a framework. Moreover, partnering in project-based environments normally downplays the idea that members have shared histories and futures. This is certainly not the case here. In the formation of RailPro, members have had past experiences of working with each other, and so they have entered this collaborative arrangement with some sense of a shared history. Despite sharing a past, the expectations of members about the future of the new collaboration were nevertheless far from uniform and synchronised at the outset. As discussed above, members had to make sense of the complex realities of how collaboration could be fostered effectively between the three RailCos. This required members to go through, in their own time, the processes of sensemaking, sense giving and sensehiding, which are often messy and difficult to delineate into neat categories of a life cycle. Put another way, whereas it is relatively easy to recognise the need for participants to develop a common future in principle, the reality is such that the participants were constantly trying to understand where their contribution to RailPro"s future lies. As Participant E puts it, members were reflecting on *"their experiences and know whether they hold knowledge that is of use"*, as they struggled to formalise the collaborative arrangements in RailPro. As illustrated in the paradox of sensemaking, this resulted in some members becoming winners and others becoming losers in this collaborative venture. As Participant A pointed out, not all the members are willing

and able to go along with the shared future concretised in RailPro. Participant A remarked, "*it was tricky to do what was best for the „Project" and still protect the interests of respective companies."* This would suggest that not everyone abided by the „programme" of this partnership formation. Bresnen (2009) coined the phrase "living the dream" to stress the lived realities of partnering in construction. Perhaps the participants in this case study are *chasing the dream*, burdened with past histories and passing through time, however asynchronously, into a possible shared future? Indeed, the notion of time and how it shapes partnering practices, and the paradox of time synchronicity, deserves more research attention.

Conclusions

"Personalities played a key role in the [partnering] success (Participant A)." At a very basic level, human relations do matter in achieving effective collaborations. But this is not the full picture. This case study research contributes to a more holistic view of how the process of partnering could potentially (and simultaneously) be driven and hampered by a range of paradoxical issues. Yet, paradoxes are rarely examined in detail in the construction management literature. Here, sensemaking, formality and time synchronity have been exposed as paradoxical constructs in the start of a new collaboration, albeit with „old" partners. These paradoxes raise a perplexing, if interesting, question to advocates of formal and prescriptive tools used in partnering (and in project-based working more generally). How did the absence of formal mechanisms lead to the observation that members were actually „doing" the collaboration and the „Project"? Clearly, the station facility was still being designed and planned for construction, despite members being clear where they stood with the relationship between their respective organisations and newly-formed one. Of course, human agency still prevails in this situation, afforded no less by the emergence of these paradoxes. Whilst the contradictions may have disrupted the idea of formal, prescriptive methods, they were also found to be generative in terms of social interactions and dialogue. What is clear from the case study is that conversations and arguments happen as individual agendas become articulated and legitimised. The only certain conclusion is that the members involved have, by living through these paradoxes and chasing the dream of more effective coordination between partners, legitimated the form of partnering that eventually makes sense (see Oliver, 1997; and Vaara and Monin, 2009). Such insights gained through ethnographic research are therefore required to explore fully the process of how partnering comes into being. Whether the outcomes are positive or negative (or even coherent with the intended strategy) does not matter so much!

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USING 'WHOLE LIFE CYCLE VALUE' TO EVALUATE INFRASTRUCTURE MEGAPROJECTS

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Abstract
Project evaluation is an effective tool in project management as it provides stakeholders with a management process through which they can learn from the past and perform better in the future. Although various project monitoring and evaluation methods have been used in the construction industry, most of these traditional evaluation approaches emphasize the three basic success criteria of time, budget and quality. However, recent research emphasizes the importance of 'satisfyting' key stakeholders. It is therefore necessary to develop a more holistic evaluation tool to evaluate projects from perspectives of all key stakeholders. However, it appears that no systematic project evaluation approach focusing on project stakeholder perspectives, has been developed.

This paper aims to develop a systematic evaluation model, based on the concept of whole life cycle value (WLCV), which integrates all the key stakeholders' value objectives and can be used to evaluate an infrastructure megaproject more holistically and comprehensively.

Projects aim to deliver value, including cost savings for client, desired functions for all end-users and other stakeholders over the whole life. It is therefore important to be able to identify, analyze and deal with the expectations of each group of stakeholders over the entire project life time, i.e. from client requirements formulation stage to demolition / re-use stage. In order to measure WLCV, we must identify its essential components, namely: significant criteria for measuring project WLCV, as well as related indicators which will help evaluate specific dimensions of the parent criteria. To be holistic as intended, both criteria and indicators should together reflect the value objectvies of all stakeholders including the client.

Based on a comprehensive literature review in evaluation and value studies, several semi-structured interviews with experts in academia and industry, and findings from the first stage of a relevant case study, this paper proposes a preliminary WLCV model for infrastructure megaprojects. A preliminary WLCV framework will be formulated in the next stage of this research, based on the findings of a planned questionnaire survey. This paper concludes with a discussion of some of the major difficulties in identifying, balancing and formulating WLCV criteria and some useful directions and opportunities for further research in this field.

Keywords: project evaluation, whole life cycle value, stakeholders

INTRODUCTION

A megaproject is described as a remarkably complex, large-scale project that has considerable influence on the economy, society and environment. The contract sum of a megaproject is usually very large, normally exceeding $ 1 billion in Hong Kong (Works Bureau, 2002).

In the past decades, while many countries planned and undertook more and bigger infrastructure megaprojects, many shortfalls have emerged in their delivery, such as poor performance in term of cost overruns, schedule delays, and shortfalls in expected benefits. This has been the case for many years and existing data show no immediate end to this situation. This megaproject paradox and shortfall was demonstrated in a seminal book (Flyvbjerg et al., 2003).

However, the rapid economic growth and the growing public expectations from public projects reveal the emerging concept that better value is more importance than the lowest cost. Saxon (2005), ASCE (2007), Levitt (2007) advocated that the construction industry should compete on the foundation of ‗added value' rather than only on cost efficiency.

Due to the strong economical and social impact of infrastructure megaprojects, it is suggested that their performance should be measured from a broader aspect – value instead of a cost perspective only. Based on this assumption, this paper presents the preliminary findings of an on-going research project titled ‗Integrated whole life cycle value framework for infrastructure megaprojects' which focuses on evaluation & monitoring project whole life cycle value (WLCV). The paper delves into the current infrastructure project evaluation situation in Hong Kong and brings out the need of a WLCV evaluation approach. The development of this WLCV model integrates all the key stakeholders' expectations into the client value system. This provides all the stakeholders a sense of ‗fairness' and ‗ownership' which encourages them to co-operate with common value objectives.

THE NATURE OF PROJECT EVALUATION

Project evaluation is an effective tool in project management which requires appropriate measurement of performance levels. It is a systematic analytical method, which is conducted aperiodically to measure and explain project performance issues (Samset, 2003). Figure 1 is derived from a relevant research conducted by Samset (2003) who presented three levels of evaluation.

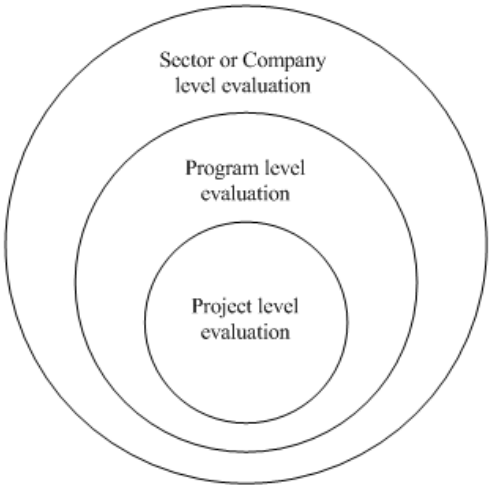


Figure 1: *Three levels of project evaluation (Samset, 2003)*

The single project evaluation can be divided into three stages – ex-ante evaluation, interim evaluation and ex-post evaluation. Nowadays, for single project, the emphasis of evaluation are put on the ex-post and interim stages and limited to the cost and quality dimensions.

It is critical to evaluate a project before commencement, as this can help determine whether the right decision is made at the start. It does not matter whether you implement a project extremely well or extremely poorly, if you are working on the wrong project.

It is also importance to involve all the relevant stakeholders from the start. As stated by Samset (2003) there will be several key stakeholders whose interests need to be considered in the process of any evaluation. In order to satisfy their needs, their preferences and attitudes should be ascertained carefully. Moreover, the earlier stakeholders are involved in the project, the better it is for effective and efficient project delivery.

In order to resolve the issues in infrastructure megaprojects, the evaluation emphasis should be on value. Also the evaluation stages should be more comprehensive. These aspirations need to be recognized in future megaproject formulation and implementation. Although, the requirement of evaluating project value during a project whole life cycle has been recognized, few studies have been conducted in this area.

THE PRACTICE OF PROJECT EVALUATION IN HONG KONG

The project evaluation & monitoring of local industry has its own uniqueness and requirements. In order to understand the current evaluation situation and identify whether it is necessary to develop a value evaluation approach, a good start would be by conducting interviews with relevant experts from both public and private sectors.

From early June, 2010 to early January, 2011, 11 semi-structured interviews were conducted with interviewees from academia, Architectural Services Department (ASD), MTR Corporation Limited (MTRC), EC Harris, AECOM and Hong Kong International Airport. Through these interviews, general opinions on the current practices of project evaluation were obtained from major clients in the local construction industry.

Based on the interviews conducted with the experts, it was observed that there has been no systematic project evaluation based on project value throughout the infrastructure projects in ether public or private sectors. Although, many major Hong Kong project clients including the ASD and the MTRC have introduced the whole life cycle concept into their evaluation, their evaluation still mainly based on the LCC not WLCV. However, the consensus now is that value is more important than only cost.

The majority of interviewees believe that a framework to guide the project WLCV evaluation process is needed to improve the overall project whole life performance, provided that it is comprehensive enough to be applicable to different types of projects, offers a sufficient degree of flexibility in different situations and will be easy to use in practice.

Another finding was that obtaining the stakeholders point of views are critical, for which stakeholder engagement is already conducted in ASD, MTRC and the Hong Kong International Airport.

THE USE OF PROJECT WHOLE LIFE CYCLE VALUE IN PROJECT EVALUATION

A review of common tools in project evaluation

Life Cycle Cost

The project life cycle cost (LCC) concept, which emerged since the 1960s, is an economic assessment indicator based on the relevant significant cost of ownership during the economic life of an item, area, system, or facility, expressed in terms of equivalent dollars (Dell`Isola 1982).

Although the LCC approach purports to include non-economic costs including those related to safety, environment, customer satisfaction etc, these factors are often only used to temper the result rather than incorporate in the final calculation. The fundamental consideration in LCC is cost which is so dominant, that it can lead to omitting, if not neglecting, these non-economic factors. Therefore, it is often likely that ‗cost' is the only consideration in the process of comparing alternatives. Furthermore, emphasis on lowest cost may lead to some significant problems. The lower cost may be obtained by mean of compromising project quality or environment. Nowadays with the increasing emphasis on sustainability both at project construction, operation and maintenance stages, these non-economic factor become more and more critical. Furthermore, LCC approach is usually based on the client point of view without considering ‗costs' of other stakeholders such as all end-users, contractors, suppliers etc, who also play an important role in the project.

Key Performance Indicators

Many previous performance measurement criteria such as Key Performance Indicators (KPIs), involve identifying all the critical indicators and providing a suitable guideline on how to measure them to evaluate project and organizational performance throughout the construction industry. For example, seven main groups including: time, cost, quality, client satisfaction, client changes, business performance and health and safety were recommended in the KPI report for the minister for construction in UK (The KPI working group, 2000). The

information obtained from the aforementioned set of KPI is used for benchmarking and helps organizations to achieve best practices. Lueng and Edum-Fotwe (2005) stated that critical performance indicators can and should be applicable to evaluate projects. However, there are limitations in applying this approach to existing project management practices. For example:

- Limitation 1: It has been noted that there should be connections amongst the indicators. The current KPIs system are used to evaluate projects typically by providing parallel comparison existing factors of time, cost, quality and client satisfaction etc (Lueng and Edum-Fotwe, 2005). Kumaraswamy and Thorpe (1996) stated that the interactions between indicators can be expressed through linkage factors / indicators. However, in most KPIs systems this kind of relationship is not presented appropriately.

- Limitation 2: The approach of the KPIs is by and large based on evaluation by client, contractor, designer and other organizations which have contractual / legal relationships with the project. Considerations of the other stakeholders such as the end-users, green groups etc are not included. According to Ward and Chapman (2008), most projects especially infrastructure megaprojects have a large number of stakeholders who contribute important components of uncertainty that can have a greater or lesser extent of impact on the project delivery process. So their opinions should be addressed appropriately. Furthermore a system value can only be measured from the stakeholders' point of views, as the purpose of the system is to provide service to them.

- Limitation 3: Inadequate contribution to the value objectives as described in the previous sections from all the stakeholders, albeit to differing extents and priorities.

Introduction to Whole Life Cycle Value

Historical development

Over the last several decades, a number of studies have focused on value such as that of Burt (1975), who stated that value includes two dimensions that are quality and cost in the construction field; Best and De Valance (1999) pointed to quality, cost and time. These previous studies mostly focus on value in a narrow sense. However, presently with the increasing injection of sustainable development criteria and concerns in construction industry planning and operations, industry and project stakeholders are widening their interpretation of value and reconsidering and redefining value by adding other factors, such as those related to the environment and society (Thomson et al. 2003a and 2003b, Abidin and Pasquire 2007). Furthermore, the value outcomes could be influenced by many factors during the project whole life cycle and the interactions between the various factors may lead to inefficiencies and ineffectiveness in the processes of delivering projects. It is thereby concluded to be necessary to research value in a broader sense that is Whole Life Cycle Value (WLCV).

In previous studies on WLCV, different researchers have chosen different definitions. Browning and Honour (2008) stated that "Whole life value is the system's attribution (which includes benefits and sacrifices)." This definition was developed in the context of system engineering and not in infrastructure megaprojects. Kerzner and Saladis (2009) developed anther definition: "The value of a product or service within the context of project management refers to the relationship between the customer's expectations of product quality and product usefulness, short and long term, to the actual amount paid for it." This definition focuses on the customers' points of view. Kelly (2009) suggested that "Whole life value is the benefit

given less the sacrifices required, related to the renewable and non-renewable resources used in the construction or manufacture and maintenance stages over a number of time periods in a given length of time, less the residual value at the end of the project."

Proposed WLCV concept

However, all above definitions were developed in special context for the purpose of those particular studies. None of them can fulfill the current needs as identified in this research. Through combining the previous definitions and injecting the findings from the current study, the following definition was developed: the project value is the sum total of the expectations (expectations here meaning: what they want to obtain from the given project and what they are ready to give up in return, including positive perspectives-benefits and negative perspectives-sacrifices) of different stakeholders for a given project. Project WLCV is the aggregated expectations of all the stakeholders for a given project over its life cycle. The client's expectations form the primary / high priority part and the other stakeholders' expectations contribute to the secondary / lower priority part. This definition is conceptualized in Figure 2.

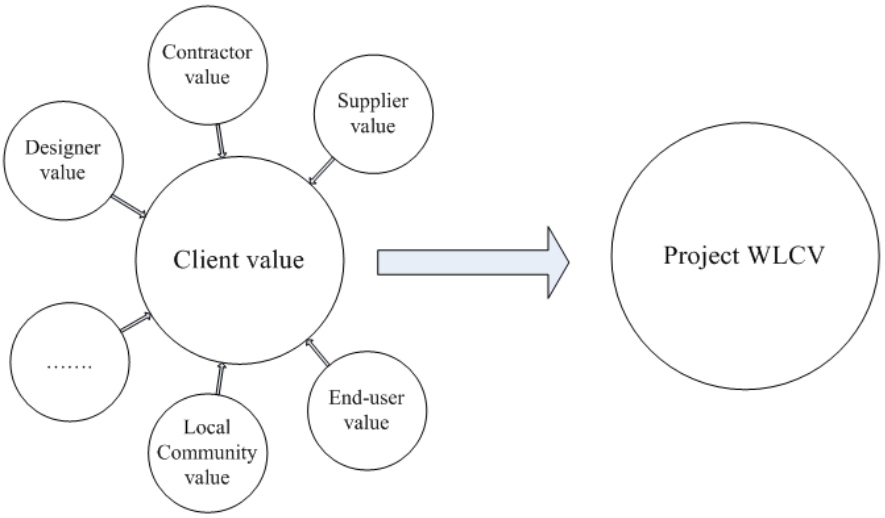


Figure 2: *The concept of project WLCV*

Characteristics of the proposed WLCV concept

The proposed WLCV concept is framed from three perspectives: multi-stakeholders, multi-stages and the dynamic nature of value. These perspectives are described as follows:

Multi-stages

In the context of the construction industry, there are many interpretations concerning the taxonomy of a project whole life cycle. For example, John et al. (2003) classified five stages: typically these are client requirements and briefing, design, installation, operations and maintenance, and disposal / reusing / recycling phases; Evans et al. (1998) divided the life cycle into three stages: design and construction, operational period, and demolition/recycling; Bennett (2003) stated that project whole life includes pre-project phase, planning and design phase, contractor selection phase, project mobilization phase, project operation phase, project closeout and termination phase.

In the current research, the project whole life cycle refers to client requirements stage i.e. formulation & briefing; design & construction stage; operation stage; demolition / re-use stage.

Multi-stakeholders

Many researchers presented different definitions of stakeholders. From the perspective of Freeman (1984) stakeholders are any groups or individuals who can affect or be affected by achievement of a corporation's purpose. Phillips (2003) presented two definitions: (1) "Those who have any input in decision making" and (2) "Those who benefit from the outcomes of a decision". Newcombe (2003) stated that stakeholders are groups or individuals who have a stake in, or expectations of a project's performance. According to Donaldson and Preston (1995) stakeholders are those who experience or anticipate experiencing potential benefits or dis-benefits as a result of the organization's actions. Despite the many definitions, most are within the context of an organization, with few focusing on project stakeholders.

In this paper, project stakeholders refer to groups or individuals who have special expectations from and vested interests in a given project; and can positively or negatively influence or be influenced by project performance. Chung (2010) developed a figure shown in Figure 3 which can assist to identify stakeholders in the current research.

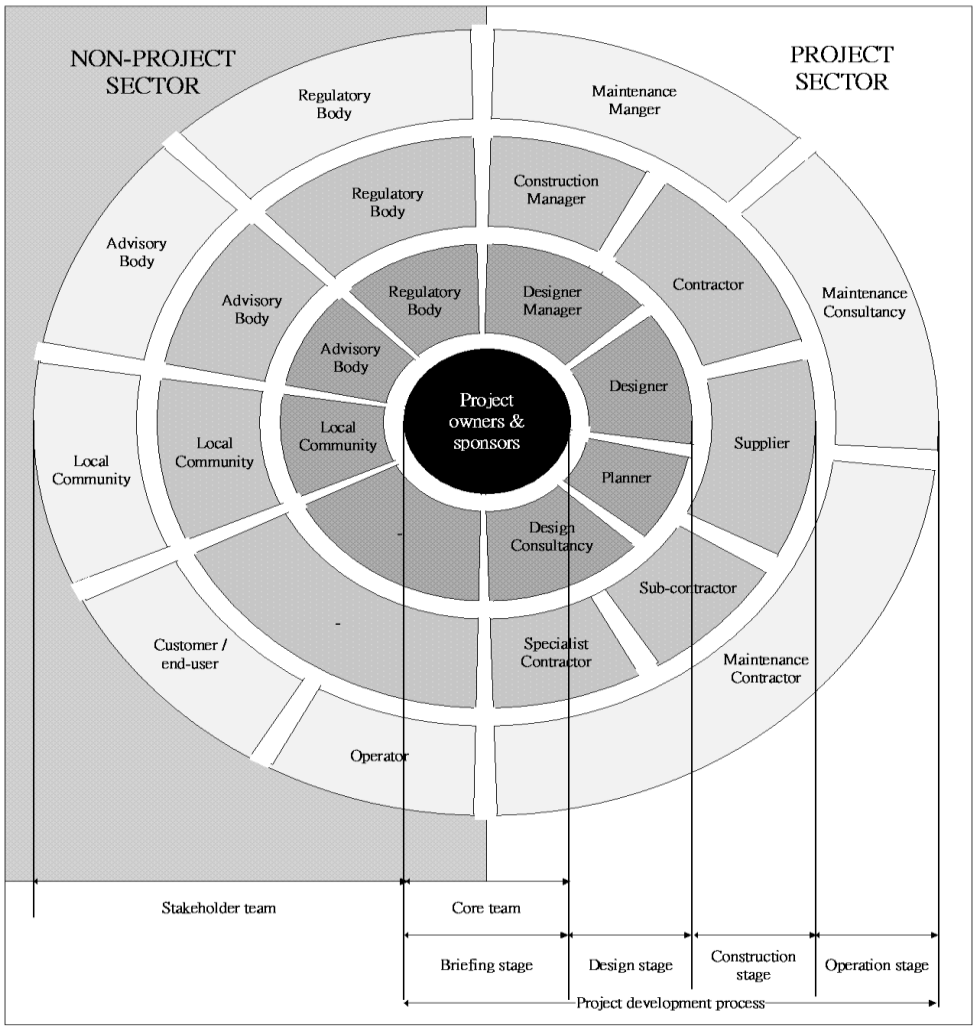


Figure 3: *Project stakeholders (Chung, 2010)*

The traditional view of the client as a single entity, who should make most of the important decisions about a given project has already obsolesced. The clients‘ views can not reflect the reality expectations of the other stakeholders. The importance of other stakeholders is widely recognized, as they can have positive or negative influence on the project performance. Newcombe (2003) applied an innovative technique to conduct stakeholder mapping in the context of a large construction project, demonstrating the importance for project managers to analyze the power, predictability and interest of key project stakeholders.

Despite many studies conducted about stakeholder management, scant attention has been received to joint stakeholder management for enhanced project value, leave along project WLCV. It is critical to consider stakeholders expectations from the project whole life cycle perspective, as the life cycle thinking applied during the decision making can provide a holistic view about the project to the key stakeholders (Thabrew et. al 2009).

The concept of combined multi-stakeholders and multi-stages is shown in Figure 4.

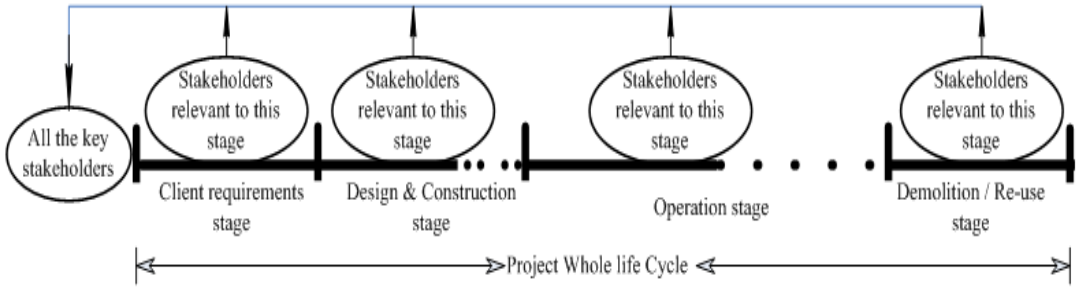


Figure 4: *The Concept of Multi-stakeholders and Multi-stages*

The dynamic nature of value

Kerzner and Saladis (2009) argued that sometimes project value can also change over time, but a project manager may not appreciate these emerging and dynamic needs. They also stated that factors, such as market-demanded changes, changing constraints and assumptions and technology advances were either not available or resources lacked the necessary skills etc, can lead to appropriate value expectations not being established, and hence trigger value shortfalls in the delivered project. So it is necessary to evaluate a project over time to detect if there are any changes that will influence the project value, and then take the necessary _ompensatory‘ actions, e.g. to change the plan or even abort the project.

Based on previous discussions, the conclusion is that it is necessary to apply the WLCV concept to evaluate the project over the whole life time. WLCV is a more holistic approach, which considers cost, quality, time and all other relevant performance factors and treats them impartially, compared with the LCC. The WLCV approach can make up for some of the disadvantages of LCC. Hence, it is possible and reasonable to introduce WLCV considerations to the process of evaluation & monitoring infrastructure megaprojects.

Feedback from industry professionals and a mini case study

Other findings from aforementioned 11 interviews with industry experts in the previous section are presented as follows:

It is very difficult to measure some qualitative factors, such as environmental protection and influence on regional economies etc.

It is also clear that we could face great difficulties in introducing a single set of value evaluation criteria for various types of infrastructure megaprojects, as each project is unique, so developing a project-specific WLCV criteria system is necessary. A more flexible model is required for project teams to formulate the most suitable evaluation system according to the specific nature of various projects. However, the new project value evaluation model should serve another objective, i.e. to provide a mechanism for the industry to benchmark project WLCV. Therefore, we should try to balance the two requirements in developing the new project value evaluation model.

After identifying the need for developing a WLCV evaluation system during the interview sections, the next step was to verify the possibility and benefits to conducting stakeholder engagement over the whole life of a project.

An on-going mini case study is being conducted in Hong Kong since October 2010. Data collection methods of the case study involve study of project documentation, interviews and observation of project meetings. This mini case study focused on the public engagement during this research stage. The project was to deck the existing Nullah and to construct an urban park on the decked Nullah. It would also expand the adjoin Road Roundabout. The project construction was commenced at the end of December 2009 and the decking work has been completed.

The preliminary findings from this case study prove that it is helpful to conduct stakeholder engagement at the beginning of the project. The public engagement in this project includes distributing leaflet to the community, liaising with Police, and DC member etc. After obtaining their viewpoints, the managers devised several strategies such as installation of Trash Net, guiding pedestrians and installing a sedimentation tank.

The key observation in terms of inefficiencies in value creation and value capture for the stakeholders in this case study are: (1) there are many different kinds of views from public and it is very difficult to get a consensus and satisfy everyone; (2) some factors can not be quantified so it is difficult to incorporate them into the decision making process, as well as to measure them.

On the positive side, the early informing of the community and relevant government departments helped the client to proceed the project with fewer complain and more co-operation. As the stakeholders had already expressed their opinions and learnt about the project progress, they felt a kind of _fairplay‘ and _ownership‘ which were incentives for them to support, or at least not oppose the project. The efficient management of the approval process for stakeholder engagement assisted in managing the issues and stopping them from flaring up into disputes.

THE PROPOSED WLCV BASED PROJECT VALUATION MODEL

Conceptual design of the model

The basic concept of this model will be illustrated in this section. This model can help the client to consider all the stakeholders‘ expectations for a given project.

Elements

An appropriate optimization mechanism will be chosen and used, along with statistical analysis to improve the WLCV model. Some information collecting methods are borrowed from a relevant research project completed in Loughborough University (IMCRC, 2005). The proposed model covers three stages: information stage, evaluation stage and re-analysis stage. The function of each stage and the database are presented in Table 1. Within the information stage, four kinds of data will be collected including: all the stakeholders of a given project; all the stakeholders‘ value objectives; weights of different groups of stakeholder; and weights of the value objectives.

Table 1: *Elements of the WLCV model*

Item	Function
Database	Providing generic data and benchmarks for comparison
Information stage	Collecting the four kinds of data for evaluation
Evaluation stage	Assessing whether the project WLCV within a reasonable range
Re-analysis stage	Re-analyzing the four kinds of data to identify the reason why the project WLCV can not live up to the client's expectations and what can be done to improve it.

Structure

The structure of the WLCV model is presented in Figure 5.

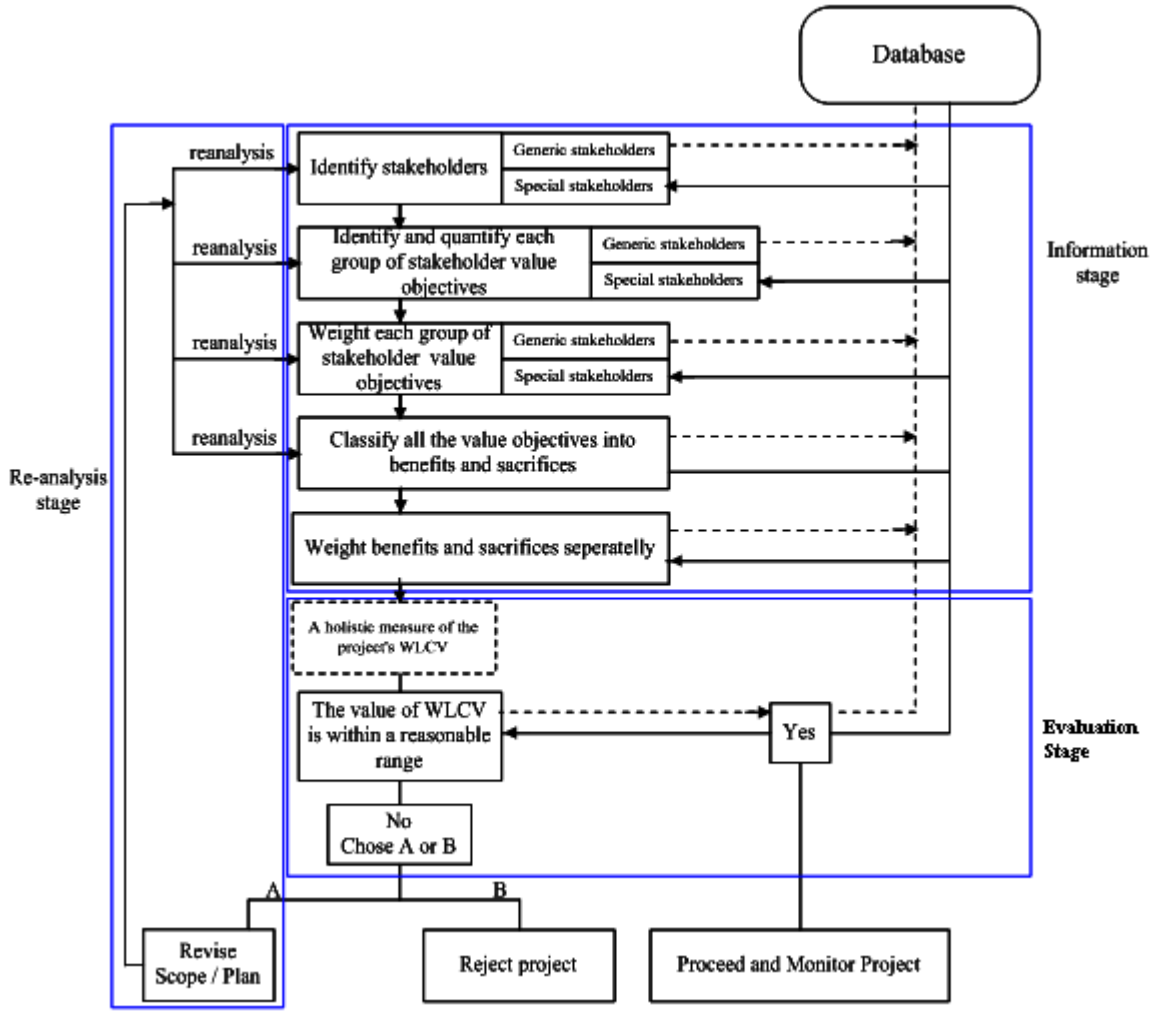


Figure 5: *Structure of the WLCV model*

These stakeholders will be divided into two kinds — project sector stakeholders who have contractual/legal relationships with the client and non-project sector stakeholders who do not have contractual/legal relationships with the client as shown in Figure 3. In operationalising the model, all the stakeholders will be identified during the whole life cycle of a project employing the aforementioned method. Next various value based decision making concepts such as lean approach, fuzzy theory etc will be evaluated for applicability and an appropriate method will be chosen. Furthermore, some experiences will be draw on from previous research work such as on ‗network value' (Kumaraswamy et. al., 2009), stakeholder management (CICID, 2007), project briefing (Chung et. al., 2009) etc and with a supplemental literature review to incorporate into the value dimensions and design of the evaluation criteria system.

Criteria system

As project value is too abstract to measure as one item, a multiple level criteria system is proposed. The strategy behind this approach is to divide project value into several sections which are much easier to evaluate & monitor. The concept proposed is as shown in Figure 6. The six levels are Project WLCV, Value Objectives (VO), Value Criteria (VC), Primary Indicators (PI), Secondary Indicators (SI), and Tertiary Indicators (TI).

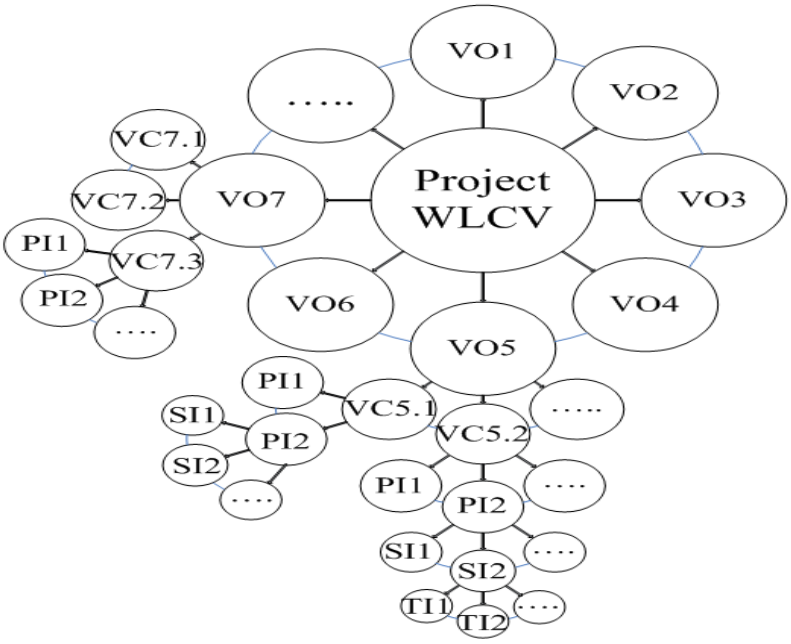


Figure 6: *Project WLCV Criteria System*

These value objectives can be divided into three categories which are the economic value objectives, the social value objectives and the environmental value objectives. This categorized approach integrates the sustainability concept into the WLCV. Also, the value objectives within each category include quantitative and qualitative types. It is much easier to quantify the former type. However, for qualitative value objectives, we can usually only obtain linguistic descriptions. Appropriate approaches (such as from fuzzy theory) will be identified to translate these descriptions into quantitative data.

The linkage factors/indicator will be introduced into this model after certain understandings of the factors interactions obtained. Thus the relationships among all the criteria and indicators can be expressed more realistically. The overall measure of the project value performance can then be more credible.

Limitations of the model

The preliminary model presented here is derived from the initial background work for a research project on ‗Integrated whole life cycle value framework for infrastructure megaprojects'. This model is thus still short of a fully researched, well structured and tested framework. It needs to be developed and adjusted with further practical data inputs and validation. Moreover, a well populated database is needed to be formulated to support this model and the formulation of a detailed guideline is indispensible. Many of these limitations will be addressed as the research project progresses as described below. However, some of them will remain beyond the scope of this research.

ROADMAP FOR FUTURE RESEARCH

An in-depth investigation on evaluating project value will soon be launched with an aim to unveil and incorporate other ‗value' factors to be considered into the detailed guidelines while evaluating & monitoring project WLCV, as well as unearth barriers to maximize project

WLCV with specific reference to Hong Kong. This will be approached through questionnaires and in-depth case studies. Further, strategies to overcome these barriers will be derived from best practices elsewhere and from experts‘ inputs. The model will be refined to reflect these limitations and accommodate the developed strategies; and will be validated by means of focus group meetings at appropriate research stages.

The findings of this particular research together with the findings for a framework of infrastructure project evaluation & monitoring, which forms the other part of this research will be the final output of the Integrated whole life cycle value framework for infrastructure megaprojects‘ research project.

CONCLUSION

The research introduces an innovative idea of using a project WLCV to evaluate projects over their whole lifetime, while addressing the conflicting value objectives among stakeholders. The final purpose is to evaluate & monitor project WLCV realistically.

The model is based on the premise that the value of a megaproject is impacted by the relative importance attributed to different dimensions by all stakeholders rather than only some stakeholders such as client, contractor etc. This model can assist the client to consider the involvement of various types of stakeholders (multi-dimension), such as all end-users, neighbors, suppliers and contractors, and different levels of stakeholders (multi-level), such as senior project manager and frontline staff. Moreover, involving stakeholders as early as possible, which can keeping potential problems from pushing stakeholders into adversarial posturing and consequential disputes, helps clients to achieve better project value.

Monitoring WLCV will also contribute to reduction of waste and environmental friendliness during the construction, operation, and reuse / demolition stages. In this regard, the need for an evaluation model of project WLCV has been proposed, especially for infrastructure megaprojects which have critical influence on the economy, society and environment. Also, this approach is seen to be capable of dovetailing well into current sceneries in the Hong Kong construction industry and in the long run will help improve infrastructure megaproject WLCV management.

The proposed evaluation system is expected to provide a sound approach to measure infrastructure megaproject WLCV in the context of Hong Kong, but can be modified and applied generally to other countries. However, the key is how to measure qualitative value objectives as well. How well the connections between the criteria / indicators can be defined and modeled will also pose a major challenge.

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DEVELOPMENT OF THE SUSTAINABLE BUILDING AND CONSTRUCTION PRODUCTS INDUSTRY IN AUSTRALIA

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Abstract

This paper draws on a major study the authors conducted for the Australian Government in 2009. It focuses on the diffusion issues surrounding the uptake of sustainable building and construction products in Australia. Innovative sustainable products can minimise the environmental impact during construction, while maximising asset performance, durability and re-use. However, there are significant challenges faced by designers and clients in the selection of appropriate sustainable products in consideration of the integrated design solution, including overall energy efficiency, water conservation, maintenance and durability, low-impact use and consumption. The paper is a review of the current state of sustainable energy and material product innovations in Australia. It examines the system dynamics surrounding these innovations as well as the drivers and obstacles to their diffusion throughout the Australian construction industry. The case product types reviewed comprise: solar energy technology, small wind turbines, advanced concrete technology, and warm-mixed asphalt.

The conclusions highlight the important role played by Australian governments in facilitating improved adoption rates. This applies to governments in their various roles, but particularly as clients/owners, regulators, and investors in education, training, research and development. In their role as clients/owners, the paper suggests that government can better facilitate innovation within the construction industry by adjusting specification policies to encourage the uptake of sustainable products. In the role as regulators, findings suggest governments should be encouraging the application of innovative finance options and positive end-user incentives to promote sustainable product uptake. Also, further education for project-based firms and the client/end users about the long-term financial and environmental benefits of innovative sustainable products is required. As more of the economy's resources are diverted away from business-as-usual and into the use of sustainable products, some project-based firms may face short-term financial pain in re-shaping their businesses. Government policy initiatives can encourage firms make the necessary adjustments to improve innovative sustainable product diffusion throughout the industry.

Keywords: sustainable products, innovation, construction industry, Australia

INTRODUCTION

World economic activity is expected to increase five-fold and global manufacturing activity to triple by 2050 (Matthews et al., 2000). With this predicted growth, increased importance is being placed on the development of sustainable products that minimise environmental impact, but also maximise performance, durability and re-use (Terry et al., 2007).

As a result of increasing public awareness of sustainable development and legislative and financial drivers, manufacturing firms are developing sustainable building and construction products to meet growing demand. Simply, sustainable products in the built environment refer to building and construction components that have environmental attributes or a lower environmental impact than alternative products (Terry et al., 2007). Sustainable products can be stand-alone, but are mostly used as a part of an integrated sustainable design strategy; and selection is rarely made in isolation. For example, the selection of a spectrally sensitive glazing product (that reflects radiant heat) would be used in conjunction with an external shade product to maximise energy efficiency.

Thus, a major challenge for designers and clients is the selection of appropriate sustainable products that are compatible in an integrated sustainable design solution. In selecting a suitable product, design considerations for the entire system should be considered such as: energy efficiency, water conservation, maintenance and durability, low-impact use and consumption (Terry et al., 2007). Construction and manufacturing considerations should also be taken into account such as distribution, efficiency in production and recycling.

This paper presents a review of the current state of sustainable energy and material product innovations in Australia. It highlights four case products, as examples of cutting edge development and discusses their proposed innovative contribution towards improving building and construction sustainability in Australia. Given the significant breadth of the topic, it has been necessary to profile selected innovations from across the full range available. However, despite the subjective nature of selection, authors sought advice from subject matter experts to confirm selection.

SUSTAINABLE PRODUCT INNOVATIONS

Case product types are now presented followed by a discussion of the system dynamics surrounding these products. The drivers and obstacles of product diffusion across the Australian construction industry are then discussed. The four case product types namely: solar energy technology, small wind turbines, advanced concrete technology, and warm-mixed asphalt, are presented in light of their expected system-wide impacts.

Solar energy technology (Photovoltaic)

Solar photovoltaic (PV) arrays generate electricity through solar energy with very little aversive environmental effects such as pollution or waste. Generally, they are also reliable products as they do not have moving parts, translating to ease of maintenance and long life spans.

Although PV solar panels are not a new technology to the building industry (the base concepts of the technology date back to the early 1900's), the technology is constantly evolving and is currently offering considerable benefits over earlier innovations. One of the

major barriers to the widespread use of this technology has been its limited efficiency in converting light energy into electricity. But as the technology has developed, so has its efficacy, which is continuing to improve. The latest performance from a photovoltaic cell device saw 40.8% of light energy converted to electricity, achieved in August 2008 (NREL, 2008). In Australia, the key market for this technology has been for 'off-grid' systems in the industrial, telecommunication and agricultural industries, followed by off-grid building residential systems (ABCSE, 2006). The off-grid applications for residential buildings include supplementing standard utility power and electricity backup. Large PV arrays have also been used in commercial buildings for offsetting power distribution during off-peak times. Recent cutting-edge research by scientists at the Australian National University (ANU) has developed transparent 'printable' PVs on a thin film polymer (Stohr, 2009). It is expected this innovative manufacturing process will not only significantly increase PV's cost-effectiveness, but open up a range of applications on buildings such as glazing integration.

Another emerging application of PVs is Building-integrated Photovoltaics (BIPV). Simply, BIPV refers to the use of photovoltaic materials as a replacement to conventional building materials, such as roofs, façades and glazing, thus improving aesthetics and integration within the architectural features of a building (Bhargava, 2007). In the Australian building industry, this innovative approach has been successfully trialled and has proven to achieve valuable electricity generation under Australian conditions (Prasad and Snow, 2004). It is expected the market for such products will expand as the PV technology further evolves.

Small wind turbines

Australia is known to have abundant and powerful wind resources, unrivalled in most of the world, which have yet to be fully tapped (Herbert et al., 2007). Wind technology has seen rapid growth worldwide (Price, 2006) and wind power currently attracts the most investment in the renewable energy resource sectors across the globe (Boyle et al., 2008). The investment in wind power generation has mainly focused on large wind farming, but an emerging area of innovation is small wind turbines that can be used to supply remote, off-grid electrical loads on various built assets.

Currently, the wind energy generation industry has invested heavily in large wind turbine aerodynamic profiling, with much less emphasis on the smaller wind turbines (Ackermann and Söder, 2000). However, small wind turbine research groups are emerging due to the increasing government emphasis on self-sufficient energy generation. For example, the Australian Government announced in August 2008 it would provide funding for a 'small wind turbine' test centre at the Research Institute for Sustainable Energy at Murdoch University in Perth, Western Australia (Garrett, 2008). Such research will assist in the development of small wind turbine technology to be used in the residential and commercial building sector. According to a global market report on small wind turbines by the American Wind Energy Association (AWEA, 2008, p.9), the recent technology advances globally in this field include:

- active pitch controls to maintain wind capture during high winds and automatic adjustments to blade pitch for best angles of attack
- vibration isolators and slower rotor speeds to lessen sound (wind turbines are traditionally very noisy)
- advanced blade design
- operational capabilities in low wind
- self-protection mechanisms during extreme wind conditions

- single models for on-grid and off-grid use
- wireless display and software support
- integrating turbines into existing structures such as utility poles, and
- aesthetically more attractive designs.

Wind turbines can be used not only for energy generation on residential buildings but also to power central air extraction/ventilation systems in large commercial or industrial buildings. A successful example of this latter approach is the CO2 building in Melbourne. The CO2 building has six wind turbines to power an air extraction system through ducts on the building's north façade. The wind turbines were purpose-built and replace the requirement for electric fans that would traditionally power air circulation systems (ABSJ, 2006).

Advanced concrete technology

Concrete technology has advanced rapidly over the last ten years. These advances have been in the areas of mixture proportions, aggregate materials, structural design, durability requirements and testing. However, many of these advances remain outside standard practice worldwide (Vanikar, 2004).

One product that has gained greater acceptance in the construction industry is High Performance Concrete (HPC). HPC contains specialised aggregate and admixture materials that are combined with traditional Portland cement (with generally high cementitous levels) to assist in achieving high durability and strong compressive performance. According to Vanikar (2004), emerging refinements include:

- the development of advanced chemical admixtures such as accelerators, retarders, corrosion inhibiters and water reducers
- advanced supplementary cementous materials such as fly ash and silica fume
- extended use of recycled materials in concrete, which are generally used as concrete and slag aggregates
- new concrete mixture proportions, as a result of improvements in concrete batch trailing and research, where continuous grading and workability tests are gaining greater acceptance
- new variations in concrete structural and durability properties suitable for specific conditions, e.g. high strength concrete for bridge design and durable concrete mixes for pavement design
- advances in concrete test procedures (such as shrinkage and air-void testing), which improve strength and durability outcomes, and
- improved concrete construction control – including advances in curing processes and the use of software to monitor concrete strength development and prevent cracking.

A recent innovation in supplementary cementous materials is a product called 'Eco-cement' developed by TecEco in Australia. Eco-cement replaces the calcium-base lime ingredient that is traditionally found in Portland cement with reactive magnesia (a form of magnesium oxide). The traditional manufacture of Portland cement requires high kiln temperatures to form calcium carbonate (and thus high energy use). However, Eco-cement can be kilned at around half the temperature (Pearce, 2002). This decrease in energy consumption can be quite significant as it is estimated the manufacture of cement accounts for approximately 7% of total man-made carbon dioxide emissions (Pearce, 2002).

According to Pearce (2002), the greatest benefit of Eco-cement over traditional Portland is its ability to rapidity absorb carbon dioxide from the air when it has been cured through a carbonation process. Therefore, if Eco-cement is used to produce masonry blocks, it has the potential to remove carbon dioxide from the air much like the function of a growing tree. Other benefits include incorporating recycled materials as the aggregate without losing structural strength. To date, this product has not gained wide acceptance within the construction industry and the base source materials remain expensive (e.g. magnetite).

Warm-mixed asphalt

An interesting and emerging product innovation in the road construction sector is a road surface application called Warm-Mixed Asphalt (WMA). Traditionally, hot-mix asphalt is created by heating a bitumen binder and aggregate to very high temperatures (around 170 degrees Celsius), which is then laid on the road surface hot and cures while it cools. Warm-mix asphalt (developed in Europe in the early 2000s), uses a two-stage process, where firstly, the asphalt is made using a specialised soft binder that allows the binder/aggregate mix to be heated at much lower temperatures (approximately 120 degrees Celsius); and secondly, a second binder is added (mainly a foam bitumen) that forms a combined mixture in similar grade to standard hot asphalt (AAPA, 2001). The use of WMA can significantly reduce cost as it uses up to 30% less fuel (a major ingredient in bitumen). It also produces a third less carbon dioxide emissions and dust than traditional methods (Whelan, 2009). Although testing is continuing to evaluate enduring performance, it is expected the warm mix may become a new benchmark for road construction worldwide (Whelan, 2009).

This paper now presents the product system dynamics surrounding the uptake of these innovative sustainable products; followed by a discussion of the issues impeding sustainable product diffusion in the Australian construction industry.

PRODUCT SYSTEM DYNAMICS

Project-based firms (such as contractors and consultants) are increasingly becoming aware of the importance of Ecologically Sustainable Design (ESD) for their future commercial viability, with many contractors expecting ESD and the use of sustainable building products to be mainstream in the next five years in Australia (Crabtree and Hes, 2009). Also, as a result of the increasing emphasis placed on ESD by construction clients and government, product supply networks (i.e. manufacturing firms and distributors) are focusing on the production and distribution of sustainable products to meet increasing demand. Currently, this demand is creating specialised markets, comprising small to medium-sized manufacturing and project-based firms in many cases.

The promotion of sustainable products is focused on the activity of the supply network (i.e. manufacturing firms and distributors). However, the development and implementation of innovative products in the marketplace is strongly driven by demand from clients and owners, and by users/facility managers who are concerned about long-term asset efficiency (e.g. life cycle cost savings). The uptake of sustainable products is also driven by project-based firms through a facilitation role. Project-based firms facilitate the diffusion of these products by prescribing to their clients the benefits that can be gained. For example, cost consultants can play a key role in promoting sustainable building options by quantifying the financial rewards and life cycle costing benefits to their clients and the design team (Clark, 2003). Also, technical support infrastructure actors (such as industry associations) play a role in promoting

the benefits of the innovative products at an industry level, and drive advances in product technology through research and development.

Regulatory and institutional actors (e.g. government authorities) within the product system assist in driving technological development and in increasing diffusion rates. The use of innovative finance options and positive government incentives are currently major drivers for the uptake of sustainable products in the Australian construction industry – particularly the residential building sector. It is expected that once the incentivised products gain market penetration and the technology advances, economies of scale will potentially bring prices down. For example, the Australian Government Solar Credit scheme offers a financial rebate for home owners, small business and community groups on the purchase of energy production systems up to 1.5 kilowatt capacity. This includes photovoltaic arrays, wind turbine and micro-hydro electricity generation (DEWHA, 2009). It is expected that increased demand, competition and production volume may bring prices down.

Government regulation also has a major role in the development and uptake of sustainable products. The Building Code of Australia (BCA) has incorporated minimum mandatory energy efficiency requirements for buildings, and Australian Standards dictate the minimum performance standards of products and new technology (such as minimum standards for the manufacturing of residential photovoltaic arrays). Also, Australian local and state governments have their own building environmental performance standards to encourage ESD in their regions. The combination of these regulatory and financial incentive approaches has been successful in promoting the uptake of innovative sustainable products in Australia; however, further education for project-based firms and the client/end users about the benefits that can be achieved may be beneficial. This would include both residential home buyers and commercial and government infrastructure clients.

SUSTAINABLE PRODUCT DIFFUSION

Innovation awareness is critical to the 'technology transfer' process. Many construction industry commentators agree that despite the increasing importance placed on ESD and sustainability, there remain barriers to wide spread adoption of these principles (and thus the acceptance of new products) (McGee et al., 2007, Crabtree and Hes, 2009). The levels of diffusion of sustainable products that are commercially available (and are set to be rolled out) is partly influenced by regulatory and pricing mechanisms in the industry (Crabtree and Hes, 2009). For example, a recent move towards the ratification of a uniform 'feed-in tariff' scheme in Australia potentially could improve the adoption of renewable energy-producing products (such as solar photovoltaic arrays) in the residential building sector. Currently, all Australian state governments have their own feed-in tariff schemes that offer residents the opportunity to be paid a premium for their locally generated electricity, to be fed back into the main power grid. Usually, locally generated electricity is metered separately from household energy usage, and is offset at a higher rate than the retail cost of the electricity from the utility company. In 2008, the Council of Australian Governments agreed to develop a set of national principles for new feed-in tariff programs (COAG, 2008). Regulatory improvements to the feed-in tariff systems in Australia have the potential to increase the cost-effectiveness of local energy production (as a part of a building system).

According to Terry, Walker-Morison et al. (2007, p.12), some of the real or perceived barriers to the diffusion of sustainable building products and materials in Australia include:

- sectoral conservativeness and slow building turnover, limiting exemplar projects to showcase new products
- diversity of rating tools resulting in confusion over the evaluation processes
- inconsistency in the industry's response due to a lack of mandatory sustainability standards
- high perceived costs, as cost evaluation is erroneously based on up-front costs, rather than on 'whole of life' costs
- inadequate in-depth knowledge to understand and assess new products and their integration and broader implications within the building system, and
- the need for new mindsets including a willingness to revise design and construction processes and timeframes to accommodate new product 'constructability' requirements.

The development of innovative sustainable products and processes are driven by the involvement of organisations large enough to absorb R&D and implementation costs. However, a major barrier to the development of these products is that the majority of the industry is made up of small to medium-sized firms who do not have the capacity to develop and implement such innovations in an emerging market. The industry needs to see the formation of new alliances between manufacturing and project-based firms to overcome cultural and resource obstacles to the development and diffusion of sustainable products and processes (Binder, 2008).

According to Crabtree and Hes (2009), a consistent approach is needed for dissemination of building product information (characteristics, costs and performance) to Australian designers and contractors. This includes improved collaboration and knowledge sharing to 'dismantle the myths and confusion perceived to be surrounding the financial implications of widespread implementation of sustainable design aspects' (p.223). It is expected that once the industry matures (and sustainable products gain greater acceptance), environmental performance will become a key consideration in the design and construction process and a consolidation process will occur (Terry et al., 2007). As more of the economy's resources are diverted away from business-as-usual and into sustainable products, some firms will face short-term pain in re-shaping their businesses. Government policy initiatives can help firms make the necessary adjustments.

CONCLUSION

This paper has profiled emerging sustainable product innovations offering significant performance improvement across the Australian building and construction products industry. These innovations contribute in a significant way to creating a more sustainable built environment in Australia. Given the significant breadth of the topic, it has been necessary to profile selected innovations from across the full range available. This selection has been necessarily subjective, but is nevertheless based on the advice of subject matter experts. It is expected future research will be able to quantify the relative promise of the profiled innovations, but as a starting point, this paper has mapped the product system dynamics surrounding the uptake of these innovative sustainable products; and identified key obstacles impeding their wider uptake.

Overwhelmingly, this paper points to the important role played by Australian governments in facilitating improved sustainable product adoption rates. This applies to governments in their various roles, but particularly as clients, regulators, and funders of education, training, and research and development. In their role as clients, Australian governments can better facilitate innovation by reviewing their specification policies and adjusting them to encourage the uptake of advanced sustainable products and associated innovations. As a result of a major shift in government policy towards this goal, it is expected private sector clients would follow suit. In their role as regulators, Australian governments face particular challenges associated duplication and uncertainty in how sustainable products are approved for use. This means that innovators often face high costs associated with gaining approval for products across multiple government jurisdictions. Also, regulatory and pricing mechanisms to encourage sustainable product use by consumers/clients require ongoing ratification across government jurisdictions. In relation to the BCA, recent reforms in environmental standards/benchmarks have helped to encourage the uptake of innovative sustainable products, yet greater emphasis on environmental performance, mandatory sustainability standards and performance-based regulations is encouraged.

Finally, in relation to education, training, research and development, the literature and subject matter experts agree that there is a lack of adequate understanding of the net benefits associated with particular sustainable product innovations. It is recommended Australian governments place further emphasis on education programs, training and demonstration initiatives to encourage a cultural shift towards decision-making based firmly on the consideration of long term whole-of-life costs and wider environmental benefits.

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FORMAL AND INFORMAL CONTRACTING WITH THE COMPETITIVE DIALOGUE PROCEDURE

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Abstract
Recent developments in the construction industry led to the need for both more and changing formal contractual arrangements and for improved informal cooperation. In this context, the Competitive Dialogue (CD) was introduced by the European Commission in 2004. This procurement method consists of several discussion rounds between the principal and potential suppliers, during which all aspects of the tender can be discussed. The CD procedure aims to align complex demands of principals with possible solutions that contractors have to offer. It is, however, unclear how formal and informal structures and processes in the CD are interrelated and are determining its effectiveness. Major question is how processes and products differ between CD-procured projects and comparable projects which are traditionally procured. *Insights of both formal and informal contracting processes are combined in a theoretical framework. Differences in (in)formal process and contract development between projects procured by the CD procedure and by traditional procurement procedures are studied in four comparable construction projects.*

Keywords: procurement, contracts, relationship development.

INTRODUCTION

The combination of increased project complexity (Baccarini, 1996; Laufer *et al.*, 1996; Alderman *et al.*, 2005; Walker, 2007), changed role of the government (Blanken, 2008) and the sector‟s poor professional functioning (Latham, 1994; National Audit Office, 2001; Dorée, 2004) form the context in which several changes in the construction industry are embedded. These changes are twofold: on the one hand they are aimed at new structures (formal processes and contracts) and on the other at new working relationships (informal processes and understandings).

Formal tasks and roles of the market and of government have changed. Public clients have less influence on the contents of works and confine themselves to monitoring and checking the public‟s interest. Conversely, market organizations have, alongside the executive, also more substantive tasks. Stemming from these changing tasks and roles, structures have been amended and are continuously developing. Integrated contract forms, PPP constructions and active discussions on aspects such as prices, risks and contractual terms are becoming more common during the procurement of construction projects. Further, there is also growing attention paid to the „soft‟ aspects of construction. The call for new cooperative forms, increased mutual trust, improved communication and mutual understanding becomes louder.

In this context, the Competitive Dialogue (CD) was introduced by the European Commission in 2004. This procurement method consists of several discussion rounds between the principal and potential suppliers, during which all aspects of the tender can be discussed. The

CD procedure aims to align complex demands of principals with possible solutions that contractors have to offer (Hebly and Lorenzo van Rooij, 2006). It is, however, unclear how formal and informal structures and processes in the CD are interrelated and are determining its effectiveness. In essence, there are two perspectives. In the first perspective, formal and informal structures and processes in the CD are serving as alternatives: what is arranged in a contract does not need to be discussed informally and vice versa. In the second perspective, formal and informal structures and processes are considered as complementary. Formal contracting processes can lead to informal processes such as the development of mutual expectations and social relationships.

Major question is how formal and informal structures and processes differ between CD-procured projects and comparable projects which are traditionally procured. Insights of both formal and informal contracting processes are combined in a theoretical framework. The outline of this study is as follows. In the next section, formal bargaining and informal sense making *processes* and the *products* of contracting - the formal and informal contract - are discussed into detail. It is explained that the linking concept between process and product is understanding. Based on the previous steps, propositions are developed based on both the policy rhetoric for the design of the CD procedure and on the theoretical insights. Subsequently, the empirical research design is presented. Differences in (in)formal process and contract development between projects procured by the CD procedure and by traditional procurement procedures are studied by selecting four comparable cases. Finally, the result are discussed and conclusions drawn.

THEORETICAL FRAMEWORK

Basis of the theoretical framework is the process model of Ring and Van de Ven (1994). This model gives an overview of how both formal and informal processes are involved in relationship development. However, in order to understand how these processes are interrelated, especially during the (in)formal contracting with the CD procedure, this model is expanded with the models of Ring and Van de Ven (2000) and Vlaar, Van den Bosch and Volberda (2006). These three relationship development models are combined into one framework for studying formal and informal contracting processes in procurement by the CD procedure. Central elements in this framework are formal bargaining, informal sense making (Weick, Sutcliffe and Obstfeld, 2005), the formal legal contract and the informal psychological contract (Rousseau, 1998). These elements will be further elaborated upon in the following sections and will guide the data collection and interpretation.

Formal bargaining

Relational development academics identify the following four mechanisms that occur in bargaining:

- *Focusing attention*: Vlaar et al. (2006) show how formal processes focus attention by pointing at order and content of decisions which are to be made.
- *Forcing articulation, deliberation, and reflection*: when bargaining over possible terms and conditions, parties are forced to make their individual and mutual goals explicit (Blomqvist et al, 2005, p. 501).
- *Interaction*: formal bargaining implies that parties exchange ideas about future tasks and outcomes by conversations and dialogues (Nellore, 2001; Yakura, 2002; Putnam, 2003).
- *Reducing biases, judgment errors, incompleteness and inconsistency*: the fact that in interorganizational bargaining processes usually several people are involved, compensates

for deficiencies in individual thought processes (Katz and Kahn, 1966; Ketokivi and Catañer, 2004).

The identified output of the bargaining process form conditions for the second part of the negotiations stage of procurement: informal sense making. Vlaar et al. (2006) state that formalization "enables, or even forces collaborating parties to engage in sense making, helping them to create common ground and achieve mutual understanding" (p.1622).

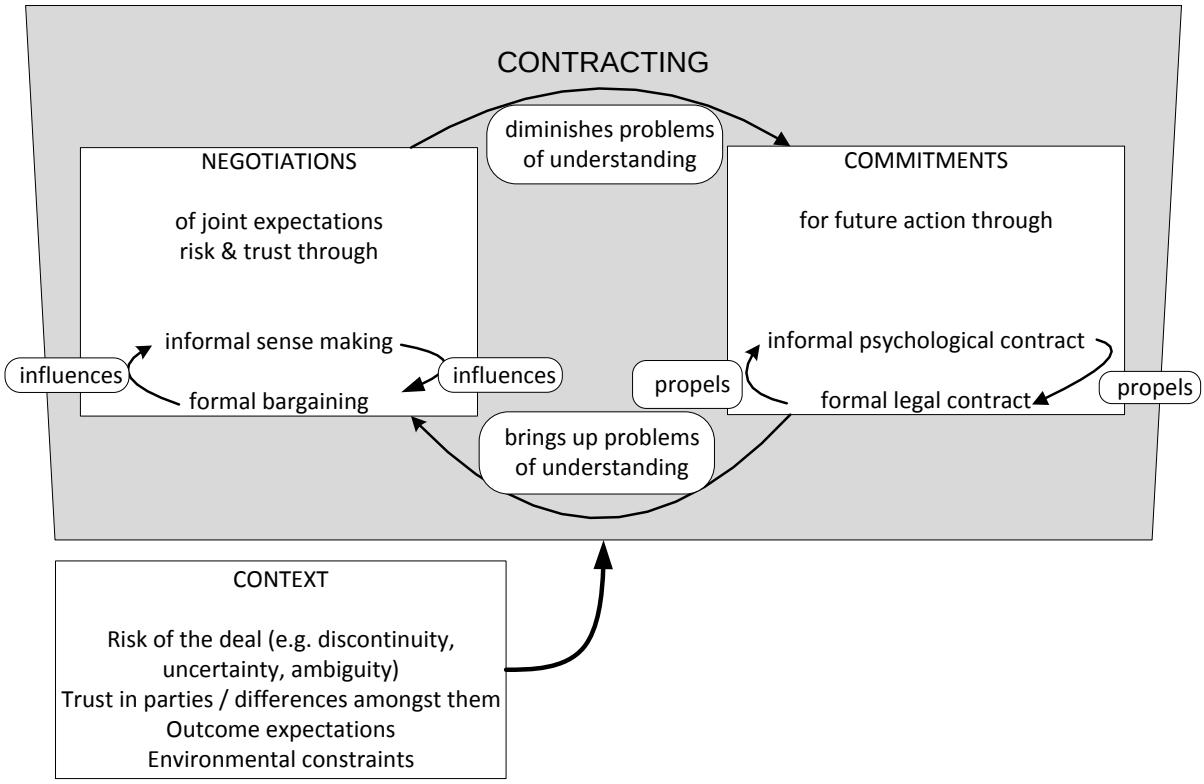


Figure 1: *Theoretical framework*

Informal sense making

Sense making is a social process during which organization members interpret their environment in and through interactions with others, thus constructing observations that allow them to comprehend the world and act collectively (Sandelands & Stablein, 1987; Starbuck & Milliken, 1988; Isabella, 1990; Sackman, 1991; Weick & Roberts, 1993). During the contracting process, two parties with differing patterns of beliefs and assumptions are to create coherent understandings in order to come to collective action (Maitlis, 2005; Weick, 1993). Since the two parties intend to work together, they will strive for congruency in views on purpose and expectations of the relationship. Sense making processes are therefore assumed to play a central role in the procurement of a project. These processes form "the primary site where meanings materialize that inform and constrain" action (Weick et al. 2005, p. 409, citing Mills, 2003: p.35). Weick (1995) describes the sense making process as an enactment process: parties produce part of the environment they face (p.30). The result of the sense making process in interorganizational contracting is to understand the transaction, the context of the transaction, the value of it to the other party and to oneself. Shared understanding between the two parties is reflected in mutual beliefs, norms, values and routines. These form the basis of the first part of the Commitments stage of procurement: the informal psychological contract.

Informal psychological contract

The psychological contract consists "of unwritten and largely non verbalized sets of congruent expectations and assumptions held by transacting parties about each other's prerogatives and obligations" (Ring and Van de Ven, 1994, p.100). Following the literature review of Van Den Brande et al. (2002), four aspects of these contracts are considered: subjectivity, reciprocity, implicitness, and obligation. These "elements of quasi-moral involvement among parties" are much more common among members of an internal organization, but can and do appear in a market context as well (Williamson, 1975, p. 38). Yet, in this research the term *informal (psychological) contract* is used. This term is used to make clear that it is opposed to the formal (legal) contract. Kadefors and Laan (2010) state that *informal control* is "about purposefully establishing norms, values and routines, to reduce discrepancies in goal preferences and inclinations towards opportunism. Consequentially, informal control reduces risk through the establishment of shared values. In this study, the informal contract refers to the implicit set of expectations between the client and the contractor and which is, unlike the written contract, continually changing.

Formal legal contract

Ring and Van de Ven (1994) describe how the informal contract becomes formally codified. As individuals act as agents for their organizations, these organizations will require formal documentation and standardization. Thus, the informal commitments made by negotiating individuals will be left in writing for their organizations and for other individuals acting as agents for those organizations. When the formal legal contract is perceived as a reflection of formal control, it contains both limitations of opportunities for opportunism and limitations of material incentives to utilize these opportunities. There are several mechanisms by which contracting parties could address these forms of control. The mechanisms, which are derived from transaction cost economics, are shift in rights/power of decision, rewarding systems, monitoring, and bonding. Vlaar et al. (2006) argues that formalization may also have negative effects on sense making, causing new problems of understanding. It may make events more comprehensible and controllable than they really are; it may lead to formalism, causing rigidity and a loss of creativity and flexibility, and diminished trust. Next to that, the writing of formal contracts may cause large efforts and huge transaction costs.

Understanding as a key concept

In the previous sections, the cycle negotiations – commitments – negotiations is elaborated upon. Key concept in this cycle is *understanding.* When having made sense of new situations, people desire to enact the input to their sense making processes back into their world to reorder it (Weick, 1995). The resulting collective consciousness, common reality, or shared *understandings* offer them a unitary basis for action. For those points on which this collective consciousness, common reality or shared *understandings* are reached, parties are in the commitments stage of contracting (Ring and Van de Ven, 1994). Yet, processes of informal sense making do also propel new formal bargaining processes. These new bargaining processes facilitate new sense making processes, which in turn could improve *understanding*. Ring and Van de Ven (1994) indicate that formal and informal processes are interacting during each stage of the development process. It is not just as if formal bargaining leads to a formal contract and informal sense making to a psychological contract. However, where Ring and Van de Ven (1994) assume formal and informal contracts to be each other‟s substitutes (existence of an informal contract diminishes the need for establishing a formal contract), the insights of Vlaar et al. (2006) suggests that formal and informal contracts serve more as complements. Developments in the informal contract effectuate developments in the formal

contract and vice versa. Understanding is assumed to be the main force in these developments.

PROPOSITIONS ABOUT THE WORKING OF THE CD PROCEDURE

The model developed, depicting how formal and informal processes and products are playing a role in inter-organizational contracting gives us an idea of the dynamics in (in)formal contracting processes involved in procurement processes like the CD procedure. This leads to the following propositions.

Context

The CD procedure was meant for the procurement of complex projects, of which technical, legal and/or financial solutions were not objectively specifiable by the contracting authority. Complex projects could be characterized by high levels of risk and insecurity about what to expect. This context is therefore included in the theoretical frame. Following Ring and Van de Ven (2000), we assume that the environmental aspects which are of importance are risk, initial trust levels, outcome expectations and environmental constraints.

Proposition A: The contracting process is influenced by aspects from its environment, like risk, initial trust levels, outcome expectations and environmental constraints.

Understanding, negotiations stage and commitments stage

The CD procedure is a new approach to tendering, with the expectancy to influence the execution of the project. One could argue that tendering equals the negotiations stage of the model developed, whilst the construction of the project starts in the commitments stage. This might sound logical when considering the contract which is signed at the end of the tendering as the formal legal contract. However, this is not in line with the assumption in the model developed that understanding and problems of understanding determine whether or not negotiations start or commitment is reached. Given this assumption, contract close cannot be seen as a demarcation point where the negotiations stage becomes commitment stage. Even the contract which is signed will be renegotiated in new series of formal bargaining and informal sensemaking. However, the contract which is signed at the end of tendering is meant as a formalization of the understandings reached during the tender negotiations and parties intend to commit to the agreements reflected within.

The parties involved might understand each other on some aspects of the contract and face problems of understanding on others, during any stage of the project. However, since it is not possible to both understand and have problems to understand at the same time, the parties are in either the stage of commitment or in the stage of negotiations for each of the aspects apart. This means that commitments and negotiations are substitutes of one another.

Proposition B: During all phases of a project, from initiation up to delivery, the parties involved go from commitment to negotiations and back, depending on whether there is understanding or not.

Proposition C: On several aspects of the project the parties are in either the stage of commitment or the stage of negotiations. Commitment and negotiations do, however, not coexist within an aspect: the two stages are serving as substitutes.

Formal and informal processes and products

Within the stage of negotiations, both formal and informal contracting processes take place. The processes of formal bargaining and informal sensemaking are both meant to decrease problems of understanding. When understanding has been reached, the stage of commitment

contains both formal and informal contracting products. The formal legal contract and the informal psychological contract are both reflecting the understanding which has been reached. The assumption in the model that within stages formal and informal processes or products are interacting, holds that formal and informal processes are each other‟s complements, just as formal and informal products.
Proposition D: Formal and informal processes and products serve as complements of one another.

These propositions are a starting point from where we will be looking at the practice of CD procurement.

EMPIRICAL RESEARCH DESIGN

To study the difference in (in)formal process and contract development between projects procured by the CD procedure and comparable projects procured by different procurement procedures, it is important that the selected cases are comparable. An embedded multiple-case study required in this case at least four comparable projects: two projects procured by the CD procedure, and two projects which are traditionally procured. Within those projects, four formal and four informal contracts are analyzed. The four projects selected are part of a maintenance program of highways including fly-overs, overpasses and other related objects in co-operation with the private parties.

Data are collected through a series of in-depth face-to-face interviews with both a contractor and a principal in four construction projects and additional interviews with informants who can say more about the projects in general (see Table 1). The description and analysis of the four case projects is based on concepts as discussed in the theoretical framework. By comparing the parties‟ experiences in both the tendering and the execution stage of traditional procured case projects with the parties‟ experiences in those stages in CD procured case projects, conclusions are drawn about the effect of differences in tendering for the construction stage of projects and the effectiveness of the CD procedure.

		Participation level		
		Fully participated in a traditionally procured project	Fully participated in a CD procured project	Generally involved in projects
Role	Principal	2	2	3
	Contractor	2	2	1

Table 1: Number of interviews, differentiated by participation level and role

Each interview took 60 to 90 minutes and was guided by case study protocols. The interviews were recorded and transcribed for systematic analysis, and complemented with information from the evaluation report, the procurement documents, contractual documents and requests to change contractual terms after contract close. This was all loaded into the data analysis program QSR NVivo, which was used to attach labels from the theoretical frame to empirical information. Using the program, text fragments with identical labels were easily compared, patterns were discovered and from that, conclusions were drawn. We sought for formal and

informal interaction patterns, and especially for similarities and differences between the traditionally procured projects and the CD procured projects. In the upcoming sections, attention is given to the traditionally procured projects and the CD-procured projects respectively.

TRADITIONALLY PROCURED PROJECTS

Problems of understanding

When the construction stage started, right after contract close, the Dutch Highways and Waterways Agency (the principal in the cases studied) and the winning contractor did not have had much contact. Except for the public inquiries during the procurement stage, no information exchange had taken place. Therefore, the mutual understanding about the meaning of the contract, its scope and the plans which were made by the contractor had to grow during the construction stage. There were several situations which caused problems of understanding in those early stages of the construction stage.

The first problems of understanding arose from different interpretations of tasks and duties. This had mainly to do with the fact that neither Agency nor contractors were having experience in the procurement of contracts with a design component under System-based monitoring (a new monitoring system of the principal or Agency). At the one hand, there were the contractors who thought it was odd that the Agency did not know what to conclude from the state assessments (did the whole bridge had to be replaced or would it be sufficient to reconstruct parts of it?). At the other hand, there was the Agency, feeling that it was the contractors‟ responsibility to make that decision and then put a price on it.

When the contractors started their work, they were confronted with an actual state of objects and roads, which turned out to differ from what was written in the assessment of the Agency. This caused problems of understanding. In the contracts it was agreed upon that in case of incomplete or insufficient data, or when the actual state of objects and roads turned out to be worse than one might expect from the state assessment, extra work would be for the Dutch Highways and Waterways Agency‟s account. The clauses of the contract provided that contractors would claim nonexistent extra work, by stating that when differences were discovered, the Agency would have to be contacted. Extra work should only be carried out after the Agency‟s consent. In practice, this was not as simple as one might expect, since works were mainly carried out during the night. And then, no agency employees were present or reachable at their offices.

The contractor‟s plans which were assessed by MEAT criteria to win the contract were only the outlines of the working and monitoring plans. These had to be specified after contract close, and accorded by the Agency. System-based monitoring was new to both the Agency and the contractors, which made that in both projects the contractors had a hard time finding the right abstraction level (resulting in loads and loads of paperwork to prove their efforts), and the Agency took its time to check the plans, and refuse them several times. It somewhat hovered between monitoring the process from distance and checking upon the details of the product itself. However, there was not all the time to keep checking and re-checking since the closure of roads involved was due on a fixed date, which came closer soon. This put high pressure on the development of the working and monitoring plans.

Summarizing, the early months of the traditionally procured projects were not contributing to positive development of the relationship between the Agency and the winning contractors. At contract close there were small problems of understanding about the working roles which each party should take. When the actual state of objects and roads turned out not to match with the description in the state assessments, these small problems of understanding grew big. The discussions over extra work which had been performed without consulting the Agency at forehand and the long time and extra versions it took before the working and monitoring plans were accepted, added to the mutually sensed feeling of misinterpretation of working roles

Negotiations and commitment

From the previous part it showed that especially the informal understanding of what was written in the formal contract differed between the Agency and the contractors. This caused that the relationship in both projects developed in negative vicious cycles. However, both the Agency and the contractors involved in the projects were committed to the projects. They were, therefore, willing to cooperate for the benefit of the project

Besides practical solutions with regard to entering the objects and highways without accepted working and monitoring plans at the closure dates, also the working relations became looser. In both projects a project re-startup was organized, which helped in the sense making process of both parties involved. After renegotiations, the parties had reached mutual understandings about the job which had to be done and the roles both parties had to take. This helped to finish the last part of the project by changed working routines and in a better working atmosphere than was the case during the first part.

Summarizing, whereas at the start of the construction stage of the traditionally procured cases the parties involved had no strong expectations, their attitude towards each other had become somewhat negative after the first construction months. Pragmatism and some project re-startups created renewed mutual understanding though, so that the last months of the construction stage went much more cooperative and smooth.

CD PROCURED PROJECTS

Problems of understanding

Already during the dialogue, the first problems of understanding arose. The first issue was the time to go through the Agency‟s available information. Candidates felt they could not assess how (in)-complete this information was, so that they could hardly determine what the assignment to the engineering firm would have to include. The available information was too much, and too poor. Besides, the engineering firm‟s appointed assessment time (15 minutes per object) was judged as too insufficient. Furthermore, candidates felt that the state assessments in their selves had to be judged too soon after delivery. However, they did not make a big deal of this towards the Agency, causing it being not discussed yet noticeably an issue.

Second cause for problems of understanding was assigning an engineering firm. It was the Agency‟s intention that candidates would jointly be responsible for drawing the engineering firm‟s assignment. However, the fact that this firm was appointed and paid by the Agency gave a different signal to the candidates. Besides that the contractors did not feel responsible for the contents of the state assessments, the given situation did also cause them to behave

opportunistically. Respondents from both the Agency and the contractors state that the drawing of the assignment to the engineering firm ended up being more a game between the candidates than a proper attempt to get the right information.

All five Agency respondents and two of three candidates agree that the candidates were more active with each other than with getting the right information in the state assessments. As if eliminating competing candidates was more beneficial to win the bid than cooperating to get clear sight of the risks of the project. This caused friction at the Agency‟s side about the candidates‟ interpretation of tasks and duties. Contractors held the opinion that they would not have to check the situation of the objects and roads themselves, since all knowledge had been delivered on paper. These problems of understanding were, however, not expressed during the dialogue. So although all parties came out of the dialogue with the expectation of having signed proper contracts, the execution of the projects showed that the understanding of these contracts was not mutual at all. Agency and contractors came to stand against each other when the actual state of objects and roads appeared not to match the expectations, formed by the state assessments.

There were several problems. First, in one case it is not clear whether a problem is the contractor‟s responsibility or the Agency‟s. Secondly, during the state assessment some things have been overlooked and later on it turned out that something was wrong. The Agency felt that the candidates had to have this checked upon, and since they did not do so, the Agency held them responsible to pay for the extra costs. Contractors held different opinions, and put claims on the Agency. Third, whilst the Agency employees were unanimous in their opinion that contractors did not feel responsible enough and were not truly committed to the project, the contractors complained about the Agency taking the contract too literally, not thinking in terms of project interest, but from the Agency‟s single-angled interest only. This was especially reflected in issues concerning the system-based monitoring. Both contractors and Agency employees felt that the system was too extensive for the small job maintenance actually is. However, with two parties holding different working routines, with claims being put and a monitoring system which is new to all parties involved, negative vicious cycles were developing. This caused for contractors that small shortcomings could result in large payments which were retained

Summarizing, problems of understanding during the procurement stage of the CD procured cases were increasing throughout the construction stage of those projects, due to differences in interpretations and expectations. During the dialogue conversations most of these issues were not discussed and therefore unexpressed towards each other.

Negotiations and commitment

Just as in the traditionally procured projects, the CD procured projects developed along negative vicious cycles as well. From the previous part it showed that especially the informal understanding of what was written in the formal contract differed between the Agency and the contractors. In attempts to make sense of the situation, both parties in each project sought for explanations. These were found mostly in doubting the other party‟s professionalism.

The parties kept fighting their differences about the actual state of works and roads, so these were only solved by tough renegotiations. The first situation (defining which scenario the found problem concerns) was looked at per occasion by the Agency. For the second situation (things were overlooked during the state assessments) the Agency and some contractors went to court. When in the first case verdict was given in favor of the contractors, the Agency and

the concerning contractor entered in a mediation process which lead to settlement. This settlement was then translated to all the other cases so that new agreements were reached about the responsibility for the state assessments.

Along with the settlement over the responsibility for the state assessments an arrangement was made over the shortcomings. Contract managers did not have to decide for themselves any more whether or not something was a shortcoming or defect; their bosses from the Agency in Utrecht took care of it from then on. It helped, according to the informants, however this did not bring in empathy or affect.

Summarizing, due to the fact that problems of understanding remained unspoken, the negative attitude of both parties towards each other influenced the manner in which they both made sense of new cues. Problems of understanding only increased during the construction stage, due to negative vicious circles of internal sense making instead of expressing problems of understanding towards each other. Tough negotiations and even law suits gave verdict in the worst cases, but could not relieve the relationship between the Agency and the contractor.

DISCUSSION

When problems of understanding due to differing ideas about risk allocation arose, the starting situation at contract close was different in the CD procured cases than in the traditionally procured cases. In the traditionally procured cases, both parties entered the construction stage rather blank: the principal and the contractor did only start to get an idea of who the other party was and what was important to him. In the CD procured cases, however, when the construction stage started, both parties had formed an image of the other one already.

Whereas in the CD procured cases renegotiations did only emphasize existing differences in norms and values, working routines and inability to empathize, which caused problems of understanding only to become worse, the contrary happened in the traditionally procured cases. There the renegotiations lead to understanding, empathy / affect and mutual working routines, even though the norms and values of the parties involved did not correspond at all spheres.

Summarized, when problems of understanding about the risk allocation had been discussed during the dialogues, it would have been likely that what happened in the traditionally procured cases would have also happened in the CD procured cases: starting to make sense of the situation without having an idea of the other party already. But since these conversations did not take place during the dialogues, the implementation of the CD procedure turned out to be less effective than expected. Both parties held the idea that the dialogue conversations had lead to proper understandings at both sides of the table. Renegotiations would not have to be necessary if the other party would act as agreed upon.

Given that the parties were not aware of the differences in understanding between them, negative cycles began to develop: observed shortcomings by the Agency were followed by proposed amendments of the contractors, followed by rejections of the amendments and putting payments on hold by the Agency, after which there was only one way out of the negativity to make the projects succeed: a conciliation board. After settlement, the parties in the CD procured cases did not work along fine and easy as was the situation in the traditional

procured cases. Instead, the working routines remained distant and stiff, due to the fact that notwithstanding open, trust-building CD conversations, the relationship was disturbed by both parties‟ responses to disagreement about the risk allocation.

CONCLUDING REMARKS

The major question was how processes and products differ between CD-procured projects and comparable projects which are traditionally procured. The actual *formal* contracts do not differ much between CD procured and traditionally procured projects. It was shown that problems of understanding were key in the development of contracts in both types of contracts. The *informal* contracts and the processes to solve problems of understanding in the construction stage of the project do differ when comparing CD procured projects with traditionally procured projects. Processes of sense making determine how parties enter into the bargaining process to a large extent. This explains why renegotiations over risk allocation differ between the CD procured cases and the traditionally procured ones. In the CD procedure parties get to know each other better during the procurement stage. This makes that sense making processes at contract close develop different than in traditionally procured cases. Interaction between principal and contractors during the contracting process make that informal contract and formal contract develop simultaneously. When the informal contract is mutually understood by both contracting parties, this might result less problems of understanding during the construction phase of a project. However, in the cases problems of understanding were only bigger for the CD procured projects compared to the traditionally procured projects. We explain this by the stressing that the dialogue conversation did not cover the whole contract. Although developing simultaneously, formal and informal contract did not develop parallel. Instead, the two grew away from one another. The answer to the major question indicates that the CD procedure‟s design and its side-effects influence the forming of both formal and informal contract. The results also indicate that formal and informal contracts are dynamically interrelated. Problems of understanding have showed to be key in the development of both formal and informal contract.

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ORGANISING LARGE SCALE GREEN COVERED ROOFS

Classification of green roof specifications and green roofs implementation; the economics of green roofs

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Abstract
Last two decades the use of plants on rooftops has grown fast. Municipalities use different arguments to initiate policies for large-scale programs for green roofs. However, there is an intriguing intertwining of two scales: building and city. To accelerate policy execution the scales should be combined, but they are not. The stakeholders, not accustomed to collaboration in this new context, keep their natural roles in their traditional organisational patterns. New patterns and new collaborations have to be established soon to speed up the process of change. This paper shows the arguments for mitigation and adaptation approaches on the scale of buildings and cities, from the point of cost and benefits for the major stakeholders. Calculations of municipalities showed that benefits for private partners, investing in green roofs, are less compared to the public benefits. Private benefits may even be negative, nevertheless the summation of private and public benefits is mostly positive. However, the accountability of calculations is minor. There is no uniform method of calculating or monitoring the effects of green roofs on building or city scale. This calls for change. A classification of uniform methods to calculate and measure effects is needed to enlarge customers confidence in the product and to suppress emerging bureaucracy due to different local approaches of policy making and policy implementation.

Keywords: green roofs, public policy, classification of specifications, classification of policy implementation.

INTRODUCTION

All over the world cities proclaim policies to support the construction of green roofs. It seems easy to argue why large areas of roofs covered with plants may contribute to mitigation of and adaptation to e.g. climate problems. One argument is that green covered roofs contribute to reduction of CO_2 emissions on the local scale of the building, which is mitigation. CO_2 reduction can be realised because there is a contribution to extending the life expectancy of the roof. There is a potential reduction in fossil energy use, especially for cooling. On green roofs water can be retained and particular matter (PM) can be captured, which are adaptation approaches. This would reduce the effects of urban heat island. Literature of green roofs specifications is available in several countries according to local circumstances (Getter Rowe

2006). When roofs are covered with plants on a large scale this will also contribute to adaptation, often being part of sustainable water management. It became clear during the last decade that an accelerated implementation of green roofs on a large scale is necessary but not easy to realise.

EFFECTS OF GREEN ROOFS FOR A BUILDING

Green roofs have positive effects on the environmental impact of a building and on the comfort in the building. Green roofs are also known as functional extra space on top of buildings with aesthetic value. How consistent are these claims?

Additional space and aesthetic value

Plants grown roofs provide space for people and provide a place for plants and animals to live. People may use the roofs as a visual object, or as a place to stay.
Clearly, a plants grown roof can make up for a lack of green, and it can be a place for living in the summer (if the roof is slightly tilted or flat). We may conclude that green roofs also can be used as an outside space for living and as a source of greenery. However, we may conclude that it is unlikely to be useful using the roof for the production of food include meat.
Some advantages are more or less intangible. These intangible claims are difficult to discuss, because they deal with subjective matters, such as aesthetic and psychological matters. Aesthetic claims state that a green roof is attractive and it can be an architectural highlight in a city. Of course this claim can also be reversed. Other people may say the roofs are extremely ugly. Psychological claims include the exciting experience you get seeing and smelling plants grown roofs.

Extension of lifetime of roofing

When a layer of soil has been applied on a roof this layer protects the construction of the roof. The roof is protected due to different effects. First, the skin of the roof is not exposed to sunlight. Secondly, people walking on the roof do not easily damage the roof. Finally, the skin of the roof is not exposed to a great variety of temperature. Usually gravel layers are used on roofs to provide a smoothing of temperature fluctuations on a roof; vegetation layers have the same effect so much more. This may even be the main thermal argument for construction green roofs. The fact is that the less the temperature fluctuations the longer the lifetime of the roofing. The influence of the green covered roof on temperature differences on the roof and consequential the influence on the durability of the roof can be technically measured and proofed (Teeuw Ravesloot 2011).

Thermal isolation

Some manufacturers of green roofs claim their particular green roof systems provide extra insulation for heat and cooling. These claims can be substantiated with calculations and measuring. However, even if these calculations and measuring would be more or less accurate and accountable, which they probably are, it would not help accelerating the application of green roofs in cities. Although cooling may be likely due to the plants and the mass of the roof, only in some rare cases a green roof system is claimed to insulate thermally, where no evidence is available. Moreover, the specifications on thermal isolation cannot be used in comparison of different green roofs systems of different manufacturers (Teeuw Ravesloot 2011). Consumers are confused by different claims that cannot be compared.

Water management
On the scale of one building the buffering of rainwater and the slowing down of rainwater run off is in rare cases profitable for the building owner or user. Substantial amounts of water on the roof will contribute to extra thermal cooling in summer, but on the other hand it cannot be excluded the same water contributes to extra thermal losses in winter situations, due to de-icing and vaporizing. On the scale of the city nevertheless, buffering and slowing down of rainwater run off can be claimed to have a profitable effect for the municipality.

EFFECTS OF GREEN ROOFS FOR A CITY

From epidemical research it is known that in cities inhabitants die earlier if exposed to extreme periods of high temperature and after exposure to smog from ozone and particular matter (PM) (Buringh Opperhuizen 2002). Especially elderly people will be affected (Luscuere et.al. 2002). The Urban Heat Island effect directly indicates the early death of people around hot and dusty areas. This is why, it is claimed that green roofs contribute directly to healthier conditions in inner cities.

Urban heat island effect
Green roofs have a positive effect on the city climate and have a buffering effect on the temperature and humidity. This dampens the Urban Heat Island effect (UHI).
Because green roofs radiate less heat, temperatures in the city would not rise as high compared to the surrounding land (city) without green roofs. The Ryerson University in Toronto has conducted studies on the impact of green roofs on the temperature in the city (Ryerson University, 2005). The studies were made for the city of Toronto (Ontario, USA). The research revealed that local and incidental green roofs reduce not really the Urban Heat Island in the city. But if really widespread green roofs were applied, the average temperature in the city of Toronto would decrease with 0.5 to 2.0 degrees Celsius, depending on the season.
Also a good green structure with parks and corridors may reduce heat stress and provide thermal reduction. Green roofs may contribute importantly to this concept. In case city planners and urban designers would cooperate, policies to counterattack UHI effects would probably be more successful (Teeuw Ravesloot 2009).

Urban water management
Cities in general and high-density inner city areas in particular have problems cooping with heavy rainfall. Not only will the buffering in open water structures be compromised, also sewerage can become incapacitated. Managing urban water becomes an important matter of hygiene.

Buffering rainwater
When the green roof is designed to store water, only a very limited amount of water reaches the drains. Rainwater pipes may even be unnecessary.

Slowing down rainwater run off
The most important characteristic is the reduction of peak load in case of heavy rainfall. When raining, the rainwater falling onto the roof will not immediately flush away into the drains. It is easy to understand the principle. Normally rainwater falling on a roof directly flushes away into the drains. On a plants grown roof water is retained by the soil-layer (or draining) of the roof. Later on, some of the water evaporates and partly the vegetation

absorbs the water, only a minor part disappears into the sewer. Due to this one can have smaller drains. Besides the wastewater may be cleaner because of the filtering effect of the roofs.
It is likely that greening of roofs can contribute to urban water management, however it will be a modest contribution (Mentens 2006).

Urban clean air program
A lot of municipalities have programs to get cleaner air. Combustion engines and other devices using fossil fuels emit particulate matter possibly causing early death of inhabitants of inner city areas. Clean air programs often include policies to cover roofs with vegetation.
Vegetation binds dust and particulate matter (PM) from the air and reduces smog as is shown in practice and research. It is unlike however that green roofs will contribute significantly to the binding of PM from city smog. Green walls are more likely to contribute since there is usually a larger leaf surface and counting PM on leaves is more accurate and valid (Ottelé et.al. 2008).

INVESTMENT IN ADAPTATION AND MITIGATION OF EFFECTS

Some effects of covering flat roofs in cities with vegetation will, on the scale of the city, contribute to mitigation of environmental pollution and degradation, especially in case of large-scale introduction of the green roofs. The mitigation effects will mainly be the reduction of cooling energy and in some cases the reduction of energy use for heating buildings. Expansion the life span of roofing materials can probable also be accounted as a mitigation effect.
Effects on the noise-reduction in cities and inside buildings, health effects as a result of clean air and intangible effects like aesthetics and the resultant direct health impact might be more adaptation. Using green roofs for buffering rainwater and slowing down the rainwater run off from roofs is most definitely a clear adaptation measure cities can provide.

Each tangible and intangible effect, adaptation and mitigation, will have a different set of stakeholders, interested in participating in the costs and mostly in the benefits of greening programs.
Each local initiative will have to face similar complex conditions to maintain interest in public benefits from investments, taking into account the context of smaller financial benefits for private investors. Several perspectives can be distinguished. From the designers perspective e.g. it seems not clear how the potential of green covered roofs can be fully organised.
Remarkable results where achieved in a London City survey for participants in the design and construction process (see figure; Voll et.al. 2007). The hypothesis was: “The physical structure of many buildings prevent the use of green covered roofs”. Only yes and no answers were allowed. It is very interesting to see that especially the initiators and decision makers do not specifically approve to using green covered roofs. Even 92 percent agrees with the thesis, whereas only 27% of the construction engineers agreed.
The explanation can be found in lack of knowledge on this aspect. Other - secondary - explanations could be:
- Lack of policy from public authorities.
- Benefits and positive effects are unknown.
- Many participants assume that costs are higher, but do not have a clue about how much higher.

– Many parties do not want to take risks in design tasks they do not know.
– Most of all the collaboration between design parties is insufficient.

Profession	Percentage of agreement
Actor analysts	67
Architects	40
City designers	33
Construction engineers	27
Developers and investors	92
Advisors ecology and water	13

***Figure**: Results of the London city survey*

From the construction contractors perspective it is important that their product will fit the private investors needs as well as the public subsidies interests and still make a profit.
The common interest of all parties involved is that no green covered roof will ever have any kind of problem. Any leakage or other damage will cause damaging of the public image of green roofs.

ECONOMICS OF GREEN ROOFS FOR BUILDINGS

The environmental effects or the image of a green roof might not be in accordance with the interest or the wish of the architect or the client. The decision making to realise a green roof involves many criteria, some of these are of economic nature.

Costs of green roofs

The costs of green roofs versus the costs of traditional roofs can easily be estimated. The roofing itself will be a little costly, further supplemented by the costs for the substrate and vegetation on top of the roofing. Considering the total building the extra costs are minor. The maintenance costs of a green roof, if grown with so-called extensive vegetation, are considered to be equal to that of traditional roofing. On the on the hand, roofs grown with so-called intensive vegetation, e.g. roofs gardens, are more expensive and do not always have a positive cost-benefit ration (Ravesloot Teeuw 2010).

Benefits of green roofs

The life cycle costing of green roofs is positive, since the life expectancy of the roofing is doubled (Voll et.al. 2007). Added value from green roofs is the decrease of the cooling demand in case cooling would be required. In some cases green roofs add extra thermal insulation and heat losses in winter situation will drop, although due to the humidity one may not rely on this. Sometimes a building owner or user benefits from the slowing down of rainwater run off and the buffering of water on the green roof. In cases the dimensions for rain pipes and sewer can be diminished. These will safe money from the initial investment budget as well from the maintenance budget. It can be concluded that apart from the higher investment costs, the life cycle costing of green roofs mostly turns out to be positive.

INTERTWINING OF SCALES

Convincing arguments for fast introduction of green roofs are known. However the calculating of effects on green roofs and the supporting arguments are executed with different methods, as well is the monitoring of these effects. Besides the weights of the arguments and the balancing of the arguments to either the scale of the building or to the scale of the city is not clear yet. Prioritizing seems to depend on local circumstances and local customs. The intertwining of those two scales complicates discussions. Technical knowledge and knowledge of costs and benefits cannot be combined properly and accurately.
It is not always clear how negative and positive environmental effects of green roofs can be explicitly identified by calculation or by measuring. A life cycle assessment (LCA) is not easy to make and it is not always evident how the costs and benefits can be estimated on the scale of a building as well on the scale of a city and how they are related.

Concerning the issues of the discussion about the method to express the environmental effects of green roofs uniformly into numbers a discussion will enrol how to express these numbers into economical estimations on both the scale of the building as on the scale of the city. The economics of green roofs are intertwined on both scales. For companies designing and constructing green roofs it will help to expand their market if it would be possible to estimate specifications more accurately and more uniform. In those case customers themselves can compare performances in relation to costs and benefits. Uniform specifications could relate to procurement criteria and product delivery systems more easily (Huovila Ravesloot 2010). To harvest the potentially major benefits of green roofs for the municipality asks for new organisational methods. Otherwise city policies and innovation of green roofs will suffocate in bureaucracy. If implementation of local policies is uniform throughout the country, private companies can put their effort in innovating their product towards customers' wishes avoiding bureaucracy.
This paper ends with the conditions for positive and successful change, organising innovation from the side of manufacturers and construction industry and de-organising organising bureaucracy of public city policies. Change in the intertwining of economics might simplify the organisation of large scale green covered roofs.

ECONOMICS OF GREEN ROOFS FOR CITIES

Municipalities use different arguments to promote policies for large-scale green-roofs programs. Goal is to achieve benefits for mitigation and adaptation approaches or to achieve sustainable water management on the scale of the city.

Calculations of the municipality of Rotterdam showed that benefits for private partners, investing in green roofs, are less compared to the public benefits on a larger scale. If the benefit from expanding the life span of the roofing material itself is not calculated as private benefit, the total private benefit even becomes negative (Moppes, Klooster 2005). However, the summation of private and public benefits is positive. The calculations also show that the total benefits are the largest in the high-density areas surrounding the city centre and the least in industrial areas. The city centre itself is most beneficial for public benefits.

For the city of Rotterdam many different kinds of calculations can be made to support public investment in private roofs. The simplest calculation would be to compare the cost to create more water buffer areas in the city centre and in its surrounding, highly populated, areas. The construction of one cubic meter of water buffer as adaptation measure in case of heavy rainfall would cost approximately Euro 1000,= to 1500,=. However, this would not be

sufficient, because there is little space to realise such buffers. The public spaces at street level are all occupied until several meters underground. To make an equivalent amount of water buffering of about 15 l/m^2 on a flat roof you would need about 70 m^2 of flat roof. So it is wise to spend Euro 1000 on creating 70 m^2 of green roofs instead. The extra investment of green roofs compared to traditional black flat roofs can vary from 15 Euro (simple do-it-yourself construction with extensive vegetation) to Euro 50 (complicated roof with intensive vegetation). With these numbers you can see that a contribution of Euro 20-25 Euro's of the public authorities for the private investment in green roofs in down town Rotterdam can be motivated.
The more complicated calculation of private and public benefits and costs on a larger scale shows remarkable little sensitivity for variations in input variables of 50 %. Sensitivity is only high on the assumption of life span extension of the roofing material. Changes in investment costs for the greening of the roof also can cause some variation. Otherwise the social return on investment on the scale of the city here is about Euro 15,= per m^2.

Most likely each city with a program and subsidy for greening roofs will have constructed some kind of similar calculation. Of course variables, input data, methods and numbers will vary and different calculation cannot always be compared. Clear understanding of the factors involved and a good management of the process can create a positive balance in a social cost-benefit analysis for all stakeholders at both scales.

DISCUSSION

However the understanding of the factors involved in organising green roofs on a large scale is not the same from all stakeholders' perspective. There is an intriguing difficulty in organising the intertwining of the two described economics. Although green roofs appear in the political policies of many cities, it is rarely part of (urban) planning in the various sectors. New patterns of collaboration have to be established between policy makers, urban designers, building owners and investors. Sometimes new collaborations appear spontaneously, but they may be hard to organise, since the stakeholders keep their natural roles in their traditional organisational patterns. They are not accustomed to collaboration in a new context. New patters and new collaborations however have to be established soon to speed up the process.

Intertwining Organisation

Speeding up the process incorporates the differentiation of subsidised green covered roofs according to local urgency and needs and to stimulate the use of green covered roofs to enlarge the effects of urban water management. Subsidy may prevent that one may hesitate to invest in green roofs and stimulate the efforts to get urban quality by means of green roofs. Instead of subsidising the green roofs it may even be better to subsidise the work of architects and urban designers in their effects to realise green roofs.
Also the management of process and maintenance plays an important role. The logistics of building a green covered roof determines the price. Of strong influence is the market situation during the year. Nevertheless, a designer can influence the price positively by designing with care in an early stage of the process. In this way many problems and thus a lot of money can be saved. Given the different roof structures of green covered roofs, additional requirements should be taken in the Dutch legislation. A major hindrance is the lack of a uniform method of calculating and measuring technical specifications of green roofs, like thermal capacity, capturing of particulate matter, buffering of rainwater and slowing down of stormwater run off. The lack of uniform demands from public authorities subsidising green roofs is creating

unnecessary bureaucracy. Also different approaches in policymaking and in policy evaluation hinder to accelerate.

The introduction of a uniform classification of technical specifications will accelerate the introduction of green covered roofs in Dutch building industry. Companies can concentrate on the innovation of their green roof systems, instead of bothering which daily arguments they have to fulfil to defend that their products meet the various requirements of the granting authorities best. In case a classification to apply for subsidies from public authorities fits within the technical classification of green roofs, rise of bureaucracy may be counterattacked. In fact the market for designing and constructing green roofs may expand rapidly, because the consumer will have less doubts on the benefits of green covered roofs. The competitions between companies will focus on quality and services, more than on declaring claims that cannot completely be substantiated. Differences in systems from different companies can be compared and can be tailored to the subsidy requirements by public authorities. Applying for subsidy will be the same in every city offering an active green-roof-policy.

CONCLUSION

The knowledge how to design, construct and maintain green roofs is available and at a high standard (Getter Rowe 2006; Teeuw Ravesloot 2011). Local initiatives show the importance of public authorities to support the construction of green roofs on a large scale. The cost-benefit of green roofs on the scale of a building is mostly positive for extensive green roofs, if the calculation is made within life cycle costing. The same might be valid for social cost-benefit calculations on the scale of a city. However, the many variables and the uncertainty of the input variables make the accountability small. Green roof technology may innovate more towards the specifications issued from public authorities. It seems that public need is more important than private interest. To align public interest and private potential it is needed to uniform the methods of calculation for green roofs specifications. This would be important for those specifications that serve public interest as well: thermal insulation for cooling and heating, water buffering and slowing down rainwater run off, as well as catching particulate matter. Such a classification would enlarge customers' confidence in green roofs. On the other hand it would be suggested to make uniform formats and procedures for local authorities, legally, financially and politically in order to reduce emerging bureaucracy. Bureaucracy is an important hindrance for innovation by the green roof companies.

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DESIGN, PROCESS, AND SERVICE INNOVATIONS TO ACHIEVE SUSTAINABILITY

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Abstract
Climate change has led to the global recognition of the need to reduce the carbon footprint of buildings. In the UK increasingly demanding building regulations require contractors to use innovative products and processes in their construction processes in order to deliver the specified environmental sustainability performance levels. Cost effective innovative solutions for achieving sustainability in construction requires considerable effort and commitment. As a fragmented and project-based industry, much construction innovation is co-developed at the project level. The major objective of this study is to analyse a construction project by exploring the role of design, process, and service innovations in achieving sustainability. In this respect, the eco-friendly accommodation at Lancaster University has been investigated as a case study. The project presents a case of client-driven innovation where building regulations on sustainability were taken into account in developing design and planning the construction process. The paper discusses the leading role of the university client as well as the role of partnering approach and community engagement in the innovation process. Finally, some recommendations are provided based on the lessons learned in this project.

Keywords: Sustainability, client-driven innovation, design innovation, community engagement.

INTRODUCTION

There have been a number of changes and challenges such as globalization of the business environment; demographic change; environmental sustainability and climate change; new materials and technologies; ICT; and governance and regulation that continue to have a significant impact on the construction industry (e.g., Hampson and Brandon, 2004; Boddy and Abbott, 2010). Foremost among these drivers, sustainability has become an increasing concern for the construction industry due to the fact that construction activities significantly impact on waste, energy use and greenhouse gas emissions. As a response to climate change and its effects on the environment and energy academics, practitioners and governmental bodies have been involved in many discussions and applications to create a low-carbon economy. There has been a growing emphasis on corporate sustainability, which is also

reflected by pressure being exerted by clients, government and other stakeholders for the industry to be more accountable for its environmental impacts (Thorpe et al., 2008). Recently issued building regulations such as the Code for Sustainable Homes (CfSH) (DCLG, 2006) in the UK require the contractors to use innovative products and processes in their construction processes in order to deliver the specified environmental sustainability performance levels.

Developing cost effective solutions for achieving sustainability in construction requires considerable effort and commitment to innovation. As a fragmented and project-based industry, much construction innovation is co-developed at the project level. The link between firm level processes and innovation at the project level should be explored to enable a better understanding of how different firms contribute to the innovation process by developing/implementing strategies, assigning resources to create ideas and diffusing them. The major objective of this study is to analyse a construction project by exploring the role of design, process, and service innovations in achieving sustainability. The project analysed is the eco-friendly accommodation at Lancaster University. This student residences scheme was the first replicable scalable model of its kind and was designed to create a social space for the students that would encourage 'good habits' in terms of sustainable living. The main innovations observed in the project were within the residences' bespoke design that adopted the 'sustainable by design' concept using offsite manufacture (OSM) driven and enabled through a lean construction approach and community engagement. The project presents a case of client-driven innovation where building regulations on sustainability and user perspectives were taken into account in developing design and planning the construction process.

INNOVATION IN THE BUILT ENVIRONMENT

Innovation may be defined as creation and adoption of new knowledge to improve the value of products, processes, and services (Ozorhon et al., 2010). The construction industry can benefit from the diverse benefits offered by innovation particularly by adoption of new methods to improve processes and organisational effectiveness. According to Lansley (1996), the occurrence of innovation within the construction industry is often characterised by the widespread adoption of new practices as a result of advances in technological and business processes and much of construction innovation is process and organisation-based (Slaughter, 1993). Innovation in construction is co-developed at the project level (NESTA, 2007).

The construction sector is viewed as a system involving clients, contractors, sub-contractors suppliers, consultants, and designers. Clients are seen by many as having a leading role in driving innovation in construction (Brandon and Lu, 2008) although this viewpoint is contested in for example Ivory (2005). Clients can act as a catalyst to foster innovation by exerting pressure on the supply chain partners to improve overall performance and by helping them to devise strategies to cope with unforeseen changes (Gann and Salter, 2000), by demanding high standards of work (Barlow, 2000), and by identifying specific novel requirements for a project (Seaden and Manseau, 2001). Contractors, on the other hand, play a mediator role in the interface between the institutions that develop many of the new products and processes (materials and components suppliers, specialist consultants and trade contractors) and those which adopt these innovations (clients, regulators and professional institutions) (Winch, 1998). Manufacturing firms invest far more in R&D than contractors and are subsequently more likely to develop technology driven product and process innovations (Gann, 1997), whereas in construction successful innovation often requires

effective cooperation, coordination and working relationships between the different parties in construction projects (Gann and Salter, 2000; Ling, 2003).

Management of innovation is complicated by the discontinuous nature of project-based production in which, often, there are broken learning and feedback loops (Barlow, 2000). Gann (2001) suggests that project-based construction firms often struggle to learn between projects, and often have weak internal business processes. Measurement of the dimensions and elements of construction innovation at the project level is key to improving the innovation performance of companies. An organisation employ a number of tools, techniques and strategies throughout the whole process and external factors such as drivers, barriers and enablers determine the effectiveness of creation and diffusion of innovation. The link between the processes at organizational level and innovation at the project level should be investigated to gain a full understanding of the drivers and underlying factors of innovation in a project setting.

A research project was carried out by Ozorhon et al. (2010) to investigate the ways in which innovation occurs in a project setting and the dynamics between project and firm level innovation. The research team collaborated with the Centre for Construction Innovation (CCI) Northwest to survey the applicants of the 2009 North West Regional Construction Awards. The awards entrants were chosen as they all believe that they are at the leading edge of construction in the region and were willing to share their innovations, and so the sample should provide an insight into perceived 'best practice'. The findings of this survey were used to guide the next stage of the research that involved the production of a series of case studies and interviews with key parties in selected projects. The particular case study presented in this paper describes the eco-friendly student accommodation at a UK University that has demonstrated numerous examples of innovation.

CASE STUDY: ECO-RESIDENCES

The eco-friendly student accommodation at Lancaster University is the first replicable scalable model of its kind and was designed as an environment that would encourage 'good habits' in terms of sustainable living. It is a successful example of collaborative partnership that achieved affordable sustainability through a series of technical and organisational innovations.

Client and regulations as the drivers of innovation

The project was very notable for the pro-active role of the client, whose drive for sustainable practices were the main drivers of innovative activities. This drive was itself reinforced through energy performance regulation such as the CfSH and specific guidance by Higher Education Funding Council for England (HEFCE). The UK Government's initiative to create sustainable homes is specified in the CfSH (DCLG, 2006). The code requires contractors to use innovative products in their construction processes in order to deliver the specified sustainable performance levels. Similarly, HEFCE guidance on universities' environmental performance provides an important benchmark. HEFCE has confirmed that from 2011, all HEFCE capital funding will be subject to Institutional Carbon Management Plans and further, that pursuant to the Climate Change Act, the Higher Education Sector is likely to be set a target of reducing carbon emissions by 80% by 2050.

In addition to the requirements of CfSH and HEFCE guidance, the University's own desire for the adoption of sustainable practices was a major driver for the success of this project. The University recognises the significant environmental impacts associated with its operations and also its responsibility to address these impacts in all areas of its activities through its Environmental Policy and Environmental Management System (EMS). The environmental impact of new or refurbished buildings is very carefully evaluated from conception, through design and construction to operation.

Another key ingredient of successful delivery of this project was the innovative partnership between the University and the developer. The University selected a residential developer as partner to design, build, fund, and manage its eco-friendly accommodation under a unique 48-year contract. This partnership firmly places the emphasis on the use phase of the building and opened the way to the adoption of the 'sustainable by design' concept (Friedman, 2007) in the bespoke design by the architect of the project, which in turn was the result of a more formal collaboration to ensure that the best ideas from around the world are brought into the organisation.

Another business partnership, 'GreenLancaster', was established between Lancaster University Student's Union, the University's Estate Management department, and the residential developer, the aim of which was to help departments across campus promote and deliver environmental initiatives. This has helped increase recycling rates, reduce toxic waste, reduce energy consumption and green the University's supply chain.

Design innovation

The design criteria focused on environmental sustainability, reduced construction and rental costs, enhanced social space, and improved design quality and specification. The key success was to achieve a highly sustainable development at an affordable cost. Affordability has been achieved by looking at the construction process and how the detail design may incorporate features which facilitate construction. The design was mainly based on the work of Professor Friedman (from McGill University, Canada), who is recognised as a world authority on the subject of affordable housing. The key features of this 'sustainable by design' concept focused on a simple design delivering high energy efficiency and heat recovery. The residences have been configured as 4-storey townhouses providing semi-independent, un-serviced accommodation for either 6 or 12 students with a large shared kitchen/dining/lounge space. The key features of this 'sustainable by design' concept are as follows:

- ***Plan:*** The designs are based on the use of modular dimensions which allow the use of building components to their manufactured sizes, such as plasterboard or ply sheets. This speeds the construction process as there is minimum requirement for cutting or fitting of components, and significantly reduced waste generation.
- ***Energy and resource efficiency:*** The design of the building, comprising terraced units is very efficient in terms of site utilisation (good floor to wall ratio), minimization of external surfaces (high levels of energy efficiency), and minimisation of material use. Designed allows the maximum use of natural light, minimising lighting requirements. Low energy fluorescent light fittings are used throughout the buildings with Passive Infra Red (PIR) detectors in communal areas. Water use is minimised by low flow rate fittings and dual flush fittings on toilets.
- ***Sustainability and renewable materials:*** The reduction of waste is central to the concept and the choice of construction materials related to carbon footprint reduction. The BRE 'Green Guide to Specification' is used to inform the choice of materials, and benign

natural materials are used wherever possible to ensure a healthy internal environment. By using timber sourced from sustainable, managed forests for the building's superstructure, the carbon footprint was reduced by one third. Timber frames were also manufactured offsite in order to minimise waste. Recycled construction materials have been used as far as possible in underlying hard-paved areas and floor-pads. Internal fittings such as showers, basins and lavatories are assembled offsite as complete 'pods' improving construction speed and reducing construction impact further.

- ***Heat recovery:*** A passive approach is used to create a very highly insulated, airtight building envelope which requires very little energy for space heating, the major energy load being to generate hot water and this is supplemented by solar thermal panels which are effective and have a relatively short payback period. A heat recovery system operates on the extract ventilation serving the shower/bathrooms, providing warm air into the internal circulation areas; while each room is equipped with a small radiator, controlled by a thermostatic radiator valve and linked to a high efficiency, gas-condensing boiler. Ventilation with heat recovery is primarily whole house mechanical ventilation with heat recovery (re-claiming 70%). Trickle vents and windows that can be opened to provide additional user controllable ventilation. The kitchen cooker extractors switch on and off automatically.
- ***Utility monitoring:*** The eco-residences have a Building Management System (BMS) which constantly communicates utility use to enable the students to monitor their carbon footprint for their townhouse which is calculated from its water, gas and electricity usage. The University also seeks to develop future university estates on the basis of sustainable principles.

Process innovation

In terms of the construction method, closed panel timber frame was the chosen solution to speed up the process and achieve sustainability. Although the systems or products used in the scheme have been used before, the main innovation in this project is that all the various design and construction approaches are brought together in a coherent, holistic housing concept that was both sustainable and affordable. Prefabrication is a major factor in keeping costs and waste to a minimum. Both the structural timber frames and bathroom pods are built off-site and delivered ready for quick installation and connection.

- ***Modern methods of construction:*** Timber frame is a tried and tested structural system. It is widely believed to be the most environmentally friendly form of construction available that conforms to MMC and OSM principles. BRE reported that that modern timber frame construction produces near zero carbon emissions (Reynolds and Enjily, 2005). Timber frame is also renowned for its excellence in energy efficiency terms. As the structures are assembled from components made to manufacturing tolerances, the better fit achieved improves air tightness and hence positively effects energy efficiency. The closed timber frames were used as the structural elements of the superstructure in the project among the many forms to choose from, including advanced and closed panel, volumetric, and hybrid systems.

  To gain the potential benefits of MMC required tighter, more reliable processes which lead to the adoption of lean principles. The lean approach meant that construction could be completed well ahead of schedule due to the unexpectedly quick insallations of the timber frames. Just in time (JIT) deliveries were fundamental to maintaining the construction programme. Lean construction is "the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value

stream and the pursuit of perfection in the execution of a constructed project" (Design for Manufacture Competition, 2005). The adoption of MMC through a lean approach required more time in the design and planning phases, but this attention to detail minimised conflicts that can dramatically change budgets and schedules. Standardisation of the finishing processes brought benefit to the supply chain, reducing wastage of materials on site as well as wasted operations.

MMC and lean construction involved different mindsets and operations that were initially threatening to members of the supply chain. Seminars and project meetings were held at an early stage with regard to the process approach and construction technology involved both to give confidence and exchange knowledge. 'Toolbox talks' were initiated with the workforce of the various supply chain partners to ensure requirements were properly implemented on site. Many detail design or construction issues incorporated in the scheme have been adopted by supply chain members as general practice moving forward.

Service innovation

The project was also notable for its use of a 'user-driven' approach to successfully deliver the environmental performance levels. The university aimed to create a social space for the students that would encourage 'good habits' in terms of sustainable living. The end user requirements were an important component of the scheme and so engagement with students began at an early stage in the design process. This aspect is considerably strengthened by the measures that are in place to monitor and provide information on energy use as a means of directly involving the students with the ongoing operation of the building. Following completion, further engagement on obtaining and addressing initial feedback from new residents was also critical. Initial resident feedback has been very positive. General comments of the students have included: 'probably the best accommodation you will live in as a student', 'light, airy and clean', 'very sociable', 'good space for a family'. This stakeholder participation model will also be used in future student residence developments.

GreenLancaster had a central role in the environmental initiative of the University. They have generated jobs for students, as well as raising the profile of environmental issues amongst staff and students. A carbon competition was launched in the University's eco-residences to motivate the students to be more environmentally conscious. This was set-up in conjunction with GreenLancaster to promote and incentivise reduced energy and utilities use, and reward the townhouses with the lowest resultant carbon footprint. Students could log onto the competition website to view the carbon footprint and utility use for their house in real-time, as well as check on who is winning. By this way, carbon emissions were reduced by 11.3% for January-April 2009 compared with the same period in 2008, when there was no carbon contest. Students achieved this by taking some simple actions such as switching off the TV at the mains, not leave anything on standby, half-filling the kettle, cooking together, and filling up the washing up bowl instead of running the tap.

Achievements of the project

Significant financial, environmental and social benefits have been achieved for both the University and student residents. A key benefit is expected to be reputational, with Lancaster University being seen as a leader in terms of environmental design and construction, but also in terms of stakeholder and end user participation in development and input into the eco-residences design and concept. External recognition and interest in the project has been very significant. Estates Department Directors from many universities have toured the eco-

residences developments. The following details some of the main achievements of the project in use compared to the previous phase:

- The cost of a student room was decreased by 7%, while rent charged to the students dropped down by 15%.
- Gas consumption is anticipated to reduce by 5-10% per student room.
- Carbon emission is predicted as 963kg CO_2/annum/student compared to the design target of 1,147kg CO_2/annum/student based on the Building Regulations.
- The transport linkages from the eco-residence developments have been carefully designed to minimise transport impacts. They are provided with excellent pedestrian linkages to the main pedestrian walkways.

CONCLUSIONS

Climate change and environmental sustainability has become a central issue for construction practitioners, policy makers, and academics worldwide. Key to this is energy efficiency and carbon reduction in buildings and as such the construction industry contributes to a large proportion of carbon emissions. The case study shows that environmental sustainability through the construction value chain can be achieved by a strong commitment to deliver innovative solutions. Due to the project based nature of construction, innovation requires a joint effort throughout the project life cycle.

In this paper, a case was analysed to exploring the role of design, process, and service innovations in achieving sustainability by investigating the role of key parties. The eco-residences project of Lancaster University was examined, where a client and regulation led innovation approach was observed with building regulations and HEFCE guidance on sustainability taken into account in developing design and planning the construction process. The University's devotion and investment in environmental issues played an important role in the design, construction, and operation of the residences. The conditions that created the commitment to a through-life solution were threefold. Firstly, the university client had wider aspirations to engender behaviour change amongst the users of its estate. Secondly, the developer's business model included a novel financial relationship that depended not only on efficient construction of the residences as a product but on their through-life use. Thirdly, the developer was using this development as a pilot in order to deliver similar schemes to universities throughout the UK with declining capital budgets. Thus, the additional investment in design for construction informed by end-users would be repaid over and over again in future projects that would be informed by data of performance in use. Although the paper is based on the achievements of a single project executed in the UK, it is expected to shed light on similar future work on investigating innovative activities in collaborative environments in different countries.

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SUSTAINABLE BUILDING PRACTICES: LEGISLATIVE AND ECONOMIC INCENTIVES

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Abstract

Sustainable building has become the buzz word of commercial construction in the U.S. during the past decade. While sustainable building practices and energy efficiencies have been on the building industries radar screen for a number of years, the media intensity and owner interest seams to ebb and flow with the cost of energy. However since the LEED system has gained such popularity in the commercial construction arena, more and more owners are demanding that their project be LEED certified; or the owner's are at least having serious talks with their architect and builders regarding sustainability and the LEED certification process.

A natural outgrowth of public awareness of energy efficiencies in the building process is governmental pressure to achieve certain prescribed outcomes. Is the government leading the charge, following a surge or acting as an impediment to the use of sustainable building practices? State and local building practices will be examined to determine if there is a trend towards either of the scenarios. While this research will primarily focus on U.S. building practices, along with federal, state and local laws that have an impact on the built environment; a cursory look at the efforts of other countries and their energy practices will be performed to provide some insight into the worldwide efforts towards sustainable building.

Keywords: Sustainable Building, Law, LEED, BREEAM, HQE

INTRODUCTION

It could be argued that sustainable building practices have always been an issue of concern with building owners. One only has to look at some residential construction practices from centuries ago to see that this is true to some extent. Owners had little choice but to build with local materials according to local or regional customs, constructing the building in such a way that a certain level of comfort was assured with the minimum use of additional resources for heating and cooling. An example of this approach is the adobe structures of the American southwest. Houses were constructed of thick adobe walls providing insulation from the extreme temperatures along with openings designed to promote a free flow of air. Unfortunately, if one moves to more temperate climates, especially in areas where abundant natural resources are available, residential owners had little reason to build in a sustainable manner. They simply built along local and regional customs, often with economy as a major objective.

If one looks at larger buildings from days gone by, sustainable building was not necessarily at the forefront of the decision making process as far as design and construction were concerned. The earliest large, non-residential buildings were religious in nature. These large

structures were built with religious custom as the primary concern. While using local materials to a large degree, the design and construction of the structure had more to do with promoting the tenets of the faith than building in a sustainable manner. A look at early English cathedrals easily demonstrates this point. Often placed on a high point to insure visibility from afar, the cathedrals tended to be large, imposing structures with soaring interior spaces but with poor natural light and ventilation. As the structures were built for a transient occupant, indoor environmental concerns were not nearly as important as with residential structures.

Changes in our design and construction processes evolve quiet slowly and reflect changes in technologies and customs. However, some changes can be promulgated at a more rapid rate if nudged along by some trend or concept. Mechanisms that have sped up the process of change and resulted in different ways of addressing our sustainable building needs can be categorized into four fairly broad groups; 1) governmental statutes, 2) building codes, 3) associations or NGOs, and 4) the marketplace through economic incentives.

While changes in these areas have occurred over the past centuries as it relates to the built environment, many of our sustainable features have come about in the past forty years or less. A significant milestone that, to some extent, marks the beginning of the environmental movement that preceded modern sustainable building efforts was Earth Day; first celebrated on April 22, 1970. This was organized by United States Senator (Wisconsin) Gaylord Nelson as a means of bringing awareness of and appreciation for our natural environment. Earth Day remained a U.S. event until 1990 when it was organized by the Earth Day Network to become a world-wide event. Now close to 200 countries celebrate Earth Day each year and millions of individuals participate in activities promoted by the Earth Day Network (Earth Day Network 2011).

A further development towards sustainable building practices is evidenced by the United Nations Millennium Development Goals (MDG). First promoted in the year 2000, the goals consist of eight international development goals aimed at improving living conditions of the world. All 192 United Nations member states and at least 23 international organizations have agreed that these should be achieved by the year 2015. They include eradicating extreme poverty, reducing child mortality rates, fighting disease epidemics such as AIDS, and developing a global partnership for development (United Nations 2011).

At the 2010 United Nations conference it was reported that some of the goals are having their desired effect, but many countries are lagging behind in their campaign of achieving the goals and will, in all likelihood, not be reached by the target year. While most of the goals are very broad based initiatives as seen in the previous paragraph, one goal – Goal 7A is titled: “Integrate the principles of sustainable development into country policies and programs; reverse loss of environmental resources”. Goal 7A is aimed squarely at those involved with the built environment, calling for governmental pressures to influence the behaviour of designers and builders involved in the development process (United Nations 2011). Although many argue that the UN MDGs are, to some extent, symbolic in nature it is clearly an indication that sustainable building practices are on the minds of many more people now than they were 40 years ago (United Nations 2011).

RESEARCH QUESTION AND METHODOLOGY

The purpose of this research is to determine whether governmental initiatives or the private marketplace is driving sustainable design and building practices? If governmental initiatives are the driving force, sustainable practices will be much more stable and long lasting. On the other hand, if it is the marketplace that is the driving force, sustainable practices will again shift with the inevitable change in the price of oil.

This study looked at various sustainable initiatives used in the commercial construction industry, to determine what drivers were behind each. As the data required by this study is public information, data was gathered through internet searches in order to gain a broad perspective on the issue using a qualitative research approach. Qualitative research can be defined as subjective, and is often structured into two categories of research: exploratory and attitudinal (Coles & Naoum 1998). The purpose of exploratory research, as used in this study, is to understand a situation, look for alternatives, and to propose new ideas (Zikmund 1997).

GOVERNMENTAL STATUTES

A statute is a formal written enactment of a legislative authority that governs a country or some subdivision of the country such as a state, province, county, city or other form of municipality (Black, H. C. 2009). Typically, statutes command or prohibit something, or declare policy. The word “statute” is often used to distinguish law made by legislative bodies from case law decided by courts, and regulations issued by government agencies. Statutes are sometimes referred to as legislation or "black letter law". As a source of law, statutes are considered primary, or the highest, authority.

Much of our legal system in the U.S. and in Western Europe has evolved from the legal system of ancient Rome, primarily the legal developments which occurred before the seventh century AD when the Roman–Byzantine state adopted Greek as the official language of the government. Following the definitional premise that statutes are laws that are written, the first legal text is derived from the Law of the Twelve Tables, dating from mid-fifth century BC. The plebeian tribune proposed that the law should be written, in order to prevent magistrates from applying the law arbitrarily. After eight years of political struggle, the plebeian social class convinced the patricians to send a delegation to Athens to copy the Laws of Solon. Around 450 BC, ten tablets were produced with laws aimed at controlling civil matters of the Roman citizenry. These proved to be unsatisfactory by the plebeians and two additional tablets were added the next year. The new Law of the Twelve Tables was approved by the people's assembly (Kreis, S. 2001).

While the Law of the Twelve Tablets is ancient in time, it provided for provisions of private law and civil procedures that survive to the present day. Primary in this regard is that the focus of rule making should fall to the local group (or, as stated in 450 BC the genos or clan); e.g., the rights of the central government are limited in their scope (Kreis, S. 2001). The U.S. Constitution, U.S. Congress and U.K. Parliament have followed this tenet as it relates to sustainable building. While there are certain central laws regarding this issue is not debated; but rather the purpose of these laws are primarily focused on providing local or regional governmental entities with avenues in which to approach sustainability.

For example, in the U.S. such seminal environmental laws as the Clean Air Act (CAA) and the Clean Water Act (CWA) demonstrate that the law can be, and has been, utilized as an important tool to address environmental challenges (Sussman, E., et al 2010). However, these laws passed in the early 1970's have not been followed by similar legislation as it relates to sustainable building. Sustainable building regulations have been much more fragmented in their approach. But as Sussman goes on to say, "[L]aws and regulations, at all levels of government, can similarly be used to promote adaptation to climate change" (Sussman, E., et al 2010).

Another governmental reaction came about due to the energy crisis of the 1970s. The soaring costs of energy and a growing concern about pollution and natural resource conservation caused the U.S. Congress to pass the Energy Policy and Conservation Act of 1978 (EPCA) that would require states receiving federal funds to initiate energy conservation standards for new buildings (Kraska, J. C. 2006). However, a telling feature between the EPCA and the earlier CAA and CWA that should not go unnoticed is evidenced from the titles of the legislation. Where the CAA and CWA are "acts" with definable requirements and outcomes the EPCA consists primarily of "policy" issues. This is not to say that the EPCA is not an important piece of legislation, because it is. However, as energy prices became lower in the 1980s and 1990s less importance was placed on the possible rigors and enforcement of the EPCA.

BUILDING CODES

A building code is a set of rules that specify the minimum acceptable level of safety for constructed objects such as buildings and civil structures. The main purpose of the building code is to protect public health, safety and general welfare as they relate to the construction, occupancy or use of the building or structure (Black, H. C. 2009). Model building codes are promoted by a group or association; and the code becomes law of a particular jurisdiction when formally enacted or adopted by the appropriate authority.

The idea of a building code is more than 3,000 years old. Even the earliest civilizations recognized that predictable and consistent minimum standards had to apply to construction materials and practice in order to provide practical and adequate protection of human life, safety and the welfare of the community at large. The Code of Hammurabi is often pointed to as the first formal, written building code. This code outlined the responsibilities of builders for the safe construction of buildings and laid out harsh punishment for those who failed to comply. Subsequent advances in building codes are often tied to some catastrophic event as it relates to public buildings or places.

For example, the burning of Rome in 64 A.D. led to improved building practices and code requirements in the area of fire safety. Likewise the great fire of London in 1666 gave rise to another early set of fire safety regulations. Sir Edwin Chadwick published a "Report on the Sanitary Condition of the Labouring Population of Great Britain" in 1842 that, for the first time, placed environmental conditions as a safety concern for the public as related to buildings and neighborhoods. And finally, the San Francisco earthquake of 1906 led to the popularity of the first National Building Code. The severity of the quake highlighted a pressing need for minimum safety standards to protect building occupants and the community

from structural hazards and in areas with seismic activity from the devastating threat of earthquakes (USGBC 2006).

As building codes advanced in the U.S., three major groups promoted their model codes and, for the most part, code usage became regionalized. The U.S. building industry recognized that one national building code, based on engineering, material science and human safety and less dependent on geographic and cultural differences was good for building safety and good for focusing participation in one national model code effort. In 1994 the three regional code organizations came together to establish what would become the International Code Council (ICC). The ICC was charged with developing a single set of comprehensive and coordinated national model codes for building and fire safety, what has come to be known as the International Codes, or the I-Codes (USGBC 2006).

From a sustainability standpoint, the I-Codes did little to promote the concept of sustainable building. However, the ICC has addressed this issue with its International Green Construction Code (IGCC) that is currently in the review process. Version 2 was published in November, 2010 and according to the ICC schedule should be finalized and adopted in March, 2012 (International Code Council, Inc. 2010). While building codes have been slow to address the importance of energy efficiency and sustainable building, they currently are in the process of doing so. It will be a few years at least before one can measure the impact that the IGCC, or other likeminded codes, have on the building industry. It will be up to local governmental entities to officially adopt the code requirements before any discernable impacts can be reported.

Already there is some movement for federal agencies and state and local governmental entities to adopt some sort of sustainable practice or code. Led by the U.S. Green Building Council (USGBC) and its LEED system (discussed more fully later), various sustainable initiatives including legislation, executive orders, resolutions, ordinances, policies, and incentives are found in 45 states, 442 localities (384 cities/towns and 58 counties), 35 state governments, 14 federal agencies or departments, and numerous public school jurisdictions and institutions of higher education across the United States (USGBC 2006).

In addition, states such as California are leading by example in adopting sustainable standards. In December 2004, Governor Schwarzenegger established green building as a priority for his administration with Executive Order S-20-04. Schwarzenegger's Green Building Executive Order (GBEO) requires state-owned facilities to be designed, constructed, operated, and renovated as "LEED Silver", or higher, certified buildings (Sussman, E., et al 2010).

California renewed its efforts in 2010 with the much-anticipated launch of its Green Building Standards Code. This mandatory code will affect all new buildings in the state. As earlier initiatives only applied to governmental buildings, this new code is a remarkable step forward. Now all new buildings in California must meet certain sustainable requirements which address a more holistic set of risks to human and environmental health. In New York City, the Urban Green Council (USGBC's local affiliate) released arguably the most comprehensive analysis and set of recommendations for the incremental greening of any building code. The work of NYC's Green Codes Task force, established by Mayor Michael Bloomberg and the New York City Council, mirrors a national trend of communities taking

action to address today's pressing economic, environmental and community health issues (USGBC 2006, International Code Council, Inc. 2010).

In some jurisdictions, model green building codes may still be several years from adoption, and even further off for enforcement. Nevertheless, the USGBC is developing a template for code compliance that can be adapted for any alternative green building method or material to overcome real or perceived barriers to building green.

ASSOCIATIONS / ORGANIZATIONS

While governmental entities have provided a broad framework of initiatives and goals aimed at sustainable building practices and building codes have responded by developing initial drafts of codes that require sustainable building practices, by far the largest contributor to sustainable building practices to date has been through non-governmental organizations or NGOs. Various associations and organizations have been formed around the world to promote sustainable building. While all have some common elements, they differ in some respects based upon their origin.

Common elements seen in the different sustainable initiatives (taken from the French model) include; 1) harmonious relationship between buildings and their immediate environment, 2) integrated choice of products, systems and construction processes, 3) low-impact worksites, 4) energy management, 5) water management, 6) industrial waste management, 7) maintenance and facility repair management, 8) temperature and humidity comfort, 9) acoustic comfort, 10) visual comfort, 11) olfactory comfort, 12) healthy living spaces, 13) healthy air, and 14) healthy water (HQE - GT International 2008).

Illustrative examples of the sustainable initiatives that have received a favorable following and show promise of adoption by a governmental entity or incorporated into the framework of a building code include BREEAM, HQE, and LEED. These three will be discussed briefly in alphabetical sequence in order to avoid the appearance of favoritism towards one over another. The list is not intended to be comprehensive, only illustrative of initiatives taking place around the world.

BREEAM System

One of the driving forces behind the European energy efficient design standards is the European Unions' 2002 Energy Performance of Building Directive (EPBD). Each of the member states of the European Union (EU) is responsible for individual implementation of the EPBD through national laws. The main focus of European sustainable building design at this time is on reducing energy use directly and carbon emission indirectly. The EPBD has five main themes; 1) certificates, 2) inspection, 3) experts, 4) calculations, and 5) minimum energy performance requirements (Yudelson, J. 2009).

Driving the EPBD is the heightened concern in Europe over the role of building energy and materials use in global carbon dioxide production, constraints on energy supplies, and the potential for catastrophic changes in the global climate as a result of increased carbon dioxide concentrations in the atmosphere. European national governments have been far more willing to accept the conclusions of climate science than American or Canadian governments and have been willing to take that science and develop practical public policies for reversing

the growth of carbon emissions. These policies include the use of subsidies and the passage of laws in order to regulate and implement these policies.

The United Kingdom has been a leader in implementing the EPBD. The government has introduced requirements for Energy Performance Certificates (EPCs) for new buildings and a Display Energy Certificate (DEC) for existing building. Each building is graded from A (best) to G (worst). Public buildings, and those occupied by public authorities, that have a total useful area greater than 1,000m2 and provide a public service to a large number of people (i.e. schools, hospitals, government or local authority buildings) are required to post their EPC or DEC. The current average building energy use lies between D and E (BRE Global Ltd. 2011).

The Building Research Establishment (BRE) was founded in 1990 and has become the leading authority on sustainable design in the United Kingdom. Privatized in recent years, it developed the BRE Environmental Assessment Method (BREEAM), which has certified more than 1,200 commercial buildings and more than 110,000 housing units. More than 800,000 buildings are currently registered and pursuing a rating (Yudelson, J. 2009, Eichholtz, P., et al 2010).

BREEAM rates building according to the nine major categories in order to receive a single score, similar to the LEED system. The scores translate into five rating categories; 1) pass, 2) good, 3) very good, 4) excellent and 5) outstanding. The BRE is also actively involved in the areas of education. As the BREEAM system is based upon a third party certification, BRE is actively involved in training assessors to verify applications and accredited professionals (BREEAM AP) to assist those seeking certification (BRE Global Ltd. 2011).

The BRE has begun promoting BREEAM International and has successfully exported its system to a half dozen other countries which now have certified buildings. In addition, BREEAM Gulf is being developed for mid-eastern countries. In 2008, the International Council of Shopping Centers adopted BREEAM as a standard for rating shopping centers throughout Europe, and the Dutch Green Building Council also adopted BREEAM as its standard (BRE Global Ltd. 2011).

Another interesting aspect of the BREEAM system is its “bespoke” rating system for building types that don’t fall within a previously defined category. The bespoke system allows for the modification of the rating scheme to meet the particular needs of unusual buildings. The LEED international system, while becoming a bit more flexible, provides for a more rigid set of standards to follow. BREEAM is likely to be the dominant rating system in many European countries. It provides a green rating system that actually works because it’s in tune with the marketplace yet retains a sense of higher purpose (Yudelson, J. 2009).

HQE System

Over the past few years, sustainable development has become one of French society's great concerns. Ministries, local authorities and all corporate segments have been making this topic central to their strategic decisions. The initiatives undertaken to ensure a "greener" world have spanned all directions, and it can now be stated that France (following years of lip service) is indeed aware of the stakes involved, as evidenced by the adoption of increasingly stringent environmental protection measures, in association with an ambitious set of objectives (HQE - GT International 2008).

The construction and housing sectors have been lumped into this dynamic. In response to these new demands, all participants in the built environment (real estate developers, social landlords, housing corporations, investors, architects, construction companies or local authorities) must comply with certain sustainable practices and production models. Regulatory changes in terms of urban planning and the application of new building standards now require all participants in the development process to more closely scrutinize the means employed to assess project impacts on the environment (HQE - GT International 2008).

Discussions held on the topic of sustainable development have mainly focused on two schools of thought. The first approaches the context from its economic and social vantage point in addition to incorporating an environmental perspective. This school expands emphasis to the architectural and use attributes of the project, introducing non-polluting materials, pursuing social goals, respecting biodiversity and addressing life cycle issues, to cite a few indicators. The second is referred to as the "energy" school and tends to group sustainable development concepts towards issues directly related to energy usage and specific objectives to reduce greenhouse gas emission. A draft law written subsequent to the Grenelle Environment Roundtable seems to indicate that the construction industry and the "energy" school of thought is moving into position as the dominant model (HQE - GT International 2008).

In terms of benchmarks, France tends to prefer associating qualitative and quantitative indicators. A French approach entitled "High Quality Environment" (HQE) begins by laying out a global conceptual matrix that differs markedly from the American LEED or English BREEAM systems, both of which are aimed at achieving a set of quantifiable objectives. The "French style" model is perceived by some as a more holistic model than its competitors. The difference with the French approach also lies in the organizational pattern among participants. HQE was originally developed in 1992 as a voluntary set of standards featuring fourteen sustainable elements divided into four major groups; 1) eco-construction, 2) eco-management, 3) indoor environment, and 4) health. Since 2004, the French have also utilized HQE as an eco-building rating system (Yudelson, J. 2009).

The current driver of French sustainable development and green building programs is the Grenelle Environmental Policy adopted in October 2007, which created a plan for promoting sustainable development, establishing renewable energy and green building construction as national priorities. In terms of specific goals, the policy calls for all new building to use less than 50 kilowatt-hours per square meter per year by 2012 and to be carbon neutral by 2020. Within the next 5 years, the policy is expected to reduce commercial energy consumption by 20% and residential energy use by 12% (Yudelson, J. 2009).

HQE’s overall goal is to generate 30% energy savings, to reduce overall national greenhouse gas emissions by 40% and to produce 16% water savings. HQE began certifying individual projects in 2005 and to date there are about 200 HQE certified buildings with an additional 500 projects in the process of becoming certified (Yudelson, J. 2009).

LEED System

In the U.S., green building initiatives began to come together more formally in the 1990s. A few early milestones in the U.S. include: 1) American Institute of Architects (AIA) formed the Committee on the Environment in 1989, 2) Environmental Resource Guide was published

by the AIA in 1992, 3) EPA and the U.S. Department of Energy launched the ENERGY STAR program in 1992, 4) the U.S. Green Building Council (USGBC) was founded in 1993, and 5) the USGBC launched its Leadership in Energy and Environmental Design (LEED) program in 1998 (Kaplow, S.D. 2009).

The sustainable initiatives to first gain traction in the U.S. were those promoted by the residential sector. These included Energy Star, Earth Craft House, Built Green – Colorado, NAHB Green Home Building Guidelines, and finally LEED for Homes. Interestingly enough, the first four each have strong regional followings with LEED for Homes playing "catch-up" at the present time. On the other hand, the LEED system is the only one that has truly made an impact in the area of commercial construction.

LEED is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across metrics considered the most important: 1) energy savings, 2) water efficiency, 3) CO2 emissions reduction, 4) improved indoor environmental quality, and 5) stewardship of resources and sensitivity to their impacts (USGBC 2006).

Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators with a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. The LEED system evaluates the building upon completion and awards it a certain level based upon the number of points achieved. The building is rated as Certified, Silver, Gold or Platinum. Most involved with the process now say that one can achieve LEED "Certified" at little or no additional cost, except for the administrative fees associated with the LEED process. Many schools or agencies that have adopted the LEED system as a means of meeting their sustainability goals often use LEED "Silver" as the minimum level of acceptability. Since its inception, approximately 7,500 commercial buildings have been LEED "certified" or officially granted the LEED seal at one of the four levels. However an indication of its increased popularity is the fact that about 30,000 commercial building are currently "registered" (USGBC 2011a). A building is registered with the USGBC when a registration fee is paid with the aim to achieve LEED certification. Upon registering a building, the project team has access to the LEED resources needed to achieve certification.

In addition to the LEED certification process, the USGBC is actively involved in educating the public and promoting sustainable building initiatives. There are approximately 80 local chapters at the present time and about 300,000 individual members of the USGBC. In addition, approximately 160,000 individuals have taken and passed the LEED AP (accredited professional) exam (USGBC 2011a).

The LEED model has received some level of international recognition and is expanding an international initiative. The LEED International Program is promoted as a rating system representing global consistency, a regional approach, and local outreach and support. Countries that have a Green Building Councils include Argentina, Brazil, Canada, Chile, Colombia, India, Italy, Jordan, Mexico, Norway, Poland, Romania, Russia, Spain, Sweden, Turkey and the UAE (USGBC 2011a).

MARKETPLACE / ECONOMIC INCENTIVES

Energy certification for a project involves several different types of costs, regardless of the certifying agency. The most direct cost is also the smallest: the fees paid to the certifying organization to register and then to certify the project. The next cost is the time and effort put into compiling and submitting the documentation required and generally managing the compliance process. This cost could be for an outside consultant hired for that task or someone on the staff of the design firm, the contractor, or the owner. This is a significant project for someone doing it for the first time, and not such a big deal for someone who does it regularly and has figured out the process and created or purchased effective tracking systems (USGBC 2011b).

Another cost consideration is the additional time and effort the high-performing building team spends on a range of scenarios to determine how the competing systems will perform and prepare cost estimates to price them out. They also have to investigate alternative products and materials and explore the feasibility of new technologies. In addition, high-performance buildings require additional commissioning that comes at a premium (Building Green, LLC 2010, USGBC 2011b).

While building owners are generally willing to pay the additional cost for certification if they can be shown the advantages, there often are other incentives to consider. One of the most effective and more popular strategies to encourage green building is to incentivize the market through financial or structural incentives. Rewarding developers or homeowners who practice green building techniques spurs innovation and demand for green building technologies (USGBC 2011c).

Structural incentives work by encouraging developers to practice green building through rewards such as additional density bonuses or expedited permitting processes. At low or no cost to the municipality, building green can be made a more attractive option to developers. Review and permitting processes vary widely in length from one jurisdiction in another, in some municipalities these processes can take up to 18 months. Allowing developers to significantly reduce the duration of this process, in exchange for committing to specific green building standards, can result in significant cost savings for the developer. This allows a municipality to offer a significant incentive with little or no financial investment, since it only requires a shift in permitting priority. Like expedited permitting processes, density bonuses require little or no financial investment by the municipality. Many municipalities allow for percentage increases in Floor Area Ratio or other measures of density contingent upon certification or proof of green building practices (USGBC 2011c).

Direct financial incentives in the form of tax credits or grants to developers who propose or build green buildings are offered in some municipalities. However, many of these programs do not directly impact a municipality's finances since the proposed developments will often increase the assessed property value in the city and which allows the city to offer financial incentives without any threat of reduced revenues. Many municipalities already offer tax credits as a means of advancing specific policy agenda (i.e., offering tax credits for a developer to build a tax generating facility). These same principles can be applied to homes or developments that achieve certain green building goals. Some municipalities that charge fees for permit review or other permitting processes have begun offering reductions or

waivers for developers following green building standards. Many times this incentive can be paired with a structural incentive such as expedited permitting (USGBC 2011c).

Unlike the other incentive programs discussed above grants will require a financial investment by the city. These programs can often be funded by one of the revenue generating strategies discussed earlier. Grants can be given to homeowners or developers to go towards certification or other costs associated with green building (USGBC 2011c).

Revolving loan funds are another approach whereby a large fund is established that can be used for low interest loans to those seeking to build or renovate to green building standards. These loans are then repaid to the fund at a rate lower than the operational cost savings from the improvements in order to lower the up-front costs associated with some green building practices and encourage home owners and developers to build green. The fund is continuously replenished by the repayments so that it can be used for additional loans.

Many municipalities are also offering free planning or certification training and assistance. This assistance may allow for a developer who is unfamiliar with green building practices to build green. Another important benefit gained from certifying a project under a formal third party certification banner is the ability to use this as a marketing tool. Some municipalities have begun to offer free marketing assistance via signage, awards, websites, press releases, and other means as an incentive for developers to build to green standards (Building Green, LLC 2010).

CONCLUSION

While governmental entities have approached sustainable building initiatives for a number of years, the marketplace has had the greatest impact. Laws or statutes often omit mechanisms of enforcement and become more of policy statements than tools requiring specific action on the part of the owner. Building codes have historically been used to protect the safety and health of the public. However, safety and health have not, until recently, encompassed factors that are considered a part of the sustainable building initiative.

However, left to our own devices, great strides are being made in sustainable building. These have materialized primarily as market reactors. Sustainable initiatives began as idealized concepts, became a reaction to increasing fuel prices, were left to associations to develop and have, in recent years, caught the attention of the public at large. And finally, sustainable initiatives are beginning to creep into governmental legislation with prescriptive requirements.

Worldwide initiatives are being embraced that will have lasting impacts on the built environment. Just a few years ago, utilizing sustainable ideas and principles came with an economic price tag. However, as sustainable building products are becoming more mainstream and sustainable design and building practices are becoming commonplace, we're seeing that we can build to a moderate level of sustainability with little additional costs. Now a number of certification schemes are being promoted that reflect the building owner's commitment and provide public awareness through the level of certification.

It must also be noted that the topics discussed in this paper are elements of the industrialized world. A significant percentage of the world's population reside in developing countries. Developing countries have yet to embrace the concepts and possibilities of sustainable building. It also must be kept in mind that we truly are in the infancy stage as far as sustainable development is concerned – and this applies to the industrialized countries. Great opportunities exist for associations and individuals involved in sustainable construction and sustainable development in the years to come.

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PERFORMANCE BASED HOUSING POLICY IMPLEMENTATION: TOWARDS SUSTAINABLE CONSTRUCTION, INNOVATION AND COMPETITIVENESS

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Abstract
The building sector is one of the most strategic sectors everywhere in the sustainability context because of it´s socioeconomic role as one of the largest employers and also because of it´s evironmental role as one of the world´s biggest polluter. The adoption of a performance based procurement process to implement the Brazilian public housing policy is, as shown in this paper, a huge step the State might take towards the promotion of sustainable construction, using it´s significative purchase power to foster a fruitful environment for innovation, sustainability and competitiveness all along the Brazilian building sector value chain, having a leading role towards the path to a global low-carbon economy – with less greenhouse gas emission, contributing to slow down global warming – and also successfully fulfilling the targets of the national housing policy.

Keywords: Public purchasing power, innovation, performance-based procurement, sustainability, housing policy.

INTRODUCTION

The construction industry is known for its huge socioenvironmental impacts and, at the same time, as one of the largest employers. This impact is higher if seen during the whole life cycle of a building, once 80% of a building cost is concentrated in it´s use and operation time (PIMENTEL e LAURINDO, 2008). The national house deficit is over 6 million homes and 95% of it is concentrated in the poor families, that is one reason of the growing public investment in this sector. For the next four (2011-2014, Dilma Roussef´s term as president) the expected investments are over 168 billion dollars – just the second version of Programa Minha Casa Minha Vida (PMCMV) with a target of building two million houses until 2014, has a 43 billion dollars investment.

The purpose of this paper is to present the main achievement of an exploratory study whose main objective was to identify the impact on innovation and sustainability of using a performance-based procurement (PBP) approach in the implementation of the public housing policy. Another objective is to present PBP as a strategic tool for promoting competitiveness, innovation and sustainability in the construction chain through the use of the State purchasing power taking this chain towards a low-carbon, more environmental-friendly, economic model.

This paper is divided in four parts, the first aims to present how the construction chain is included in the sustainability context, in other words, this section presents the main challenges the building sector faces in the transition to a more sustainable context.

The second section presents the role of innovation in the sustainability context, how to promote it and use it to guide the construction value chain towards a low-carbon business model, that is, how to foster innovation in order to enable building professionals to project, plan, build, maintain, rebuild and demolish building that will cause the mininum environmental impacts possible as well as promote socioeconomic development of it´s dwellers.

The third section is an assessment of the impact of the use of Performance Information Procurement System – PIPS, a PBP methodology – by the governmental agency responsible for implementing the public housing policy on the two topics presented before: innovation and sustainability, based on the international experiences and the existing theory about innovation and sustainability summarized in this paper.

The fourth part presents the final considerations of the aforementioned study.

THE BRAZILIAN CONSTRUCTION VALUE CHAIN AND SUSTAINABILITY

The building sector, in Brazil and all around the world, has a strategic position in every country´s development agenda because it is one of the largest employers and also one of the biggest polluter. In Brazil, this sector represents 5% of national GDP – if considered the expanded sector (called ConstruBusiness) this participation goes up to 15% (FDC, 2009) – and contributes with around 17% of all new job posts created in the country (MTE, 2010).

Since the first meetings about the environmental issue in the 1970´s, the pressure for sustainable behavior is fastly getting stronger, be it due to more clarified citizens/consumers or be it due to the more frequent natural catastrophes that shock – and affect – all mankind (JACOBI, 1999; MANZINI; VEZZOLI, 2002). In this scenario, one of the planet´s biggest polluting industry is not immune, therefore, it is fundamental that all actors in the construction chain search and/or develop competences that enables them to deliver solutions that satisfies consumer´s needs and preserve the environment.

Several tools have been developed to guide States, companies and civil society towards sustainable development, whose most accepted definition is the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”, presented by the Brundtland Report in 1987. One of this tools is Agenda 21 that can be defined as “a planning tool to build sustainable societies, in different geographic basis, that conciliates environmental protection, social justice and economic efficiency” (CIB, 2002) and can be split up from the global agenda into smaller agendas for regional, city levels or even for economic sectors agendas.

On this work of fostering sustainable construction, John et al. (2001) present the story of Agenda 21 for Sustainable Construction that defines sustainable construction as:

> “Sustainable construction is a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity” (CIB, 2002: 8).

Although this Agenda was created to developed nations, this definition can be extended to all countries. According to John et al (2001) what must be rethought are the actions determined in the Agenda when used to guide developing countries in the promotion of sustainable construction.

The discussions about this focus Agenda were presented in 2002 and, as discussed by John et al. (2001), it deals with the specificities of the developing world, such as how to make sustainable houses accessible to millions of people who don´t have enough purchase power to buy houses on their own and the challenge to promote sustainable construction in areas where the basic infrastructure is bad – from the components/materials production according to some specification to bad roads and problems with energy and water supply (CIB, 2002).

The Agenda proposed by is organized in 6 groups of action and outlines the main challenges the building sector´s agents in developing countries will face in the context of sustainability. Several actions proposed in the Agenda 21 are similar to the actions presented as challenges in the prospective study for the future of Brazilian building sector, corroborating the analysis made in that study and presented in this paper.

On the global context of sustainability, the Brazilian building sector must make the ongoing transition from a quantitative model of reproducing standardized houses to a qualitative perfomance-based model that delivers the needed amount of houses, while respecting the environment, the society and being economically feasible.

According to this Agenda, all participating actors must assume their responsability on this transition. The research and education sector, the private sector, the clients and the government and it´s regulatory agencies must unify their efforts and cooperate in order to raise an institutional environment that fosters innovation, the commitment to quality and performance. Partnerships must be sought to finance research of new technologies and techniques. Information and knowledge must be disseminated to promote a more conscient market that understands the impact of purchasing decisions. All roles must be reviewed, all agents must be aware of their importance in the search for a more balanced, sustainable building sector.

In order to understand the competitive situation of this Brazilian industry and to identify the challenges companies would face in the future, a prospective study coordinated by professors Dr. Alex Abiko and Dr. Orestes Marraccini Gonçalves to the Ministry of Developmente, Industry and Foreign Market.was conducted at the Engineering School of Universidade de São Paulo in 2003 for a ten-year period (PCC, 2003). This study presented the main challenges the building sector would have in order to keep growing and be competitive in the new century.

These are the main challenges: need to increase productivity, develop human resources skills, promote integration among all players in the value chain (universities, government, private companies, civil society), expand credit to build and buy houses, solve the 6 million houses deficit concentrated in the poor families, manage the growing land cost, promote a sectorial commitment to quality development, rethink regulations based on prescriptions and standards and institutional organization of the housing policy, foster innovation and sustainability and improve management skills across the whole chain – self-construction, building project, consumer orientation (knowing customer´s needs) and research (PCC, 2003).

Focus on the end-user is essential to promote quality homes and it´s lack is notable in the popular building projects, reflecting the production model stablished after the Military Coup of 1964, that Bonduki (2000) defines as central-developing opposed to the new model he defines as environmental-participative and that is still incipient. According to the author, this central-developing model lasted until Collor government (1993), when "dozens of bad quality and bad location houses were financed and built by suspect companies and people who could afford them didn´t want to live there and those who would accept living there couldn´t afford. In the end, lots of these units were left unfinished or empty".

Corroborating Bonduki´s definition, Leite at al. (2006) studying buildings of the Programa de Arrendamento Residencial (PAR – a leasing program of popular housing to low income population, created in 1998) operated by CAIXA stated that the client that most influences the requirements of the building project is CAIXA. These requirements, on the PAR´s buildings so far, don´t come from a systematic process starting in the end-user, but from guidelines of the program developed by the Ministry of Cities and by technical specifications made by CAIXA´s technicians. There is no community participation in the definition of these house´s charachteristics.

Medvedovski et al. (2006) also studying PAR found results that show there are problems in maintenance of the buildings, on the building management – specially in the relation between the building managing company and the dwellers – and in the houses´ characteristics that are changed by it´s own users because they don´t their needs satisfied. This interventions not only might harm the building structure, safety and integrity but also shows a clear house deficiency to fulfill the user´s needs and expectations.

The improvement of management process, from project to production and delivery of buildings, must also take in consideration the needs of end-users, their participation must be sought in order to avoid delay in delivery due to changes in projects and higher costs due to this changes or even because the buildings, once they do not satisfy users´ needs, must be frequently modified (GUERRA et al., 2009).

An Ernst&Young (2008) study shows that from 2007 to 2030 the economic condition of families will sensibly change; it is expected that until 2017, 57% of all new families (that means new homes) will be on the base of the social pyramid while after 2017, 78% of all 19,9 million families will be part of the middle class, that means they will have different expectations on their homes and that must be part of the house project if we think about sustainability and flexible homes that could be rebuilt rather than totally replaced by another one.

Bonduki´s environmental-participative model is more compatible with the idea of sustainable development than the central-developing model but it is still not a reality all over the country and it´s not an only one organization responsibility to implement it. It is a city plan and not just a housing plan, being fundamental the participation and integration of several actors.

Workforce qualification, partnership among actors, search for continuous innovation and competitivity, a performance-based legal and regulation framework and constant investments are the main tools to overcome the obstacles to achieve the sustainability goal. These challenges towards sustainability are very big and the work to be done is really hard but with the right planning and an effective coordination of policies and strategies of all chain´s actors

it will be possible the construction sector becomes a leading sector in the transition to a more sustainable business environment.

THE SUSTAINABILITY CONTEXT AND THE ROLE OF INNOVATION

As it happens with sustainability, innovation has several definitons, we will adopt in this paper the following concept based on Slaughter (1998 *apud* BLAYSE;MANLEY, 2004), Blayse & Manley (2004), Sakar (2007), Smeraldi (2009) and Drucker (2011) definitions: innovation is the capacity to identify, develop, adopt and explore new uses to existing knowledge in different contexts or new knoledge in exisiting contexts. The first application will be named *incremental innovation* and the second one *disruptive innovation*.

Innovation is nowadays the most important building block of competitive advantage in any company, in the long term this capacity to generate new ideas, new uses for old ideas or any mix of that will determine which companies will survive and which will not in this fastly changing world (HILL; JONES, 2009; LYNCH, s/d).

If we think sustainability – or sustainable development – as the balance of human actions´s impacts among humans and between humans and nature, there is no other alternative but change the actual production and consumption model as well as all social relations – of exploitation, misery and exclusion – that come with it. In order to incorporate the planet´s capacity to regenerate it´s resources and benefit the whole humanity for several generations we must be able to innovate.

The innovation focused on sustainability, is defined by Rennings (2000) as eco-innovation, “all measures of relevant actors (firms, politicians, unions, associations, churches, private households) which develop new ideas, behavior, products and processes, apply or introduce them and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets”.

We will incorporate the concept of eco-innovation to the previous definition of innovation, so the use of the terms innovation and eco-innovation won´t be distinguished in this paper. Therefore, innovation definition will be used as follow: the capacity to identify, develop, adopt and explore new uses to existing knowledge in different contexts or new knoledge in exisiting contexts aiming the promotion and implementation of sustainability.

Including the promotion of sustainability in the concept of innovation instead of treating this kind of innovation as another type shows there is no other alternative for companies but to incorporate the search for sustainable business in their strategies, objectives and processes (NIDUMOLU, PRAHALAD and RANGASWAMI, 2009). These authors show the implementation of sustainability doesn´t mean higher costs, it´s usually the opposite, several successful cases show the implementation of sustainability leads to cost reduction, higher productivity and market share even during period of crisis.

Loures (2009) summarizes the importance of innovation to achieve sustainability:

> “We must call attention to the essential nature of innovation when we deal with sustainability. The challenges created by global issues, specially climate change, and the natural human desire for continuous life quality improvement, require creative answers and significative qualitative gains in productivity that don´t compromise the future

> generations possibilities. If we really want to use the best humanity has to offer, we must give a special attention to the human dimension, making that knowledge and creative abilities are released emerging the truly culture of innovation" (LOURES, 2009: 94).

Smeraldi (2009) states that rather than incremental innovations, radical or disruptive innovations will lead the path towards sustainability because of their own nature of breaking rules and paradigms.

The development of sustainable products, or at least more eco-friendly products, needs several changes in companies´ structure, culture, market knowledge and also in the assessment of products impacts on the environment. The development process of sustainable products is still in a transition moment from a "green" improvement of the actual products to a real process of creation of new sustainable products that will substitute the existing ones. This transition is companies´ greatest challenge once it transcends the departmental frontiers – and even organizational frontiers – and demands an integration of different professionals and players all along the production chain (PUJARI, 2004).

Focusing the building sector, these trends and needs to promote sustainability become an evident challenge to companies and professionals. The operation period of a house, as shown before, represents 80% of all building cost (PIMENTEL e LAURINDO, 2008). Brazilian data on the resources consumption of the building sector shows that "40% of all extracted natural resources are allocated to in the building sector, 50% of all urban solid waste come from buildings and demolition, 50% of all electric energy consumption is used in the housing operations" (CORCUERA, 2008), 12% of all carbonic gas emission come from Portland cement production in Brazil, sand consumption in the metropolitan region of Sao Paulo is approximately 12 million cubic meters per year, more than 68,5 million tons of waste is annually produced in building and demolition activities, higher than the urban solid waste produced and five times higher than the resources consumed to build (JOHN et al, 2004).

John (2009), citing Kilbert, presents six principles that must be observed when thinking of construction sustainability: 1) Minimize resources consumption (conservate); 2) Maximize reuse of resources (Reuse); 3) Use renewable or recycled resources (Renew/Recycle); 4) Protect the environment (Nature Protection); 5) Create a healthy, non-toxic evironment (Non-toxic) and; 6) Search for quality in the building environment (Quality). Therefore, the following steps are important during the building process: 1) Building implementation, construction project and process; 2) Material selection; 3) Energetic planning; 4) Waste management; 5) Air quality and; 6) Project for flexibility. All this principles and steps demand increasing productivity of all resources – human, energetic and material.

As the house is inevitably a (material) product, only the search for dematerialization and service emphasis cannot promote sustainable constructions. It is fundamental that the incorporation of sustainable principles happens all along the process of project, production, delivery, use and rebuild/demolition of a house. That´s where innovation must happen: the search for new housing solutions that will balance social demands, economic feasibility and environmental protection while promoting human development in all surrounding area.

Concluding, sustainable construction is not only the building project itself, it reaches out these frontiers and includes the surronding area, the building integration in the urban tissue, the social relations generated and the economic opportunities created.

PIPS AND THE IMPACT ON INNOVATION AND SUSTAINABILITY IN THE BRAZILIAN BUILDING SECTOR

One important issue to be discussed is the development of performance norms instead of prescriptive norms and it´s impact on the building sector. This transition from a prescriptive model to a performance model is strategic to the promotion of sustainability and innovation and it is getting stronger (ALMEIDA, 1997) with the strengthening of global markets and real time communication across nations empowering consumers and putting stronger pressure on companies´ reputation – the most valuable asset organizations have nowadays (BORGER, 2001; GUNNINGHAM, 2005).

The main support on the use of economic tools and performance norms is that once this regulations determines what is expected from companies´ activities instead of how companies must operate (command and control model), these companies are free to find the best value alternatives that attend the regulation´s expectation and the economic demands of companies (ALMEIDA, 1997; PEREIRA et al., 2007; VARELA, 2007). Although results are achieved faster in command and control methods, the use of economic tools and performance norms foster innovation and a proactive behavior of companies, however, it is essential the participation of all actors in the construction of these performance demands sharing knowledge and comprehension of what is expected (SEROA DA MOTTA, RUITENBEEK e HUBER, 1996; SEROA DA MOTTA, YOUNG, 1997; PeBBu, 2005).

In this transition context, the performance based procurement is a strategic tool to change the players behavior, once:

> "The intent is to (…) shift the paradigm from traditional 'acquisition think' into one of collaborative, performance-oriented teamwork with a focus on program performance, improvement, and innovation, not simply contract compliance. Performance-based acquisition offers the potential to dramatically transform the nature of service delivery, and permit the federal government to tap the enormous creative energy and innovative nature of private industry" (GSA, 2001: 3).

PeBBu Final Report (2005) stresses two main characteristics of performance concept application:

• Use of two languages, one to the demand and another to the supplier of the solution for the expected performance. It reflects the change in roles played by consumers and suppliers. In a performance based context, consumers use their voice (VoC) to express WHY and WHAT the building solution must attend/perform while suppliers will offer HOW this performance/goal will be achieved, in other words, the development of the solution goes from the consumer to the supplier. This is the greatest breakthrough in the building sector, although it is not new (there are register of performance based demands in Hamurabi´s time), performance based approach in the building sector is not frequently used (PeBBu, 2005, CHONG et al., 2007, KASHIWAGI et al., 2010).

• Need to validate and verify the results achieved compared to the expected performance. It is necessary from the selection of the building solution to the assessment of the performance during the effective building operation. Several methodologies were developed to help this assessment such as Serviceability Tools & Methods®(ST&M®) by Internation Centre for Facilities, a KPI list by the US Federal Facilities Council and the Construction Product Directive by the European Union (PeBBu, 2005).

There is not enough experience in performance based procurement that enables a building to be entirely planned, procured, delivered, maintened and used based on performance documents, so a blend of the two models (performance and prescription) is still needed, however it is important to keep in mind the shift in the role of consumers and suppliers/contractors, where the first says WHAT they want and the sencond present HOW they will fulfill it. Despite the challenges in implementing this structural change, countries like Australia, Canada, Finland, the European Community as a whole, Hong Kong, the Nordic Countries, Singapore, South Africa, Spain, The Netherlands and the United Kingdom have been testing PBP where clients understand this approach serves their purposes better (PeBBu, 2005).

In this paper research it was adopted a 17-year tested methodology called Performance Information Procurement System (PIPS), created by professor Dean Kashiwagi at Arizona State University in 1991. This system is based in the Information Measurement Theory (IMT), Kashiwagi Solution Model (KSM) and the Construction Industry Structure (CIS). All these components are continually followed, assessed and updated in order to strengthen the proposed model and simplify it (KASHIWAGI, 2010).

IMT concepts basically show that: decision making brings risk and demands ones subjective bias and experience to make it; the use of dominant information – clearly identifiable and understood data – is the main resource to minimize decision making; the past performance and future capability enables one to predict future performance and; experts can identify risks before they happen and they can simplify complex information into simple explanations to non-experts (CHONG, 2007).

PIPS have been tested over 700 times, for over 17 years, projects worth more than 2 billion dollars. The results show an average of 98% customer satisfaction (projects delivered on time, within budget and according to expectations), reductions of 90% in project management transactions and less than 1% “surprise factor” of nonperformance (KASHIWAGI, 2009, 2010).

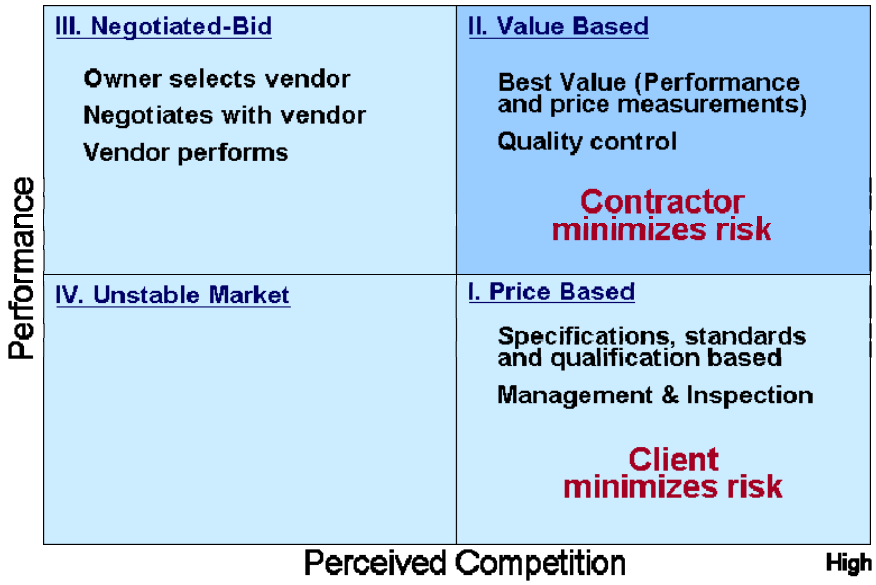
Duren and Dorée (2008) make a critical assessment of Kashiwagi´s declared results and identified that even some numbers are overestimated, the average results found are higher than the ones from traditional low-bid contracts. The authors also use the New Institutional Economics (NIE) to explain these results instead of Kashiwagi´s IMT, KSM and CIS and found PIPS has a great potential in reducing uncertainty, opportunism and transaction costs.

The KSM aims to identify if a person has more of visionary characteristics (called Type A) or management/control characteristics (called Type C) in an extreme characteristics model. The most indicated type to support and implement PIPS is Type A, because of it´s characteristics these kind of people use more logic than personal bias and experiences to choose experts, delegate responsibility and release control, minimizing risks as show in the IMT concepts (SULLIVAN et al., 2007).

The CIS classifies an industry into four quadrants according to the perceived competition and the performance factors (Figure 1). Nowadays construction industry all around the world is in the first quadrant – price based – where the clients minimizes risks they identify by managing and controlling all contractors actions (ADEYEMYI et al., 2009, KASHIWAGI et al., 2009).

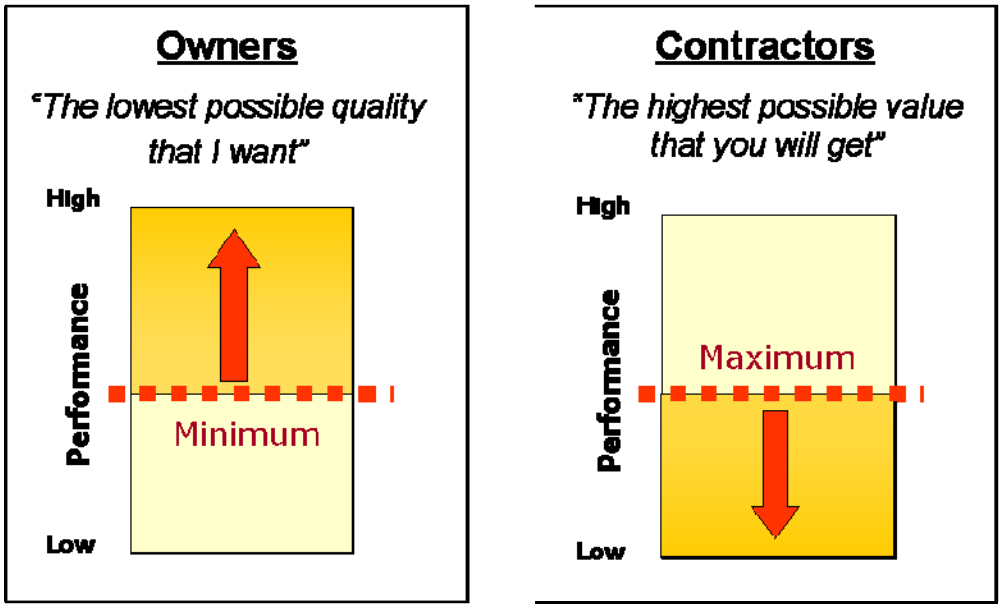
This price-based model not only reduces contractor´s perfomance but also stimulates a reactive behavior where contractor will do exactly what the client specifies, instead of analyzing all the risks the client may not have identified that would impact on performance (Figures 2 and 3), that´s why this delivery system (based on client´s control over contractors and price based selection) is considered the main source of the problems identified in the delivery of construction (not in time, out of budget and not satisfying consumer´s expectations) and not the lack of technical expertise of players as it was thought (ADEYEMYI et al., 2009; DUREN & DORÉE, 2008; KASHIWAGI et al., 2009, 2010).

Figure 1: *Construction Industry Structure (CIS)*



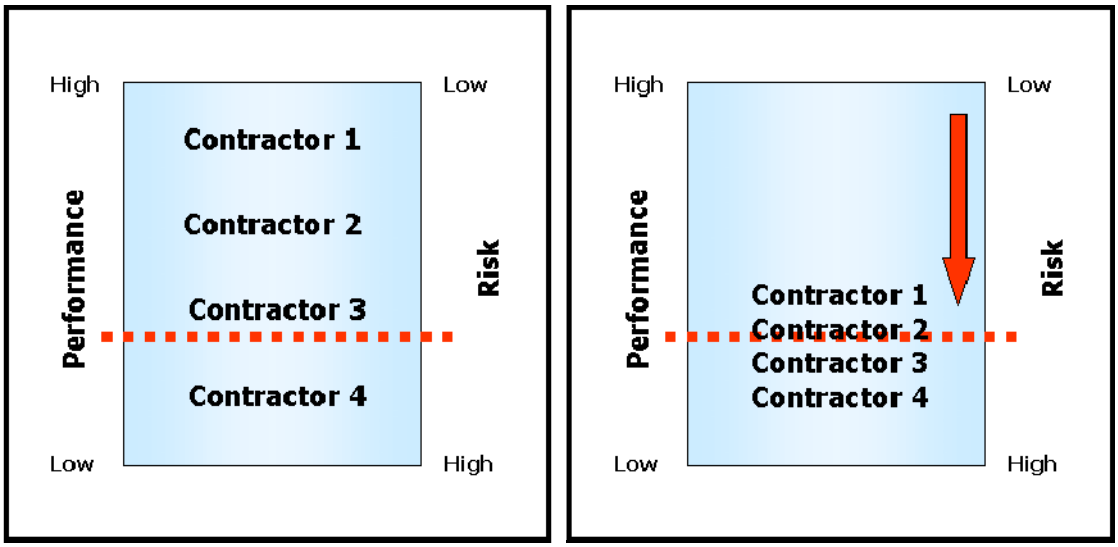
Source: KASHIWAGI et al., 2009.

Figure 2*: Problem with Price Based Procurement*



Source: KASHIWAGI et al., 2009.

***Figure 3**: Price Based Award*



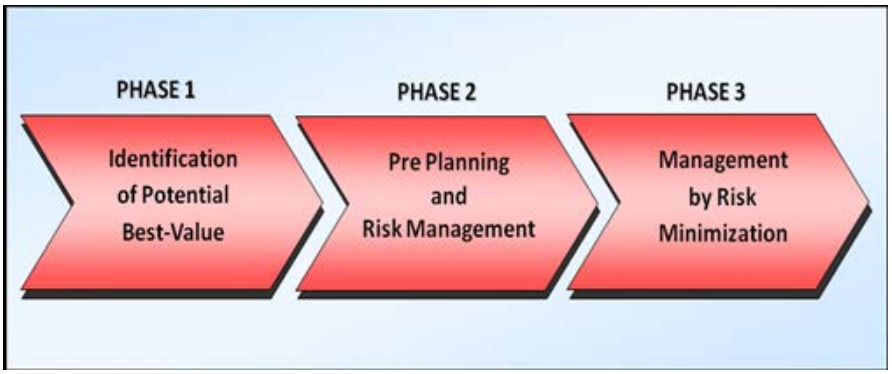
Source: KASHIWAGI et al., 2009.

PIPS proposition is to reduce as much as possible all decision making based on subjectivity and increase the use of dominant information (clearly identified and understood by anyone) to identify the best perfomer, the best constructor that will be selected to present the best solution (HOW) to the customer´s needs and expectations (WHY and WHAT) based on it´s past performance and it´s proved capacity of risk management and customer orientation.

PIPS – as well as other perfomance based procurement methods – will foster a transition from quadrant I to quadrant II: best value quadrant in the CIS represent a context where contractors have high performance in a competitive context, clients are satisfied once they choose the best value contractor, in other words, best performance (project on time and within budget) for the lowest cost (ADEYEMYI et al., 2009).
PIPS structure is briefly presented by Kashiwagi (2011):

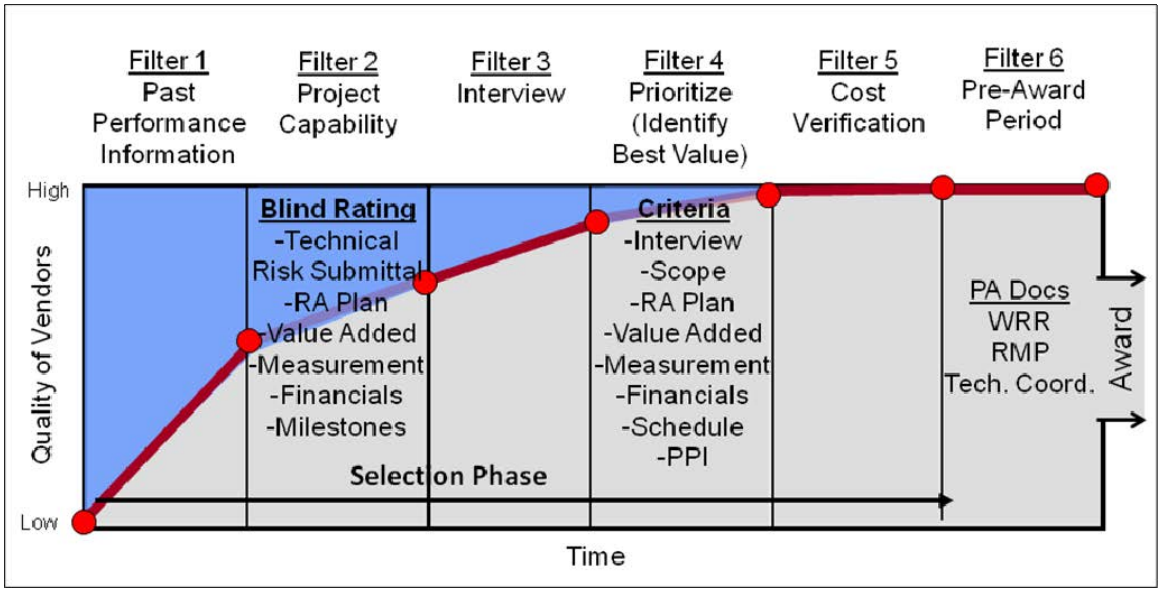
> "The BVP/PIPS has three phases: selection, pre-award, and management of the project risk.
> The selection phase has five filters: past performance information, competitive ability to manage and minimize project risk, interview of key personnel, prioritizing the vendors and doing a dominance check to ensure that the best value vendor is the best value.
> The client's representatives assume the vendors are experts through the selection process then assume the best value vendor is not an expert in the pre-award phase to minimize the risk of the vendor. The paradigm is to minimize the need for technical decision making in the selection process, and maximizing the need for the best value vendor to prove they are an expert in the pre-award phase.
> The previous paradigm also forces vendors to show dominant differential in performance that minimizes the need for any technical decision making by the client.
> The risk is shifted to the vendors to show value through dominant expertise, knowing that experts minimize both risk and cost, thus providing the best value for the lowest cost" (KASHIWAGI, 2011: 36).

Figure 4: *PIPS Phases*



Source: Adeyemyi et al., 2009.

Figure 5*: Five Filters of PIPS Selection Phase*



Source: Adeyemyi et al., 2009.

The proposition of PIPS adoption in the implementation of the Brazilian public housing policy incorporates ten points that we consider essential to promote sustainable construction using the public investment in the sector:

1) Stimulate cooperation among participants of the sector;
2) Stimulate construction companies to understand and attend dwellers needs and expectations;
3) Promote the building integration in the urban tissue, fostering socioeconomic integration of it´s dwellers;
4) Promote the search for sustainable solutions in all building phases, specially during it´s operation period;
5) Stimulate creativity during the building project, fostering innovation;
6) Focus on the building expected performance not on specifications and standards;
7) Stimulate continuous search for quality and development;
8) Promote building solutions compatible to regional specificities;
9) Stimulate social participation in the building selection phase and;

10) Foster human resources´ development throughout construction value chain.

The flexibility found in the PIPS guidelines allows all points to be incorporated in the public housing policy implementation. One important change proposed is to use the statement of objectives instead of specified models for popular houses – the current practice adopted in the public housing policy.

A request for proposals (RFP) must be done in a way that lets the market (building companies) free to create new solutions that attend the expectations and objectives declared in the RFP. That is the first condition to promote innovation according to the theory presented.

Demanding solutions that take into consideration local specificities and the needs of dwellers, plan the integration of the building – and it´s people – in the urban tissue and fostering economic opportunities for these people are the main drivers to find real sustainable construction proposals.

The maintenance of the requirement for companies to be certified by the Brazilian national program of quality and productivity in habitat fosters the continuous search for development and quality and strengthen the relationship among players across the building sector and use the State power to facilitate the market development and proactiveness not just reactiveness and compliance.

A selection committee can be made with representatives of several professionals of CAIXA (the responsible operator of the public housing policy). This multidisciplinary group has a very important role in the blind assessment and interview phases and during the pre-award meetings where the project risks can be discussed as well as the assessed capacity of the contractor to perfom according to what was asked.

The focus on the capacity of the contractor to perform according to what was asked and manage the project risks not the focus on the compliance of this contractor to the standardized house presented by CAIXA is a great step towards the transition to a participative, sustainable model of promoting the public housing policy.

Once the contractor is selected according to it´s evident capacity to perform successfully, the project is presented to the committee and can be discussed based on it´s attendance to the objectives requested by CAIXA as well as the effectiveness of the innovative solutions presented. All explanations must be based on dominant information and technical certification of the solutions capacity to perform according to what was asked.

Despite the need of technical certifications, according to IMT findings, any expert – in this case, the contractor – can explain the complex details of it´s expertise knowledge in a simple way anyone can understand, so, we believe technical explanations and discussions won´t be a problem to keep the participative structure of the process, in other words, committee members don´t have to be experts in engineering or achitechture to know whether a contractor is capable or not to perfom and solve any risk identified in a project.

After all discussion on project risks (mainly of non-performance) are over, the contract is signed based on the risk management documents, the project developed along with the informations provided during the selection and pre-award process. CAIXA must follow the

building phase according to the risk management plan (assessing if the contractor is managing the risks identified and what it is doing to mitigate any risk that might happen) and contractor must do what they know how to do best: build and deliver according to the customer´s expectations on time and within budget.

To conclude, we can say the main achievements of the exploratory study summarized in this paper are: • the use of PBP to implement the Brazilian public housing policy, which means basically select contractors that will have their projects financed, enables a wider range of project options that incorporate both regional and sustainable aspects as well as develop regional economic agents in the building value chain like material suppliers and local maintenance companies; • a faster approval process; • a cheaper and faster conflict resolution actions in very common problems identified in the existing buildings such as painting and lighting maintenance and security; • a more participative and transparent process; • innovation, the most important builiding block of competitive advantage, is also stimulated by this performance-based model of implementing the national housing policy that promotes also sustainability and competitiveness in the whole construction value chain. In other words, the use of a performance-based approach in the public housing policy has great potential to promote sustainable construction in it´s holistic concept previously presented.

FINAL CONSIDERATIONS

This paper summarizes the main achievements of an exploratory study on the impact the use of performance-based procurement in the implementation of the Brazilian public housing policy has on innovation and sustainability in the building sector.

Although the study was focused on popular housing that is financed by governmental policies and is, nowadays, the most attractive niche in the building sector, the discussion about sustainability transcends this niche. Sustainability has been a market strategy to differentiation and that is, by definition, not sustainable. The responsible use of resources and universal access to houses are fundamental to build a truly sustainable society where everyone has a decent place to live and has support to develop their capabilities to contribute to the whole society improvement.

The achievements shown in the exploratory study, although based on Brazilian experience on public housing policy, are based on international theory of innovation, sustainability, performance based procurement and sustainable construction, therefore, it can be extended to other countries. We must be aware, however, that the implementation, or even a proposition of implementation as the one made to Brazil, must be adapted to the countries´ reality: social and environmental demands, public policy characteristics and current position of Construction Industry Structure and industry level of development.

We believe the intent of the paper was achieved and some opportunites for future research in this area are: the acceptance of this new procurement system by the main actors responsible for this policy implementation; the level of development of each agent identified in the Agenda 21 – how commited to these strategies are they? –; the development of an educational program to train all actors participating in this procurement process and; the development of mathematical methods to assess reputation and a selection score to determine whether companies will or will not have their projects financed.

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NEW OUPUT QUALITY INDICATORS IN CONSTRUCTION PRODUCTIVITY MEASUREMENT

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Abstract
Productivity increase in the construction industry is often seen as low. Construction innovation projects could be prioritized partly based on expected contribution to industry productivity. Quality change in construction outputs and inputs is crucial. The purpose is to explore new output quality indicators. The analysis draws upon life cycle analyses for facilities, project benchmarking schemes and environmental assessment systems. Disruption of client core activities due to technology and method choice in construction projects should be taken into account, and also the willingness of clients to pay for risk reduction. The result is a set of output measures. Primary output is identified as 'useful area'. Secondary output measures, with estimates provided by expert panels, would include effects on future energy consumption, effects on other future operations and maintenance resource needs, effects on client/user disruption, reduction of client/user risk during operation and maintenance, user comfort, architectural quality, and external societal effects. However, it would not be feasible or even desirable to collect a wider range of data routinely for the production of official statistics at the industry level.

Keywords: productivity, life cycle analysis, benchmarking, services, innovation

INTRODUCTION

Official statistics in OECD countries usually indicate that the annual rate of productivity increase in the construction industry is low. Earlier research has identified several reasons, including quality measurement errors (Crawford and Vogl, 2006; overview by Huang et al., 2009). As a consequence, international comparisons of construction productivity growth at the industry level, including the partial measure of labour productivity, are difficult to perform and to interpret (Ive et al., 2004). More recently, comparative analyses across industries and countries within the European Union and in relation to the US, relying on the EU KLEMS database, have been made available for the 1980 to 2005 period (Timmer et al., 2010).

Despite the problems associated with productivity measurement for the construction industry, it can be argued that construction innovation projects could be prioritized partly based on their expected contribution to industry productivity. This assumption has been made in the Swedish *Bygginnovationen* (The Construction Innovation, www.bygginnovationen.se) project, operational in its first phase since 2009. How to measure quality change in construction outputs is a crucial question, although there is also a problem with input qualities that change, such as educational heterogeneity in labour inputs. Developing productivity measures for the purpose of selecting innovation projects requires that the quality measurement issues are penetrated. As with the approach chosen by Goodrum et al.

(forthcoming), the ambition has not been to devise new metrics that could be applied throughout the industry for the production of national statistics. However, the exercise might give rise to new ideas for routine collection of productivity data.

The purpose of this paper is to explore the possibility to introduce new output quality indicators in construction productivity measurement. Construction productivity can be analysed at the industry, firm, project and activity/task level (Huang et al. 2009), and there are complicated relations between measures for aggregate and activity levels (Goodrum et al., 2002). For the assessment of innovations, higher levels than the construction project seldom appear to be useful, and there are lower levels such as technologies and components that may be relevant. Both contributions to total (multifactor) and to partial (usually = labour) productivity should be possible to measure, while output and input definitions should be as far as possible consistent with the OECD (2001) recommendations for industry level productivity measurement. This suggests an ambition to measure outputs according to market prices for construction projects, which means a client-oriented view of the value of innovations.

As the construction industry (NACE 41-43) includes both new construction and repairs, and also the whole range from housing to heavy civil engineering, it was decided to attempt the identification of a single set of measures that could be applied to proposed innovation projects of all types and not only for new construction. There will then be a need for estimating different weights for quality measures when applied to different types of construction: assessing a refurbishment innovation project that claims reduced disruption of building user activities is obviously different from assessing a new greenfield construction technology. It should be pointed out that an assessment of contribution to productivity is only one of several tests that an innovation proposal must pass in order to be supported by the *Bygginnovationen* project in its second phase, beginning in 2011; the commercial viability of an innovation project has to be analysed separately.

QUALITY CHANGE IN PRODUCTIVITY MEASUREMENT

Recent developments in service productivity measurement (Djellal and Gallouj, 2008) show that many issues encountered in the service sector are of relevance when analysing productivity growth in the construction industry. One relevant example of new approaches to the measurement of quality change in service outputs include the recognition of how the productivity of professional services is related to the productivity of whatever these services are intended to support as intermediate inputs, although this insight is hard to translate into data collection. Hitherto, the concept of ‘client productivity’ has only been used in the context of management consulting services (Martin et al., 2001), but it could equally well be applied to construction.

Another possible extension of traditional data sources is when data from customer satisfaction surveys are brought into the analysis (Färe et al., 2002). Just as in many services, there is the added complication of the customer participating in the production process of construction, e.g. when approving technical and schedule changes at construction site meetings. Co-production easily leads to the question of how co-productivity can be measured.

Although there remains a potential for the hedonic approach to qualities associated with built facilities, the estimation of implicit prices for housing attributes (Zabel, 1999; Leishman,

2001) is subject to severe limitations in the number of attributes that can be included, and for other types of facilities, even if omitting refurbishment projects, the unique features of each facility are clear obstacles. However, there are other sources of inspiration for better measures of construction output qualities, and the analysis presented below draws upon elements of life cycle analyses for facilities, project benchmarking schemes and environmental assessment systems. Furthermore, successive changes in government regulations for construction appear to offer clues.

Life cycle analyses

Many clients are thought to take the life cycle consequences of choice of materials, technologies and design more seriously than they used to do. Since the 1970s, client concern with energy cost for the operation of facilities has increased the demand for construction output qualities that raise the need for a range of inputs, and the more recent policy interest in construction sustainability emphasizes the relevance of life cycle assessments (Ortiz et al., 2009). Among public infrastructure clients, there is a growing awareness of future costs of maintenance and operations, as for steel bridges (Lee et al., 2004). If more clients are to be understood as basing their decisions on an investment view of the facility to be built, there is a number of issues to be resolved before we know the effect (as implicit prices for construction output qualities that correspond to facility features that lower future costs). One of these issues is fundamental: estimating the implicit discount rates that various categories of clients in various regions could be said to apply in their investment decisions.

Client concern with the life cycle aspects of facilities would be reflected primarily in design specifications and thus influence contract sums. The rise in long-term qualities is unlikely to be registered in traditional measures of construction outputs.

Project benchmarking

Since the UK Egan report in the mid-1990s, inspired by survey practices in the car industry, schemes for benchmarking performance in construction projects have gained widespread popularity (Costa et al., 2006; Rankin et al., 2008). In what ways do these mostly client-oriented schemes point to new output quality measures?

Construction project benchmarking can be seen as the outcome of a combination of ideas taken from customer satisfaction surveys and the project success literature. As yet, we are unable to impute what the actual client demand levels are for project attributes currently used in project benchmarking schemes. Applying the Just-in-Time principle is a good example of how a supplier might exhibit lower productivity and the customer firm a higher productivity, unless there is a compensating price premium paid by the customer. Traditional measures of construction productivity obviously fail to reflect whether contractual time schedules are met. On the contrary, for the customer who is unable to open a new production line because the built shell is not ready, there will be a measurable loss of productivity. Time precision, probably like cost precision and quality precision, is a service process quality that has not been thought about in the context of construction productivity, although it is likely that there is an implicit price for such qualities.

For the purpose of selecting innovation projects, it seems necessary to take into account the disruption of client core activities due to technology and method choice in construction projects, not least in the context of repairs and refurbishment. In general, the experiences from project benchmarking indicate that the willingness of clients to pay for risk reduction in construction projects might need adequate measurement as one or more output qualities. Now

it can be argued that there will only be weak reflections of service process qualities, as well as attitudes to risk, in construction contract sums, because clients tend to select as contractors those who have submitted the lowest tenders. However, there are signs that even public clients, whose freedom of choice is more restricted by procurement legislation, increasingly rely on non-price criteria for the award of contracts and that soft qualities such as ability to work in partnering relationships can be recognized by procurement officials and affect the ranking of submitted tenders in a way that corresponds to a set of implicit prices.

Environmental assessment schemes

The ongoing diffusion of environmental assessment systems such as LEED, BREEAM and CASBEE gives rise to the question of to what extent environmental ratings are associated with output quality changes. Eichholtz et al. (2010) have provided evidence of the economic value of 'green buildings', which should be possible to interpret as affecting construction productivity. One aspect is that clients might show willingness to pay for the image effect of owning a certified building, but this may be nothing but a transitory phenomenon.

These assessment systems offer numerous ideas for measures of environmental qualities. This is also the case with current European standardization efforts, primarily the EN 15643 series Sustainability of Construction Works - Sustainability Assessment of Buildings, which is intended to cover more than environmental sustainability, for which there is already the draft standard EN 15978 Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method. It remains to be seen whether there will be a similar degree of consensus for measuring social and economic performance.

Construction regulations

In the context of selecting innovation projects, one reason why trends in the development of construction regulations are a potential source of relevant measures for construction output qualities is that in the future, existing technologies and designs may become obsolete due to government decisions. Additionally, an increased reliance on market pricing of public services that are currently offered free or at subsidized prices may in time make construction firms internalize effects that currently are external to the market mechanism. Prescient firms might recognize this and direct their demand for construction qualities accordingly, perhaps also influenced by assessment systems such as those mentioned above.

Returning to the idea of considering effects on client productivity, fire regulations for commercial buildings can be chosen as an example. Here there are three effects of regulations to be considered: (i) on client productivity, (ii) on third party (= neighbour, e.g.) productivity and (iii) on public services (= firefighting, e.g.) productivity. As to client productivity, the first of the three effects, a paternalistic view is that clients are subject to search costs for information, or that they suffer from bounded rationality so that they are unable to act fully in their own best interest.

SUGGESTED OUTPUT MEASURES

The result of this analysis is a set of output measures, where the primary output is identified as 'useful area', subject to a set of correction factors. Secondary output measures would include effects on future energy consumption, effects on other future operations and maintenance resource needs, effects on client/user disruption, reduction of client/user risk during operation and maintenance, user comfort, architectural quality, and external societal

effects. However, for a given proposal for a construction innovation project, most of the secondary output values would have to be estimated by expert panels according to simple scales in relation to defined reference buildings and reference technologies, which would represent a typical current base level in the domestic market for new construction or refurbishment.

The examples of related terms in Table 1 have been collected from Gilchrist and Allouche (2005), Hawk (2003), Lee et al. (2004), Rankin et al. (2008), REHABCON (2004), Rouse and Chiu (2009), and proposed European standards for Sustainability of Construction Works.

Table 1: *Suggested output measures.*

Output	Explanation	Examples of related terms
Useful length/area/volume	A user-oriented measure of capacity. Can be modified with a 'future capacity for flexibility' coefficient and coefficients for site-specific factors	urban/rural, geological and climatic factors
Energy	Discounted future reduction for the facility in use [kWh]	fuel consumption
Other operations and maintenance	Discounted future reduction of non-energy operations and maintenance resources for the facility in use	routine maintenance/rehabilitation; feasibility of post-repair monitoring, normal service life of repair
Disruption	Reduction of disruption of user activities	quality issues – available for use; user costs; traffic delay cost, noise/dust/vibration; repair time, cost of business disruption
Risk	Reduction of non-deterministic effects for the customer, within the contractual period and during the subsequent life of the facility (discounted, probability weighted)	time, cost, quality deviation; highway vehicle damage, vulnerability costs; fire safety; security
User comfort	Discounted future user comfort in excess of reference comfort levels	user costs; indoor air quality, acoustic performance, accessibility, smooth travel exposure; comfort and convenience, safety of users; traffic accidents
Architectural quality	Discounted future owner and user architectural experience in excess of a reference level	aesthetic contribution
Social effects	Discounted future reduction of negative external (non-market) effects	environmental damage, business effects; sustainability – design; indirect socio-economic losses; effects on third parties, environmental costs; property damage, noise, emissions, vibrations

A note on inputs

To obtain partial measures of productivity, the ratio between selected output measures and input measures can be estimated. The main input categories chosen here are Labour, Materials, Energy, Services and Environmental externalities. These categories can be divided into subcategories; 'waste' can appear both under (bought) Services and under Environmental externalities. Also with inputs, there is a problem with quality changes that are ignored or underestimated traditionally, such as heterogeneity of labour input, where shifts in educational level should be taken into account (Jorgenson et al. 2003). If wages or salaries reflect educational levels and skills, they would be better measures than number of manhours worked, used indiscriminately for the calculation of labour productivity.

CONCLUSIONS

Over the years, an increasing part of the value of construction outputs in typical OECD countries appears to have shifted towards qualities that are difficult to measure directly when applying conventional methods for calculating industry productivity. When selecting innovation projects according to their expected effects on construction productivity, it is important to devise a wide set of output measures that reflect a broader view of qualities, although it would not be feasible or even desirable to collect a wider range of data routinely for the production of official statistics at the industry level. For the purpose of international comparisons of productivity data, it is necessary to retain classifications and methods of measuring outputs and inputs that minimize the need for subjective assessments of intangible qualities. Unfortunately, this also reduces the usefulness of productivity data aggregated the industry level in many countries; analysis of these data can no longer be reliable guides to the development of either government policies or corporate strategies in regions where construction demand has shifted towards a wider set of qualities that are difficult to measure.

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SOME LEGAL ASPECTS OF BIM IN ESTABLISHING A COLLABORATIVE RELATIONSHIP

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Abstract
Working with BIM will have legal consequences. In the Netherlands these consequences are feared by some and seen as an obstacle to wide spread use of BIM techniques. Unnecessarily so. In the paper it will be shown that according to Dutch law liability issues nor copyright issues nor issues of procurement law should be seen as an obstacle. What is needed however is a proper set of general conditions, which are broadly accepted by both employers and designers and contractors.

Keywords: Legal aspects. Construction contract law. Copyright law. Procurement law.

INTRODUCTION

Construction projects involve the work of many different parties. It is widely acknowledged that communication problems are an important source of budget and time excesses as well as errors in design activities and execution. One new exciting way of communication is working with a Building Information Modelling. Working with BIM has many different legal aspects: The contractual relationship between parties will need to be adjusted. The usual general conditions have not taken into account the aspects of working at the same time in one model by different parties. Nor can they. Therefore new contractual documents need to be developed which cover the relationship between the parties working the BIM team as well as between the parties and the owner. The aspect to be highlighted in this paper is the liability question. Than there are aspects concerning procurement law: is it possible to demand that tenderers work with BIM? What does this mean for tenderers who don't work with BIM? Can they be excluded? In this paper these aspects will be dealt with from a Dutch point of view. There are more legal issues to be dealt with for example on the validity of the electronic signature, the obligations to retain information electronically etc.

In this paper BIM is understood as: 'digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, [that] is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of the facility'. This definition comes from US National Institute of Building Sciences (NIBS) and seems to be widely acceptable, in any case by lawyers given the fact it is used in the paper published in 2008 by the UK Society for Construction Law Contract issues in the use of construction building information modelling (the paper is written by Kimberly A. Hurtado and Patrick J O'Connor Jr, and can be obtained from the website from the UKSCL, and was published in 2008 in the International Construction Law Review, p. 262-272). This definition contains two important characteristics of BIM: the computable representation of a facility and the life-cycle approach. What is lacking in the definition is the fact that BIM makes it possible that several people can work at the same time in the computable representation. It is this aspect that basically causes most legal questions. I deliberately use the word questions and not problems, because there are legal questions to be faced, but, as will be shown in this paper, these answers can more or less be given easily.

THE NEED FOR NEW GENERAL CONDITIONS

Introduction

The relationship between the employer and the designers and contractors is governed in most countries by general conditions. In the Netherlands the most used general conditions are: The New Rules 2005
Legal relationship client–architect, engineer and consultant DNR 2005, the Uniform Administrative Conditions 1989 (it is expected that in 2011 a new version of these conditions will be published, an English translation is available at www.ibr.nl.) concerning the relationship between employer and contractor in the traditional model and the Uniform Administrative Conditions for Integrated Contracts 2005 for the design and build model (available in English via www.bna.nl and www.nlingenieurs.nl). None of these conditions have any specific clauses on working with BIM. Earlier research has shown that the content of these general conditions forms no obstacle to working with BIM. From a contractual point of view the main issues are the ownership of the intellectual property rights to the design, the liability for mistakes made in the BIM design and the matter of organizing the actual working in BIM by several people. How to deal with these matters?

Intellectual property

In the non Dutch literature the question concerning who owns the intellectual property rights during and after working in BIM does not seem to cause many legal concerns (H.W. Ashcraft, Building Information Modelling: A Framework for Collaboration, in The Construction Lawyer, 2008, nr 3). That is not the case in the Netherlands. Architects especially have made clear that they are reluctant to work with BIM, because they see their intellectual rights threatened by it. Since the intellectual property rights of architects, notwithstanding their mandatory legal protection as well as protection in the general conditions, are often violated (there is a considerable amount of case law proving this point), this fear is well understandable. But it must be remembered that this violation is due to the behavior of powerful employers and not due to the legal system. The working with BIM does not make it easier to violate the property rights of the architects, but does raise question on ownership caused partly by matters of the law of evidence.

Who is the owner of the design that came into being in a cooperation facilitated by BIM? The starting point according to the Dutch law on intellectual property is that the maker of a design is the owner of it. It should be noted that the terminology (maker of the design) is neutrally formulated and is not limited to only architects. Anybody can have an idea that is worthy of the protection of the Law on Copyright. So it is mistaken to say, that architects who are attached to their legal protection should not be part of a BIM team, because the protection is relevant for all members of the BIM team, which is clear when looking at the Dutch copyright law article 6. But who owns the copyright if there is teamwork? The law does not answer this question just like that. According to Dutch law one has to distinguish between a ‘communal work’ (gemeenschappelijk werk) and a ‘combination of works’. An example of a communal work is the work of an opera writer and the writer of the libretto if both writers worked together on a specific opera. The idea is that the contributions cannot be subject of an independent judgment. If an independent judgment is possible, like with an illustrated book and indeed in many cases of music and words than the Dutch law determines these works to be a combination of works. The determinant factor is: can the contributions be identified and separated. The distinction is of importance because of the legal consequences attached to it. In

case of a communal work the right to exploit the work accrue to all the authors jointly and acts of exploitation need the consent of all the authors as well (art. 26 Auteurswet and article 3:166 Civil Code). In case the work is not deemed to be communal every author can independently of the other ones exploit his rights. It needs to be mentioned however that the law in this case is not mandatory, so other agreements can be made. And a second point is that reasonableness and fairness can be of influence on particular acts. Reasonableness and fairness are also applicable in case of a communal right, art. 26 Auteurswet. One question that is not dealt with in Dutch (case) law is if it is of importance what the size is of the share of one author. It is feasible to argue that if one author had a share of 70% in a design this might influence the way he excersises his rights.

So how are we to qualifiy the design activities when working in BIM? The answer to this question is dependant upon the way the architect, the consulting engineer and the contractor worked together. Is their working to be compared to the opera writer who writes in close cooperation with the libretto writer, than the Dutch law will qualify the result of this cooperation as a 'communal work'. However this way of closely operating together will not often take place. More often it will be so that the architect makes the general design, after which the consulting engineers and the contractor appear to make the 'technical and execution' designs adding their design parts in the BIM model independently of the architect and independent from each other. Architect, engineer and contractor all use the same technique and work in the same virtual surroundings but the results of their activities can be identified from one another and separated intellectually. The fear of many architects that someone else will illegally use and claim their design is this way of working less realistic than in the traditional way of working, because electronically every 'entry' is registered with time and name. The Dutch copy right law considers the result of this way of working as a combination of works provided of course that these works are eligible for being qualified as a work to be protected by the copyright law (only original works are to be protected, see article 10 of the Auteurswet). The fact that certain works are not protected by the copyright law because they lack a certain originality does not mean the law does not offer other ways of protection. Possibly the law of tort offers protection against violation of certain ideas being used in this way of working.

In conclusion: in principle there is no legal difference when parties work in the traditional way or when they work in BIM. The difference is formed only by the 'more primitive' means used to design with in the traditional way not by new legal consequences of working with this new technology.
What is important is that the persons working together in a BIM surroundings make clear arrangements concerning the qualification of their work and the legal consequences. The law allows parties to make their own agreements and since they know best what suits their particular work they should formulate these legal consequences themselves before starting their activities in BIM.

Liability

Since a few years the English speaking world has become acquainted with the model of Early Contractor Involvement. It came into use because of the underlying assumption that if use was made of the execution knowledge of the contractor in the design phase the execution could take place faster. Because of the shortage of houses after the war, caused by the baby boom, speed was of the utmost importance. A special feature of this model (called in Holland: the building team) is the allocation of the liability for design errors. Liability lies not with the

party who suggested a certain idea leading to damages, but with the party in whose specific field of professional knowledge the idea lies and who has accepted this idea. Thus if the contractor suggests something lying in the field of the consulting engineer and the consulting engineer accepts this idea 'as if it was his' and it turns out to be a wrong suggestion leading to damages, according to the general conditions governing this model, it is the consulting engineer who is liable and not the contractor. This is the model in which the contractor joins the designers before the execution of the design. In the Netherlands this model has been known since the Second World War (Van den Berg, 2007, p. 323).

The question that needs answering looking at the way persons work in a BIM setting is, can their relationship be qualified as a 'building team' in the specific legal meaning of the words in the Dutch general conditions on this model (this is the VGBouw Model Bouwteam-Overeenkomst 1992, published in 1992 by the organization of contractors Vereniging Grootbedrijf Bouwnijverheid)? The answer is to be denied. The reasoning is that although contracts in Dutch law have in general no set form and the formation of a contract can take place in any form, the construing of a building team from the sole fact that parties work at the same time in a BIM needs too much to be assumed that this consequence is actually wanted by the parties. More information on the intentions of the parties is needed to draw the legal consequence, that although a specific agreement establishing a building team in the legal sense of the general conditions is lacking, nevertheless such an agreement can assumed on the basis of the way parties behave. So that means that while working in a BIM team the contractor suggests a modification in the work of the consulting engineer, it all depends on whether or not the agreement of the consulting engineer with this suggestion can be seen as he wanting to take over the liability for the suggestion of the contractor. In other words the sole working in BIM creates no new or different law of liability.

So how is the liability allocated in the case of a mistake made in a BIM team not being a building team?
Once again a distinction has to be made, somewhat comparable to the distinction between the communal work and the combination of works in the copyright law. How is the BIM team to be qualified? Is the BIM team to be qualified as a form of coordinated design activity or as a form of an integrated design activity?

In the Dutch legal literature (Van den Berg, 2007, p. 329) the coordinated design activity is described as a form of cooperation by designers individually contracted by the employer. These designers have their own obligations arising from their contracts with the employer, they consult one another on a regular basis in order to make the design parts fit. Cooperation is not the main theme of this 'team'. It fits with this way of working, that each party is liable for his own work. This is not the whole story however, because according to most contracts (and if this obligation cannot be based on the contracts it will follow from the law) between employer and designer there will be a duty to warn against mistakes made by the other members of the 'team'. If that duty was breached liability might shift partly or completely to the person who should have warned. In any case the liability will be joint and several and leave the sorting out of the exact parts to the designers and not to the employer.
It is to be understood that this theoretical model might not be realised in practice. The temptation will be great when working like this, to cooperate more closely than the model allows for. If that is the case, the other model, the integrated team, comes into view.

In the integrated team the cooperation is far closer: two or more parties have accepted an assignment to be fulfilled collectively. The participants in this model will constantly look at

the work from the other members of the team, comment on that, alter it, correct it etc. If this happens it might be argued because it is impossible to distinguish who has made which suggestion, that the result of their activity is one work and with this qualification goes collective liability. This is argued by Van den Berg (Van den Berg, 2007, p. 330). But is this situation the situation of the BIM designers? Van den Berg did not take into consideration one of the typical features of working with BIM: the additions made to the model, the changes and corrections etc. are exactly traceable. So an essential part of his reasoning leading to collective liability seems to be not applicable in the BIM situation. But that is not quit correct: because in a BIM model we know exactly who added something to the model, but we do not know whose idea this was. So the argument for collective liability still stands. But is this liability to be preferred? And what about the division of the liability between the parties of the team?

My suggestion would be the following: in the relationship BIM team and employer collective liability is indeed to be preferred. In the relationship between the members of the team the liability should ideally be allocated according to the Dutch general conditions for the building team.

I would therefore like to argue as follows by starting from the viewpoint: what fits with the idea of working in BIM. To use BIM optimally cooperation between all workers in the BIM team is to be stimulated to the utmost. Allocation of liability to the person to whom a mistake can be traced will per definition lead to discussions between the team members being held liable and the employer that party A who was held liable is not liable but that party B was liable or that party C should have warned against the mistake, so he is liable as well, which party C will of course deny. This kind of arguments are not attractive for the employer. BIM is supposed to make his life easier, by using a technique that is superior to the present techniques, but faced with this allocation of risks, the employer might want to stick to other techniques. So the allocation of the risk must be attractive to the employer and not be more of a burden than necessary. This brings me to the idea of collective liability as suggested by Van den Berg for the integrated building team, because this fits with the nature of the way one works in BIM, or should work in BIM: as a real team.

Being liable to the employer collectively does not mean however that at the end of the day all members have to bear a part of the financial burden of a mistake of one of them. It only means that the employer can choose any one from the team members for the total amount of the damages. But after having paid these damages, the paying member of the team turns around and asks the other members to contribute. How much each member has to contribute, is dependent upon the agreement the team made: possibly only the member who is responsible for the mistake has to pay for the mistake (perhaps together with the member of the team who should have warned against this mistake); possibly all members bear the costs of the mistake in equal amounts or in an amount in accordance with their share of the work in the team. This is an issue the parties of the BIM team have to decide upon in advance.

My suggestion concerning the division of the obligation to contribute at the end of the day (so among the members of the team) would be to follow the allocation of liability according to the Dutch general conditions for the building team: liability should be borne by the party in whose specific field of professional expertise the suggestion lies and who has accepted that idea. This way we stimulate legally what might be a very good side effect of the BIM way of working: to stimulate all parties of the team to come with creative ideas from; but because not every idea is per se a good idea the party most suited to do so, should be obliged to check this

idea and ‘put his money where his mouth is’ by accepting legal responsibility for it. This way we combine creativity with guarding the soundness of ideas. Thus the contractor suggests something in the field of the construction engineer; the consulting engineer looks at the idea and accepts it as a sound idea and adds it to ‘his part’ of the BIM model assuming that the members of the team have designated who takes care of what and who is authorised to add what to the model. This is something parties working in the BIM have to agree upon explicitly and clearly in advance as well. Assuming that the consulting engineer is the only one who can add the idea (because it is in his field and that is the way parties agreed upon in advance), we can assume that the act of adding the idea to the BIM model is prove of his accepting the liability for the idea. BIM makes problems of proof less of a problem. There is hardly any case law on building teams notwithstanding its broad use in the Netherlands. The problem of proving that a party made an idea his own in the building team has never been in a problem in case law as far as I know. All in all the questions on liability in the BIM team are not leading us to a very different approach in comparison to existing ways of working. This conclusion is somewhat similar to what is to be read in Consensusdocs 301, Building Information Modeling (BIM) Protocol Addendum ,1.1. General Principles: ‘This Protocol Addendum does not effectuate or require a restructuring of contractual relationships or shifting of risks between nor among the Project Participants other than as specifcally required per the Protocol Addendum and its Attachments.’ We can use existing examples and apply them to working in BIM.

In conclusion it might be hoped due to the fact that mistakes become visible in an earlier and virtual phase, that damages will decrease.

What does the owner get?

Another question to be answered regarding working with BIM is: what rights does the employer get when the model is handed over to him? The owner wants at least the right to realise the design like with any other design he contracted for. But does he also get the right to alter the design? And if he has that right: does that mean he is entitled to work in the BIM model to design the alterations before executing them or does he have to ask the original designers to change the model such that execution can take place safely? In a recent discussion I heard someone draw the comparison between the rights of the builder of a website and the rights of the employer for whose organisation the website was built. It is possible to make the website in such a way that the employer can change anything, but it is also possible to limit the rights to do so and make the owner only licensed to a ‘limited use of the website’. These are also issues that need a legal strategy before rights are turned over.

Organisation of the BIM team

In the Dutch general conditions for both the relationship employer and contractor and the relationship employer and designer the question of coordination in case the contractor or the designer is faced with other parties working at the same project is dealt with. In the first relationship the obligation to coordinate the works lies with the supervisor on the side of the employer (clause 31 Uniform Administrative Conditions). In the relationship employer and designer the general conditions (The New Rules 2005, clause 6.2)) the employer is obliged to point out a party who will be responsible for ‘the tuning in of the activities of the different consultants and which participant is responsible for steering the process of the activities of the different consultants’.

If an employer wants a design to be made in a BIM team which forms, he will be obliged to take care the leadership of this team or the coordination in this team is properly organised. Failing to do so will give the members of the team claims for loss of time and or claims for damages. Basically the situation in a BIM team is not different from the situation in which in the traditional models parties have to work together. In the Dutch general conditions for the building team it is the employer as well who has to deal with the coordination of the team. Of course he can delegate this task to another member of the team, or he can let the work be done by a third party. Obviously that last choice will not change the liability of the employer to the members of the team.

ASPECTS OF PROCUREMENT LAW

One of the issues raised in the Netherlands is if procuring agencies can demand the use of BIM technology by tenderers knowing that this technology is not widespread yet and actually only used by a very few tenderers. Would this not favour these companies in a way unacceptable from the viewpoint of equality and guarding against favouritism?

I would like to argue as follows. In the Consideration on Directive 2004/18 one can read:

‘(29) The technical specifications drawn up by public purchasers need to allow public procurement to be opened up to competition. To this end, it must be possible to submit tenders which reflect the diversity of technical solutions. Accordingly, it must be possible to draw up the technical specifications in terms of functional performance and requirements, and, where reference is made to the European standard or, in the absence thereof, to the national standard, tenders based on equivalent arrangements must be considered by contracting authorities. To demonstrate equivalence, tenderers should be permitted to use any form of evidence. Contracting authorities must be able to provide a reason for any decision that equivalence does not exist in a given case. Contracting authorities that wish to define environmental requirements for the technical specifications of a given contract may lay down the environmental characteristics, such as a given production method, and/or specific environmental effects of product groups or services. They can use, but are not obliged to use appropriate specifications that are defined in eco-labels, such as the European Eco-label, (multi-)national eco-labels or any other eco-label providing the requirements for the label are drawn up and adopted on the basis of scientific information using a procedure in which stakeholders, such as government bodies, consumers, manufacturers, distributors and environmental organisations can participate, and providing the label is accessible and available to all interested parties. Contracting authorities should, whenever possible, lay down technical specifications so as to take into account accessibility criteria for people with disabilities or design for all users. The technical specifications should be clearly indicated, so that all tenderers know what the requirements established by the contracting authority cover.’

In the Annex VI, belonging to this Directive the definition of certain technical specifications is described as:

‘For the purposes of this Directive:
1. (a) "technical specification", in the case of public works contracts, means the totality of the technical prescriptions contained in particular in the tender documents, defining the characteristics required of a material, product or supply, which permits a material, a product or a supply to be described in a manner such that it fulfils the use for which it is intended by the contracting authority. These characteristics shall include levels of environmental

performance, design for all requirements (including accessibility for disabled persons) and conformity assessment, performance, safety or dimensions, including the procedures concerning quality assurance, terminology, symbols, testing and test methods, packaging, marking and labelling and production processes and methods. They shall also include rules relating to design and costing, the test, inspection and acceptance conditions for works and methods or techniques of construction and all other technical conditions which the contracting authority is in a position to prescribe, under general or specific regulations, in relation to the finished works and to the materials or parts which they involve;
(b) "technical specification", in the case of public supply or service contracts, means a specification in a document defining the required characteristics of a product or a service, such as quality levels, environmental performance levels, design for all requirements (including accessibility for disabled persons) and conformity assessment, performance, use of the product, safety or dimensions, including requirements relevant to the product as regards the name under which the product is sold, terminology, symbols, testing and test methods, packaging, marking and labelling, user instructions, production processes and methods and conformity assessment procedures;'.

From these citations one can conclude that specifications not only are important for the result of the activities of the tenderer but possibly also for the way this result is reached, in our case while working with BIM. If the contracting agency wants the tenderers to work with BIM the agency must be prepared to answer the question calling into doubt that an equivalent of this way of working does not exist. If it can answer this question proving that that this way of working is new and unique and no other way of working can reach an equivalent than the law of procurement does not seem to be a obstacle for requiring the tenderers to work with BIM.

For Holland the relevant legislation, article 23.2 BAO forbids the contracting agency to use unjustified obstacles. Meaning: obstacles as such are not forbidden, which makes sense, because the superior capacity of one party over another in for example technical ability will always be an obstacle for the other party, and it is not forbidden to prefer the tenderer with the highest level of ability as long assuming the criteria are proportionate and aimed at favouring one particular party (the text of this article in Dutch: De technische specificaties bieden de inschrijvers gelijke toegang en leiden niet tot ongerechtvaardigde belemmeringen in de mededinging voor de openstelling van overheidsopdrachten). Important are also clauses 23.11 en 23.12 BAO (the text in Dutch: BAO art. 23.11. Een aanbestedende dienst maakt in de technische specificaties geen melding van een bepaald fabrikaat, een bepaalde herkomst of een bijzondere werkwijze, noch van een verwijzing naar een merk, een octrooi of een type, een bepaalde oorsprong of een bepaalde productie, waardoor bepaalde ondernemingen of bepaalde producten worden bevoordeeld of geëlimineerd, tenzij dit door het voorwerp van de overheidsopdracht gerechtvaardigd wordt. Art 23.12. Een aanbestedende dienst mag de melding of verwijzing, bedoeld in het elfde lid, opnemen in de technische specificatie wanneer: a. een voldoende nauwkeurige en begrijpelijke beschrijving van het voorwerp van de overheidsopdracht niet mogelijk is door toepassing van het derde en vijfde lid, en b. deze melding of verwijzing vergezeld gaat van de woorden «of gelijkwaardig». These clauses forbid among other things the contracting agency to point to specific ways of working except when this is justified by the subject of the contract. Arguments to be used to show that there is a justification to demand that the work is done with BIM are that this way of working is a modern way of working which is comparable to working with a computer, so this might well be the normal way of working in the near future, that mistakes will be avoided, that it will lead to better relationships between all concerned, that the government by stimulating this use will make use of it more wide spread which is beneficial for the whole sector (including the

private market) etc. It seems to me arguments can be used very easily to justify this new and promising technique.

So in answer to the question on procurement: an optimistic viewpoint can be taken here as well: once again the law is no obstacle for the use of BIM.

CONCLUDING REMARKS

Liability, copyright and procurement law are legal issues are often called upon as standing in the way of widespread use of the BIM. I hope I have shown in this article that this is non issue. Certainly these issues have to be dealt with, and preferably in general conditions acceptable to all parties concerned. But they can easily dealt with. An example might be taken from the models used in the USA: ConsensusDOCS ,an Electronic Communications Protocol Protocol Addendum 200.2 and from the AIA: Building Information Modeling Protocol Exhibit, Document E202-2008. More information can be found by using the term IPD (integrated project delivery). It is important however to do this soon, because BIM is becoming fast the way to design.

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THE USE OF THE UK BENCHMARK MODEL TO DEVELOP A STANDARD GLOBAL APPROACH TO CONSTRUCTION DATA

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Abstract

The human population of the world has grown rapidly in the last fifty years. The impact of the population explosion has also had a dramatic effect on the built environment. Yet it is difficult to find a source of statistical information on a global scale that combines the data that is available. Unless there is a measure of construction activity throughout the world there is no way of gauging the scale of the issues involved.

There is a need to know the location of activity, the types and quality of output, and the numbers and skills employed in the construction workforce. Only when these measures of the construction industry are found, policies to deal with construction problems, such as homelessness, migration, health and safety, training and skills, trade in materials, carbon emissions and many other issues can be assessed by the international community.

Setting these issues to one side, a benchmark model of construction based on the UK construction industry is considered. Such a model might be used to calculate the size and growth rate of the global construction industry and this can be used to compare to other estimates of global construction. It is suggested that the global construction industry, using the benchmark model as an international standard, can itself then be used as a benchmark to compare more detailed national construction statistics.

The benchmark model uses Gross Fixed Capital Formation (GFCF) taken from National Accounts. This is then applied to a breakdown of construction using UK Construction Statistics Annual (CSA). The model establishes the breakdown of construction for any country on the assumption that the breakdown in any country will be approximately similar to the breakdown in the UK and the UK breakdown represents a typical national construction industry.

In particular this paper deals with the issue of the most appropriate variable to use to relate GFCF available in every country's national income data to the detailed analysis of UK construction data for the sake of building the benchmark model. There are three options, namely: total GFCF, the total construction element in GFCF or all new work in the CSA. No statistically significant differences are found between any of the variables but for theoretical and operational reasons the preferred option is the total construction element in GFCF.

Keywords: global construction data, UK benchmark model, gross fixed capital formation, all new work.

INTRODUCTION

Construction appears in the Nomenclature Générale des Activités Économiques dans les Communautés Européennes (NACE), which is the agreed statistical classification of economic activities used by the EU. The UK version is the Standard Industrial Classification system, (currently SIC 2007). Both NACE and the SIC are consistent with ISIC, which is the International Standard Industrial Classification agreed at the United Nations for the purposes of global comparisons. In the SIC 92 (Office for National Statistics, 2011b) all activities were divided into sections and Section F covered construction, which appeared as a 2-digit classification: 45 Construction. In both NACE and the SIC, construction was further divided into 4 main 3-digit categories, namely 45.1 Site preparation, 45.2 Building of complete constructions or parts thereof; civil engineering, 45.3 Building installation, 45.4 Building completion, and 45.5 Renting of construction or demolition equipment with operator. Unfortunately, these categories are not particularly useful for the analysis of construction activities in terms of types of output, types of firms, and market sizes. The SIC 92 has been replaced by the SIC 2007 (Office for National Statistics, 2009) together with new 3 and 4-digit codes and descriptors. The 2 and 3-digit codes are shown in Table 1.

Table 1 *UK Standard Industrial Classification of UK Construction*

Section F Construction
41 Construction of buildings
41.1 Development of building projects
41.2 Construction of residential and non-residential buildings
42 Civil engineering
42.1 Construction of roads and railways
42.2 Construction of utility projects
42.9 Construction of other civil engineering projects
43 Specialised construction activities
43.1 Demolition and site preparation
43.2 Electrical, plumbing and other construction installation activities
43.9 Other specialised construction activities n.e.c.

In section F of the ISIC, (United Nations, 2008) there are only three main 2-digit codes within construction. They are 41 for the construction of buildings, 42 for civil engineering and 43 for specialized construction activities. Construction of buildings, which is also given a 4-digit classification, 4100, includes complete residential or non-residential buildings. Civil engineering is divided into three classifications, namely 421, the building of roads and railways, 422 the construction of utility projects, such as pipelines, communications, reservoirs, pumping stations and power plants and 429 which covers all other civil engineering projects, including refineries, harbours and outdoor sports facilities other than buildings.

Not only are definitions and classifications highly complex and variable even between the SIC, NACE and ISIC, they also change over time to reflect changes in technologies and output. There is no agreed method for estimating the size of construction industries in different parts of the world apart from the NACE and ISIC definitions given above. In any case construction data is not always available. As a result there is a need to estimate likely construction output in different countries. As Gruneberg (2008) has pointed out the OECD has modelled global infrastructure construction output using a top down approach based on

an estimate of the value of existing structures, national income and the size of the global population. This data set can be used to assess the growth and size of construction markets throughout the world and gain a view of the scale of the challenge facing national and global organisations such as international development banks, the United Nations, the Organisation for Economic Co-operation and Development, the World Bank and the International Monetary Fund. However, it is not the only approach that can be adopted.

An alternative bottom up approach, devised by Gruneberg (2008), makes use of construction data and estimates construction output as a ratio of construction to gross fixed capital formation (GFCF). To begin the discussion of appropriate statistics for construction, the UK database of construction is used and the ratio of UK construction to UK GFCF can then be applied to other economies. Clearly, where this fails to produce data that resembles available construction data and information, modifications can be made to the results for any given country.

Of course the estimates will vary depending on the method used and the appropriateness of the model, when it is applied to particular countries. Nevertheless, it is important to begin the process of assessing economic activities that have an impact on the environment. Few activities can have the effect both locally and globally that the construction sector has on the environment.

Indeed, the capacity of the global construction industry is challenged by the growth of the world population and expectations regarding standards of living in different countries. Thus, as the population of the world approaches 7bn people, according to the US Census Bureau (2011), it is expected to continue growing to over 9bn by 2050, albeit at a declining rate of increase. Indeed the rate of growth in population is on a downward path from a high of 2.2 per cent per annum in the 1960s to less than 0.5 per cent by 2050. It is currently estimated by the Bureau to be growing at just over 1 per cent.

Not only are the absolute numbers of people increasing but at the same time the expectations of the populations in many ountries appear to be rising, as the so-called BRIC countries, (Brazil, Russia, India and China), increase their domestic consumption, making further demands on the environment and resources in line with their growing levels of income. The question then arises as to whether or not construction has the capacity to deliver and what effect delivering sufficient buildings and infrastructure will have on global resources and the environment.

In looking at national income data the construction industry is often seen as being approximately 5 to 8 per cent of the economy. This, however, only estimates the value added activities on site. Taken as a final good, including all the material and labour inputs, construction activity contributes between 15 to 20 per cent of the annual output of economies. As a consequence of using value added by industrial sector as the basis for aggregating national data, the impact of construction activity is often undervalued and overlooked.

DEFINITIONS AND PROCEDURES USED IN THE BENCHMARK MODEL

It is therefore important to discuss ways of deriving reasonable estimates of construction outputs. The most readily available international economic data is provided by the United Nations and other international organisations. This data includes the National Income accounts of all members of the UN, given in a common format agreed globally. In these sets

of national income accounts is a chapter headed gross fixed capital formation (GFCF). Within the CFCF is construction output. This component of GFCF is itself broken down into two components and these can be used to model a breakdown of construction data into different categories based on the pattern of output in a benchmark country or international average. In the absence of an international average breakdown of construction output by type, it is suggested that the UK construction data be used as a benchmark until a more appropriate standard is found. Of course any country might be used as a standard for this purpose until work can be carried out to find a more suitable international norm, if such as thing could be arrived at.

The actual method involves taking UK construction output data as an example. Each category of output in the data, such as housing, infrastructure, commercial and repair and maintenance are used to establish its percentage of total output by using the mean ratio for a given number of years. Table 2.8 in Construction Statistics Annual provides new build construction output only. Thus infrastructure forms a percentage of UK construction output and within infrastructure the different components can be estimated. Using UK Construction Statistics Annual the average distribution of unfrastructure can be calulated as illustrated in Table 2.

Table 2 *Average UK Infrastructure by Type of Infrastructure 1997-2008*

Type of infrastructure	***Percentage of infrastructure***
Water	15.50
Sewerage	10.82
Electricity	8.39
Gas	4.00
Communications	6.62
Air	4.83
Railways	15.93
Harbours	5.36
Roads	28.54
Total infrastructure	100.00

Based on data taken from Table 2.8d, Construction Statistics Annual, ONS (2010)

Table 2.8 in Construction Statistics Annual provides new build construction output only. The estimates for new build therefore need to be grossed up to find the total value of construction output or an estimate of the total value of all output including repair and maintenance for any given component of construction output where this is not given in the data. This is done using Table 2.2 to find the average ratio of new build to total output. For example, between 1997 and 2008 this was 0.56 of total construction output. The inverse of 0.56 is 1.79 and this inverse can be used to estimate total construction output or the total including repair and maintenance for any element within the data set.

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This percentage of total construction output is then used as the coefficient of the value of the construction element in annual GFCF to estimate the value of housing or infrastructure or other component in any given country. The same method is used to establish coefficients for all components of construction output for each year.

DISCUSSION

This modelling of the construction industry based, as it is, on existing international data and the UK is of course to some extent an arbitrary method based on a number of assumption. However, it is invariably necessary to make a number of assumptions in order to make an operational assessment to form the basis of rational decision making at an international level. The assumptions are that the same pattern of construction output exists in every country, when clearly it does not. One obvious case would be where the UK as an island, depends on ports and harbours for much of its trade. Ports and harbours do not feature as highly in land locked countries or countries with land borders with its neighbours.

A second assumption is that buildings in one country are equivalent to buildings in another. For example, residential buildings in the UK need to withstand weather conditions ranging from relatively mild winters to relatively mild summers compared to seasonal variations in Russia. Buildings therefore need to be constructed to withstand greater or lesser variations in climate in different countries and need to be built to different standards to meet those requirements. Similarly North African countries do not require buildings to withstand the winter conditions experienced by those of Northern Europe.

Gruneberg's benchmark model is based on the combination of the GFCF of the national income accounts of each country and the ratios of construction to GFCF in the UK. In this model Equation 1 shows construction new build (NB) and repair and maintenance (R&M) as a ratio of GFCF, based on the ratio of new build to GFCF and repair and maintenance to GFCF in the UK. The data is taken from the UK National Income Accounts and the Construction Statistics Annual.

$$I = (\Sigma\{RNB/GFCF\}/n)(GFCF + [\Sigma\{R\&M/NB\}/n]GFCF) \quad \text{(Equation 1)}$$

where I = total new build and repair and maintenance
n = number of years

Having established the ratio of total construction output to GFCF, it is then possible to estimate the component parts of the output of construction in terms of the different types of buildings and output of construction, such as housing, commercial and infrastructure. For example,

let INB = infrastructure new build, and
IR&M = infrastructure repair and maintenance = (R&M/NB).INB

Then,

$$I = aGFCF + abGFCF \quad \text{(Equation 2)}$$

where a = Σ{INB/GFCF}/n, that is the average annual ratio of INB/GFCF
and b = Σ{R&M/NB}/n, that is the average annual ratio of R&M/NB.

The reduced version of the equation for infrastructure becomes:

$$I = a(GFCF + bGFCF) \quad \text{(Equation 3)}$$

Using this method, Gruneberg (2008) found the average ratio of infrastructure to GFCF from 1998 to 2005 was 4.08 per cent.

In order to improve on the model given in Gruneberg (2008) a modification of the model involves replacing GFCF with one of three options, namely the construction element of

GFCF alone or all new work as given in Table 2.1, Construction Statistics Annual (Office for National Statistics, 2011a). The original benchmark model used total GFCF but GFCF includes non-construction investment, namely plant and machinery. A revised version of the UK benchmark model should therefore be based on the built element only of GFCF.

Revised version of the benchmark model

In order to demonstrate that this produces a significantly different result, it would be necessary to show that annual changes in the built component of GFCF are significantly differently from annual changes in GFCF as a whole.

When this test was carried out on UK national income accounts data, the following results were found, using Excel:

Table 3 *New construction as a component of GFCF and total GFCF***.**
Analysis by type of asset at current prices £m

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
New dwellings, excl land	21664	22516	23928	25222	25700	27394	29806	34499	38462	44298	47489	53331	55767	50292	39558
Other buildings and structures	31843	32825	35455	40274	42934	43175	44932	47562	52295	50530	56709	60454	68755	76973	68869
Total construction	53507	55341	59383	65496	68634	70569	74738	82061	90757	94828	104198	113785	124522	127261	108427
GFCF	117448	126291	133776	155997	161722	167172	171782	180551	186700	200415	209758	227234	249517	240361	205063

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Components may not sum to totals due to rounding.

Table 4 *Regression Statistics of new construction as a component of GFCF and total GFCF.*

Multiple R	0.982134151
R Square	0.964587491
Adjusted R Square	0.961863452
Standard Error	4867.985874
Observations	15

ANOVA

	df	SS	MS	F	Significance F
Regression	1	8391254685	8391254685	354.101922	8.18E-11
Residual	13	308064724.1	23697286.47		
Total	14	8699319409			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-24616.02559	6023.36836	-4.086754142	0.001284642	-37628.7	-11603.3
GFCF	0.608222727	0.032322021	18.81759607	8.18305E-11	0.538395	0.67805

From Table 4 the differences in the two variables GFCF and the total construction element were found to be significantly different (t = 18.8, with 14df). This would indicate a preference for the construction element of GFCF rather than total GFCF.

Turning now to the first differences of these two time series, given in Table 5, namely the construction element in GFCF and GFCF itself, a similar result is found in Table 6. Even

when comparing annual changes in these variables, significant difference between the behaviour of the two variables can be identified (t = 6.63 with 13df).

Table 5 *Annual change in total new construction in GFCF and total GFCF £m*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Change in TNC	1834	4042	6113	3138	1935	4169	7323	8696	4071	9370	9587	10737	2743	-18838
Change in GFCF	8843	7485	22221	5725	5450	4610	8769	6149	13715	9343	17476	22283	-9156	-35298

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Note: First differences of current data have been used

Table 6 *Regression Statistics of first differences in new construction as a component of GFCF and total GFCF.*

Multiple R	0.886365165
R Square	0.785643206
Adjusted R Square	0.767780139
Standard Error	3474.466789
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	530940288.1	530940288.1	43.98143057	2.42318E-05
Residual	12	144863033.7	12071919.47		
Total	13	675803321.7			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1140.056718	1018.996455	1.118803419	0.285120118	-1080.14583	3360.259265
Change in GFCF	0.444663653	0.067049718	6.631849709	2.42318E-05	0.298574867	0.590752439

Turning to the use of construction output data rather than the value of construction in the GFCF, Table 7 gives the indices of the current values of UK annual total construction new build and GFCF respectively. Again, from Table 8, these two time series are significantly different (t = 7.35 with 14df). Therefore the output of the model will depend to some extent on which of these two time series is selected in the model.

Table 7 *Indices of annual total new work and total GFCF*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
All new work	45	47	50	55	60	63	67	76	85	96	100	109	118	114	93
GFCF	56	60	64	74	77	80	82	86	89	96	100	108	119	115	98

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Table 2.1, Construction output, Construction Statistics Annual, 2006, for years 1995 to 1998, and Construction Statistics Annual, 2010, for years 1999 to 2009
This table is based on an index of UK construction at current prices, 2005 = 100 and an index of UK GFCF at current prices, 2005 = 100.

Table 8 *Regression Statistics based on annual total new work (Table 2.1, Construction Statistics Annual) and total GFCF.*

Multiple R	0.904494901
R Square	0.818111026
Adjusted R Square	0.802953611
Standard Error	3.511944344
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	665.7058407	665.7058407	53.97431233	8.89339E-06
Residual	12	148.0050369	12.33375308		
Total	13	813.7108776			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.354344218	1.029987925	0.344027546	0.736778825	-1.889806684	2.59849512
Change in GFCF	1.044403955	0.142159193	7.346721196	8.89339E-06	0.734665683	1.354142228

Table 9 *Indices of annual differences in total new work and total GFCF*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Change in all new work	2	3	4	5	3	4	9	8	12	4	9	9	-3	-21
Change in GFCF	4	4	11	3	3	2	4	3	7	4	8	11	-4	-17

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Table 2.1, Construction output, Construction Statistics Annual, 2006, for years 1995 to 1998, and Construction Statistics Annual, 2010, for years 1999 to 2009
This table is based on an index of UK construction at current prices, 2005 = 100 and an index of UK GFCF at current prices, 2005 = 100.

Table 10 *Regression Statistics based on first differences of annual total new work (Table 2.1, Construction Statistics Annual) and GFCF new construction.*

Multiple R	0.906646947
R Square	0.822008686
Adjusted R Square	0.807176077
Standard Error	3.474112213
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	668.8774096	668.8774096	55.41902039	7.79397E-06
Residual	12	144.833468	12.06945567		
Total	13	813.7108776			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.432338423	1.066273497	-0.405466725	0.692270322	-2.755548796	1.890871951
GFCF constr.	1.036626928	0.139249314	7.444395233	7.79397E-06	0.733228737	1.34002512

Finally, the difference between the first differences of the indices of new work and the construction component in GFCF in Table 10 are also significant with t = 7.44 with 13df. Again this reinforces the need to select the time series rationally.

The rationale for selecting the construction component of GFCF is that it appears in the national income accounts of all countries. As it appears in all national income accounts, it can be most easily applied to any country in the world and combined with UK construction data using coefficients to represent the proportion of total annual output in any one year attributable to any particular variable. In this way national construction data can be estimated to find output and other aspects of the construction sector within each country. This would only provide an approximate model of any country or region's construction sector. Local knowledge and contingent factors would also need to be taken into account.

CONCLUSION

We reject the null hypotheses that there are no significant differences between the GFCF and the construction component of GFCF and construction output all new work in the Construction Statistics Annual. We also reject the null hypotheses that there is no significant difference between annual changes in total GFCF, the annual changes in the construction component of GFCF and indeed the total new work found in Construction Statistics Annual.

The use of the construction component of GFCF is suggested as the most practical time series to use in the benchmark model to link with national accounts data and this should be used in conjunction with the construction data found in Construction Statistics Annual to form the benchmark model. This method for establishing the link between individual countries and the benchmark model could be applied to any country.

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SUPPLY CHAIN PARTNERSHIP WITHIN HOUSING RENOVATION – APPROACHES AND EXPECTATIONS IN THE DUTCH HOUSING ASSOCIATION SECTOR

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Abstract
Supply chain partnerships within housing refurbishment have not been given much specific attention which may be found surprising because the refurbishment market is becoming of increasing importance compared to new construction and has specific characteristics that require adapted approaches to supply chain integration. In this paper approaches, expected benefits and challenges of supply chain partnerships within housing renovation are explored. From general literature on building process innovation, dimensions of supply chain integration and potential advantages and challenges of have been derived and employed in a preliminary inquiry among Dutch housing associations and their partners that are experimenting with supply chain partnering in housing refurbishment projects. The results indicate that approaches are in a relatively early stage of development towards 'mature' supply chain partnerships. Furthermore, many of the general expectations also apply to the Dutch housing refurbishment sector, but at a more detailed level, refurbishment may require specific attention for the division of tasks and risks between the partners, particularly regarding communication with tenants.

Keywords
Supply chain partnership, housing associations, refurbishment

INTRODUCTION

Supply chain partnering and integration has become a prominent topic of research and debate within the building sector. Several advantages have been attached to building processes that emphasize partnerships between clients, contractors and suppliers in the construction industry, such as decreasing the waste and improving value to the client (e.g. Black et. al., 2000; Bresnan and Marshall, 2000). Nevertheless, most studies have focused on supply chains within new building projects, with some having a specific focus on the housing sector (e.g. Barker and Naim, 2008; Hong-Minh et al., 2001). Publications on supply chain integration in housing refurbishment are scarce. This may be found remarkable, since investment in refurbishment has become increasingly important. As for example Thomsen and Van der Flier (2009) show, the number of new housing construction in Europe constitutes only about 1 percent of the number of existing dwellings, which indicates the importance of maintenance and refurbishment of the existing housing stock to keep housing supply in line with changing demands. Within the current economic climate, the pressure on the existing housing stock to accommodate changing needs, has even further increased, due to the decline in new housing construction in Europe in recent years. According to Mulder (2010) housing construction in Europe, excluding Spain and Ireland, decreased by 10% in

2008, 15% in 2009 and 4% in 2010 compared to the previous year. Housing refurbishment is often a more complicated task than new construction, certainly in cases in which refurbishment encompasses substantial functional and technical improvements to improve the economic and environmental sustainability of the dwellings. Compared to new construction, it is often less easy to develop a more or less continuous production flow, because each dwelling has its own specific challenges. Moreover, refurbishment has to take into account the current tenants, which may create additional socio-economic problems, but also opportunities by knowing the preferences of end-users. At the same time, this complexity may increase the need for supply chain partnerships, in which knowledge of clients, contractors, sub-contractors and supply industry is used efficiently in an early stage of the redesign process. Therefore, combined with the increasing market share for housing refurbishment, there is a (potentially) large opportunity to increase supply chain partnership in housing refurbishment as well.

The market for housing refurbishment is highly fragmented. The existing stock encompasses a wide variety of dwellings and tenures. This paper is focused on the social rented stock, employing recent, innovative practices that are applied by Dutch housing associations and their contractors. There are several reasons why this sector is of particular interest. In contrast to private (owner-occupied) housing, the social rented stock is generally operated by professional management (although to different extents), which enables the development of professional partnerships. Furthermore, throughout Europe, a substantial share of the social housing stock has been built in the (early) post-war period. This part of the housing stock is often encountering a range of physical as well as socio-economic problems and has increasingly been considered to be out-of-date, which increases the need for refurbishment. Moreover, a large part of this stock consists of (large) housing estates that have been constructed in a highly repetitive manner, which potentially enables the introduction of a ‘reconstruction flow’, project learning and strategic supply chain partnering.

In the Netherlands there may be relatively large opportunities for increasing supply chain partnerships in the social rented sector. The Dutch social rented sector stands out internationally due to its large share in the housing stock; in 2009 2.3 mln dwellings out of a total stock of 7.2 mln, approximately 32%, (www.cfv.nl). This stock is operated by housing associations, which are private organizations that have the public task of providing housing to households who have difficulties to obtain a dwelling on the housing market on their own. On average, a housing association owned 5,800 dwellings in 2009 (www.cfv.nl) which are operated by a professional management. In the Netherlands, there has been an increasing interest in supply chain partnership in the construction sector in general and in the social rented sector as well. A survey by EIB (2007) indicated that the clients’ preferences have shifted towards building processes that are based on increased partnership. Furthermore, several Dutch housing associations have begun to experiment with supply chain partnership in new construction, maintenance and refurbishment (e.g. Straub, 2007 and 2009; Van der Brug (ed.), 2009; Vernieuwing Bouw, 2010).

Linking the reducing opportunities for demolition and replacement strategies with continuing challenges to improve the socio-economic and environmental sustainability of the housing stock, it can be expected that housing associations will place more emphasis on management and refurbishment. The financial pressure also stimulates housing associations to increase the efficiency of their organization and building processes, which in turn stimulates their interest in the opportunities that supply chain partnership generates for cost reduction. In addition, many housing associations encounter a shortage in professional skills among their staff

(FLOW, 2007), which is likely to increase in the future due the ageing and retirement of experienced staff with technical skills, thus increasing the need for more efficient sharing of knowledge and staff with their contractors.

This paper aims to contribute to filling the apparent gap in research on supply chain partnerships in housing refurbishment. Specific opportunities of increasing supply chain partnerships in housing refurbishment are discussed as well as various shapes of supply chain integration that are applied by Dutch housing associations, employing literature on the (housing) construction sector. Data was used from 9 housing associations and their partner-contractors that are experimenting with supply chain partnering in housing refurbishment within a knowledge exchange project initiated by the authors.

Section two discusses the dimensions that can be used to typify the approach towards supply chain partnerships. Section three gives an overview of the potential advantages and challenges that have been subscribed to supply chain management in literature. Section four discusses the approaches and expectations of the housing associations and contractors involved in our exchange project. Section five sums up the conclusions.

DIMENSIONS OF SUPPLY CHAIN PARTNERSHIPS

Numerous definitions of supply chain partnerships and related concepts can be found in literature. Table 1 contains a selection of these definitions which can be used to identify key characteristics of supply chain partnership.

Almost all definitions emphasize supply chain partnership is based on transparency, trust and mutual interests. This approach is usually stated as being opposing to traditional procurement approaches, which are characterized by hierarchical relations between functional and organizational divided units within the production chain. Some definitions also emphasize the importance of long-term relationships that enable continuous improvement in the supply chain. This implicates that the partnership should exceed individual building projects. Risk and profit sharing has also been mentioned as an essential component and could be a key characteristic to create the equality and common interests that may be necessary for successful partnerships in the construction industry as well. Another feature of supply chain partnership is that it involves the whole production chain and not just the client and the principal contractor, ideally involving the end-users and supply industry as well. Perhaps more specific for the construction industry, supply chain partnering implicates that contractors and other parties are involved in a much earlier stage in the building process. Within traditional procurement approaches, the contractor is involved after the design has been fully completed. In a building team, the contractor is involved in the elaboration of the design as well, but within (full) supply chain partnership contractors will be involved from an early stage in the design process and will continue to be involvement in the management of the buildings.

In construction practice, supply chain partnership occurs to varying extents. From the characteristics of supply chain partnerships dimensions according to which the extent of supply chain management can be derived. These dimensions are summarized in Table 2.

Table 1: *Some definitions of supply chain partnerships and related concepts*

Source	Definition
Kim e.a., 2010, p. 188	A supply chain partnership is a strategic alliance to achieve business advantage and exclusive goals by paying attention to critical success factors such as organizational commitment, co-ordination, leadership, trust, communication, conflict resolution, techniques and resources.
CIIPTF (1991) and NEDC (1991) in Hong-Minh e.a. 2001, p. 50. Cox en Townsend, 1998 in Khalfan en McDermott, 2006, p. 145	Partnering is a long term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources (…).The relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation and the continuous improvement of quality products and service.
Ellram en Krause in Minh e.a. 2001, p.50	Supply partnering is an ongoing relationship between firms which involves a commitment over an extended time period, and a mutual sharing of information and the risks and rewards of the relationship.
Lambert e.a., 2004 in Kim e.a., 2010, p. 188	A supply chain partnership is a tailored business relationship based on mutual trust, openness, shared risk, and rewards to create business performance.
Coopers en Ellram, 1993 in Vrijhoeff en Koskela, 2000, p. 170	Supply chain management views the entire supply chain, rather than just the next part or level, and aims to increase transparency and alignment of the supply chain's co-ordination and configuration, regardless of functional or corporate boundaries.
National Agency for Enterprise and Construction, 2004 (Denmark)	Partnering is a type of collaboration in a construction project based on dialogue, trust, openness an with early participation from all actors. The project is carried out under a mutual agreement expressed by mutual activities and based on mutual economic interests.

Table 2: *Dimensions of the extent of supply chain partnerships in building processes*

Dimension	Full supply chain partnership according to this dimension occurs when:
Building life cycle	Partners are involved from initiative till management phase.
Production chain	All parties in the production chain are involved, including subcontractors, suppliers and end-users.
Continuity	Partners are involved in a series of projects.
Risk and profit sharing	Risks and profits are divided between the partners in a balanced and transparent manner.

In addition to the dimensions to assess the extent of supply chain partnership, different approaches can also be found towards the (initial) selection of partners by the clients. In Dutch housing associations' practice (European legislation for public tendering is not mandatory for Dutch housing associations) three different approaches can be found (e.g. Straub and Van Mossel, 2007; Vernieuwing Bouw, 2010). A first approach is that partners are selected on the basis of past experiences. Some housing associations that have begun to experiment with supply chain partnership have selected contractors with whom they already had a satisfying relationship. The level of partnership is increased by having the partners involved in a much earlier stage in the design process and giving them much more responsibility in working out of the design and building plans on the basis of budget restrictions and general performance criteria set by the housing association. Sometimes framework agreements are set up between the housing association and the contractors for continuity in the relationship. In a second approach, partners are selected on the basis of their competences for partnership rather than on the basis of a bid for realizing a concrete design,

after which the housing association forms a design and construct team with the selected contractor(s). In a third approach, a housing association invites consortia of contractors and subcontractors to bid for a building project with a concrete plan on the basis of only some general performance criteria and budget restrictions. The best plan and therefore partner consortium is then selected in a transparent setting after which the selected consortium can further develop and build their plan.

OPPORTUNITIES AND CHALLENGES OF SUPPLY CHAIN PARTNERSHIP

Several (potential) advantages are attributed to supply chain partnership. Hong-Minh et al. (2001, p. 51) summarize the "principal benefits that can be achieved by entering into a partnership…as; on-time delivery (hand-over), on-budget completion, value for money, end-consumer satisfaction, improved quality, improved working relations (team-work spirit) and reduced conflicts (Lamming, 1993; Cooper et al., 1996)". Many of these advantages have also been recognized in practice, as can be derived for example from a survey by Akintoye et al. (2000) in which contractors from the UK state similar reasons for entering into partnerships (see Table 3).

Perhaps the most frequently stated advantage of supply chain partnership within the construction industry is that it can reduce waste. According to a survey conducted by USP Marketing Consultancy (2008) costs as a result of waste in the Dutch construction sector have been estimated to be over 11% of the total turnover, with one of the most frequently mentioned reasons being a lack of cooperation with regular partners in the construction supply chain. But supply chain integration could lead to additional cost savings as well, due to a reduction of the costs of the procurement process itself as well as the avoidance of overlap in the work of the supply chain partners. Straub (2009) concluded an average cost reduction of 20% due to performance-based contracting in housing maintenance compared with traditional contracting. Vrijhoef (2009) states that supply chain management in a new housing construction project, conducted in partnership between housing association Com.wonen and contractor Dura Vermeer, has led to a cost reduction of 8%. Similar effects have been found in studies from the UK (e.g. Hong-Minh, 2001; Khalfan and McDermott, 2006). In addition to cost savings and the other factors already mentioned above, supply chain partnership has been stated to contribute to innovation (e.g. Spekman et al., 2002; Soosay et al., 2008, Khalfan and McDermott, 2006). This could be of particular relevance for developing and implementing the necessary innovations for improving the sustainability of the housing stock.

Next to the advantages, (successful) supply chain partnership also generates challenges for the organizations involved. In this respect, the results of a study by Briscoe et al. (2001) among smaller and middle-sized contractors are of specific interest for the refurbishment market in which such parties are often a logical partner for the housing associations (see Table 4). Briscoe et al. mention as important skills to be developed: ICT skills, communication, marketing, client-oriented behavior, being able to deal with academics, architects and clients, as well as leadership skills aimed at cooperation and innovation. Many studies emphasize the importance of soft skills, such as trust, leadership and commitment (e.g. Kim et al., 2010; Table 5).

Table 3: *Principal objectives in developing construction supply chain collaboration*

Principal objectives	Overall
Benefits to the client	4.53
Improved customer service	4.50
Reducing bureaucracy/ paperwor	4.50
Increased profitability	4.48
Cost reductions within organisation	4.38
Increased market competitiveness	4.35
Benefits to the supplier	4.03
Improved quality assurance	3.93
Overall supply chain reduction	3.70

Source: Akintoye et al. (2000, p. 163).

Table 4*: Necessary attitudes within supply chain partnerships*

1. Full communication with partners
2. Working together (rather than trying to take advantage)
3. Sharing of information and knowledge (often with common IT systems)
4. Straight talking with no hidden agendas
5. Rapid responses to queries and requests for help
6. Enabling partners to perform (providing partner training if required)
7. Teamwork and interdependence
8. Seeking continuous improvement through co-operation
9. Willingness to change to accommodate partners
10. Open accounting and making timely payments
11. Profit sharing on a "win–win" basis
12. Common interest in providing client satisfaction

Source: Briscoe et al. (2001)

Table 5: *Critical success factors for supply chain partnerships according to literature*

	Mohr and Spekman (1994)	Parung and Bititci (2006)	Brinkerhoff (2002)	Lambert *et al.* (2004)	Beach *et al.* (2005)	Riggin *et al.* (1992)	Archer and Cameron (2005)	Fuller and Vassie (2002)	Maloni and Benton (1997)	Perry and Sohal (2001)	Maheshwari *et al.* (2006)
Leadership		○	○	○	○	○	○		○	○	○
Commitment	○	○	○	○	○	○	○	○	○	○	○
Coordination	○	○	○	○		○			○		○
Trust	○	○	○	○	○			○	○	○	○
Communication	○	○	○	○	○		○		○	○	○
Conflict resolution techniques	○	○	○		○				○		○
Partner capability		○	○	○			○		○		○

Source: Kim et al. (2010)

Approaches and expectations in Dutch housing associations' refurbishment

As stated in the introduction, pairs of housing associations and their (principal) contractors that have begun to work on the basis of supply chain partnership in refurbishment are participating in a two year project, initiated by the authors, to exchange knowledge and experience. Five housing associations are really partnering, another 4 have shown interest in the project and started participating although they did not have a partner at the moment of writing. They are to find a partner during the first months of 2011 in order to continue participation. The project has started in January 2011. The participating organizations were selected on the basis of their willingness to participate and co-finance the project. They were required to bring in a concrete refurbishment project in which they have begun to, or will begin to within a short period, to develop, employing principles of supply chain management. At the start of the project, the organizations have been asked to typify their partnership on the basis of the dimensions and approach towards partner selection as have been described in section 3. Furthermore, they were asked to state their expectations about the opportunities and challenges that supply chain partnership will generate for them within the selected project. The results of these inquiries have been discussed in a workshop with the involved parties in order to validate and complement the outcome. In this section we will summarize the findings of the first stage of this project.

Approaches according to the dimensions of partnership

In order to classify the approaches of the participants, each couple was asked to fill in an inquiry where they could express their used approach, if already decided. If they did not decide yet, they were asked to state their preference. Five inquiries were returned before the completion of this paper. In a plenary session the results were discussed and a common conclusion was derived as well as its advantages and disadvantages.

Building life cycle

The following 6 phases were distinguished:

1. Initiative and feasibility study
2. Project definition
3. Design phase
4. Execution
5. Evaluation and transfer to maintenance department
6. Maintenance phase

Three of the couples have started their partnership in phase 1 of the project, whereas one couple started in phase 2 and the last couple started during phase 4. In the plenary session the general opinion was that the best moment to start was during the first phase, however right after the first initiative, as the initiative is a matter of corporate strategy of the housing association. The main benefit of an early involvement was stated to be the optimal use of knowledge, to improve the process and outcome of the design and execution phase. The main disadvantage of early involvement was stated to be the lack of competition and possible resulting uncertainties about the market conformity of the price level.

Production Chain

The number and nature of partners involved in the production chain are quite different. In all cases the involved parties are at least the housing association together with the general contractor. Two respondents stated to involve parties such as sub contractors for electrical equipment and HVAC-systems, consultants for building physics or construction and local authorities as supply chain partners as well. The other three have one or two other parties

involved as supply chain partner. In the plenary session it was concluded that the potential advantages of supply chain partnering would benefit from involvement of partners as soon as it is clear that their expertise is necessary. This implies that particularly in more complex refurbishment projects, a wider range of parties should be included in the partnership in an early stage of the redevelopment, of course also depending on the available expertise within the housing association and general contractor.

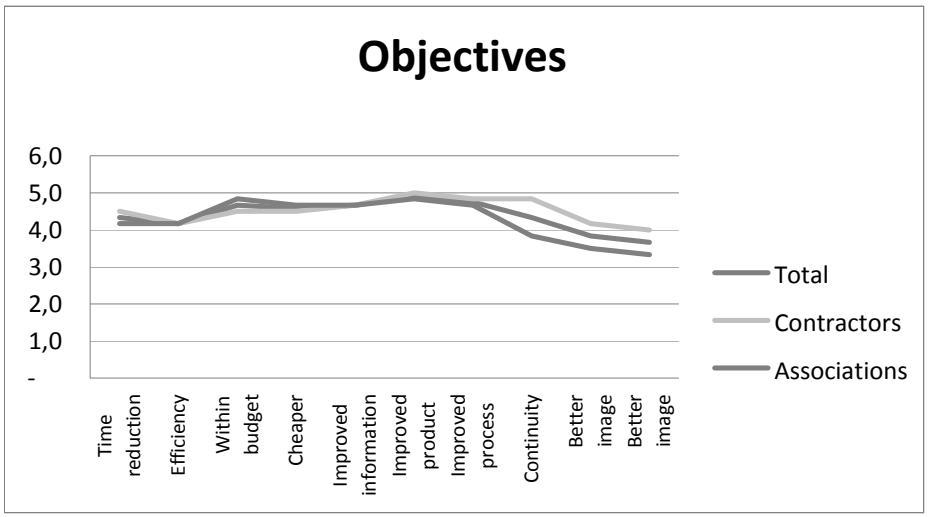
Continuity
Four of the five couples had selected their partner with the intention to maintain the partnership for a long term, although no specific agreements had been made about future projects. The benefits of a longer term relationship were confirmed in the plenary session. Benefits of a long term relationship were stated to be among others: more efficiency (‘learning opportunities resulting in a lower price and faster process) and working satisfaction, as people grow used to working together as a team, with common objectives.

Risk and benefit sharing
At this stage in the exchange project, the partners have not made agreements on risk and benefit sharing yet. During the plenary session it became clear that the most important condition for effective risk sharing is to create as much as transparency as possible. When all parties express their possible risks, a comprehensive risk management can be set up and agreements can be made on how to deal with each risk. However, some associations also stressed that the risks of the actual building process should remain with the contractor, since otherwise, the housing association would take on risks outside its core business and contractors might have less incentive to remain within the budget.

At the plenary session it was concluded that all cases involved in the exchange project have explicit elements of increased supply chain partnering, but it was also acknowledged that these were just the first step of growing towards mature partnerships, which require much more explicit and further reaching choices about the involvement of more parties in an early stage of the redevelopment project, the responsibility for maintenance after the refurbishment, the application of ‘framework’ agreements that involve partnership over a number of projects and much more explicit agreements on sharing and division of benefits and risks.

Expected advantages
From the 16 inquiries, 12 were returned in time for inclusion in this paper (75%), equally divided between general contractors (6) and housing associations (6). During the plenary project session the results have been discussed and complemented. The evaluation scale rated from 1 (very unimportant) till 5 (very important). Figure 1 depicts the average results for the importance of the objectives of supply chain partnering in the housing refurbishment projects. As can be seen, most of the objectives are ranked as important or very important bv both housing associations and contractors. Of relatively less importance for housing associations are the possibly positive effects on the company’s image as well as the continuity of the company and the workflow, which is not remarkable, since these factors are mainly of importance for the contractors, because these factors help them to maintain or improve their market position.

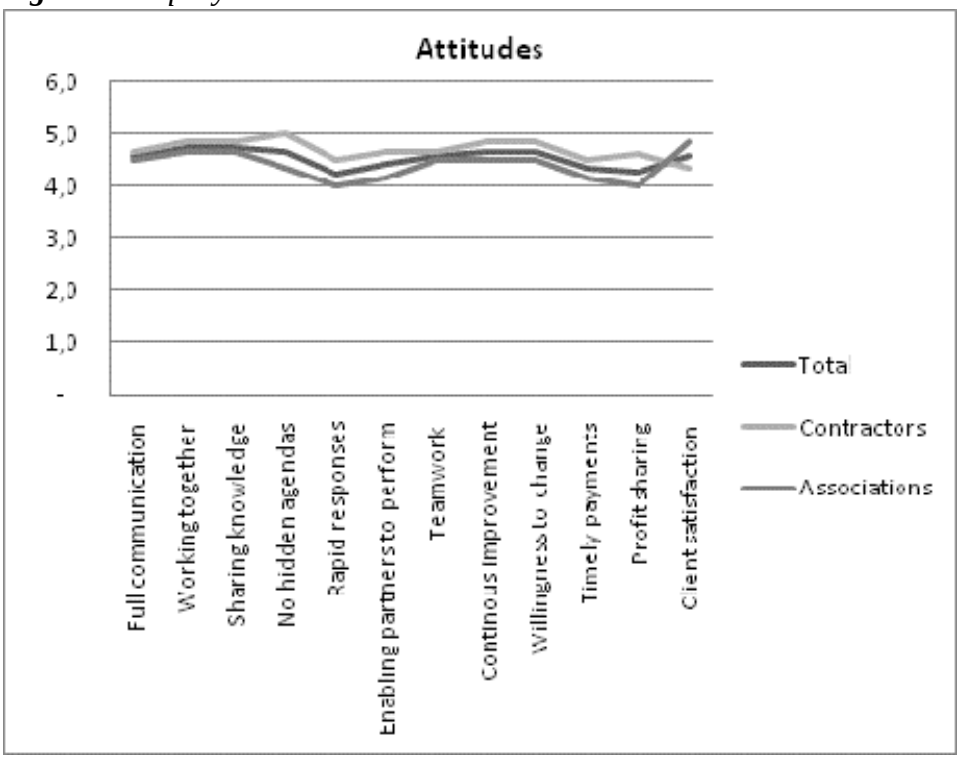
Figure 1: *Inquiry results on objectives*



Expected challenges

The participants were also asked to address their expectations about the challenges for successful supply chain integration. These challenges were divided into attitudes of the partners and (other) success factors.

Figure 2: *Inquiry results on Attitudes*

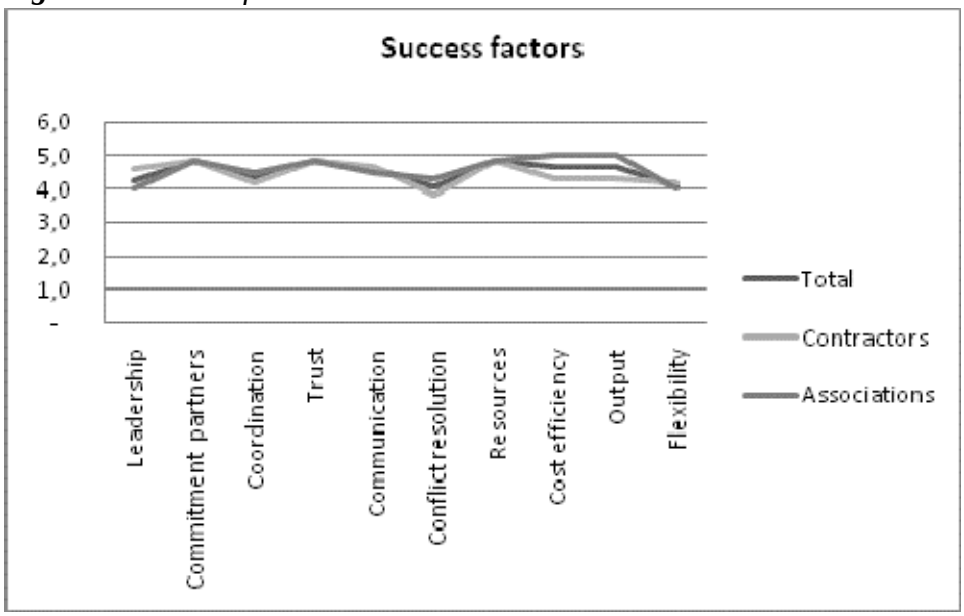


The participants were asked to express their sense of importance of the attitudes as found of major interest for successful partnering by Briscoe et al. (2001), shown in table 4 in the previous section. In general Briscoe's attitudes are considered of high importance, as the average results are rated between 4 (important) and 5 (very important) (see Figure 2). Although the small number of inquiries makes it impossible to make any statistically sound comparison, some of the topics to which the housing associations and contractors responded

differently were discussed in the plenary session to test if there was any significance to the differences and if so, what the background of these differences were. 'Straight talking with no hidden agendas' was evaluated of relatively high importance by the general contractors. At the plenary session the contractors stated that this could be because they sometimes feel accused of working with hidden agendas by their principals, while this is not the case. 'Rapid responses to queries and requests for help' scored relatively low among the housing associations while one could expect that associations find this topic more important than contractors, because any delay is in the associations' disadvantage. The workshop participants stated that, when working as partners, the roles and responsibilities are more clear and the contractor can take more decisions, without referring to the responsible person(s) in the housing association first and thus they expected it to be less of a challenge within supply chain partnerships.

The success factors of partnering according to literature were also evaluated by the participants of our project. Again, they were asked to rate the factors on a scale from 1 (very unimportant) to 5 (very important) (see Figure 3). The average scores are between 4,0 and 5,0, which confirms the expected importance of the success factors derived from previous studies for the Dutch housing associations' refurbishment practice as well. The topic 'Conflict resolution techniques' is scored relatively low by both contractors and associations, which may be found remarkable in an environment known for its conflicts. According to the participants, the explanation for this low score is that working as partners results in clearer and/or shared responsibilities and a focus on common interest. Thus, they expect that conflicts will be reduced or even avoided as a result of supply chain partnering.

Figure 3: *Success factors*



This emphasis on 'soft skills' needed for successful partnering as stressed in previous studies was confirmed in the exchange project as we asked the participants to give their 'top 3' challenges for the project. Among the top 3 of challenges, 2 topics relate to the necessary soft skills and attitudes:

1. How to change competences and mentality and how to create sense of common responsibility?
2. How to create trust among partners?

3. How to share risks and profits among all partners and which (legal) contracting options are appropriate to formalize the partnerships?

Overall it was concluded that many of the expected advantages and challenges of supply chain partnership within housing refurbishment concur with the generally expectations about supply chain management in construction. At the plenary session, the most specific challenge for the application of supply chain partnership within housing refurbishment was stated to be the communication with the tenants. Since tenants are a natural part of refurbishment projects, choices have to be made about who communicates with the tenants, which may also differ from phase to phase in the redevelopment process. Some housing associations stated that supply chain partnering generates specific opportunities for communication with the tenants, since the contractors are sometimes taken more seriously by the tenants if they say that some refurbishment options are not feasible, while the tenants may sometimes suspect the housing association of having a hidden agenda. Other housing associations stated that there could also be a pitfall in involving the contractor in communication with the tenants, since the contractor might promise some things which may eventually be outside the association's budget restrictions. Furthermore, and perhaps specifically for the social rented sector, it was questioned if and how the tenants should be involved as a 'full' partner in the refurbishment process. Although, perhaps ideally, mature supply chain partnership would imply that the tenants as end-users are involved as partners throughout the process, this might not be preferable in the social rented sector since tenants usually pay a rent under the market price and therefore do nut fully bear the financial consequences of the decisions made in the redevelopment process. Furthermore, may tenants do not aspire an active role in building processes.

CONCLUSION

Linking the reducing opportunities for demolition and replacement strategies with continuing challenges to improve the socio-economic and environmental sustainability of the housing stock, it can be expected that housing associations will place more emphasis on management and refurbishment. Financial pressure also stimulates housing associations to increase the efficiency of their organization and building processes, which in turn stimulates their interest in the opportunities that supply chain partnership generates for cost reduction and other potential advantages. In this paper we have explored what the approaches and expectations of Dutch housing associations and contractors in refurbishment projects are on the basis of an inquiry among participants in a knowledge exchange project. It is concluded that all cases involved in the exchange project have explicit elements of increased supply chain partnering, but it was also acknowledged that these are just first steps towards mature partnerships, which require much more explicit and further reaching choices about the involvement of more parties in an early stage of the redevelopment project, the responsibility for maintenance after the refurbishment, the application of 'framework' agreements that involve partnership over a number of projects and much more explicit agreements on sharing and division of benefits and risks. It is also concluded that many of the expected advantages and challenges of supply chain partnership within housing refurbishment concur with the generally expectations about supply chain management in construction. The most specific challenge for the application of supply chain partnership within housing refurbishment relates to the communication with the tenants: if, how, when and by whom tenants should be involved in the redevelopment process is a specific question that requires much attention in supply chain partnerships for housing refurbishment.

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CONFLICTING FLEXIBILITY

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Abstract
New buildings are designed for first users. For a sustainable approach there are many advantages in designing in flexibility and adjustability in order to enable and facilitate the other sequential users. For the first investor this flexibility is translated into improved exit values due to increased potential. The second investor is acquiring a building with multi-functional opportunities.
The politically stimulated combination of schools with day care is generating several new design commissions in the Netherlands lately. These projects are characterised by a high level of user related features. At the same time these kinds of buildings are confronted with an additional need for flexibility due to (demographic) developments in the neighbourhood. There are some good examples of such projects, but there is a distinguished need for additional workable solutions. One of the design projects of the faculty of Architecture started a research by design project to establish an architectural approach for the combination of elementary schools with after-school child care in different scenarios: transformation of an existing building in a shrinking village, as a replacement in a urban setting and as a new addition to an existing school in an area with growing potential. The combination of scenarios strongly suggests a focus on flexibility during the building's life time. The growing area will create a peak demand, so even if it does not become a shrinking city after a while, the combined school will still have a fluctuating capacity need. However in this research by design course, accomplished by architectural students, it can be observed that not the life time flexibility, but the daily flexibility, needed by the combination, takes all the creativity. It is already almost too complex to create multifunctional spaces to be used for learning zones in day time and play area and child care zones afterwards. Compared to other types of projects, the first user approach related to architectural design is in this function mix getting even more attention with the specific requirements, up to the level of dedicated furniture.
The solutions provided by practice for the life time flexibility are in many cases related to an even more complex function mix. If a new neighbourhood first can be characterised by a peak in delivery, followed by baby care, elementary school and child care, higher education and taking care of the elderly people afterwards, the relation with different care functions becomes more obvious and time related. The synergy between those functions can be very promising in the right combination. Such a view on the neighbourhood suggests social centres developing and changing over time together with their servicing area. The context will lead to certain investors willing to fulfil their social and sustainable ambitions.
The research by design itself will have a satisfactory result for the institutions dealing with the implementation of after-school child care if the proper selection of design suggestions is

produced. These institutions will represent the first users. The scientific and social significance will be in the developments clearing the conflict by giving an answer to both the daily as well as the life time flexibility.

Keywords Flexibility, elementary schools, after-school child care, mixed function, multifunctional accommodations

INTRODUCTION

The building sector shows rather specific settings of partners around specific types of projects. This paper will discuss the agenda of flexibility for future demands along the developments of elementary schools in combination with after-school child care and additional communal functions. In order to be able to break through the tradition of these typical setting a more abstract view is required. Solutions rising from this view are suspect by default, since the abstraction itself, the alterations and possible extension of the scope, in this case to the communal functions are not proven. The proof of the pudding is in the eating? At least for sure there is the need for change. (1) There is a need for improved daily flexibility in the way limited space is used by different functions. (2) There is a need over time in the way (public) buildings are used with changing quantitative requirements to the functions. Probably the same for commercial buildings but in such a setting the drivers are more clearly. (3) An additional need over time in changing of qualitative requirements. The community will have other demands in future for the public buildings based on demographic changes but also due to a different (and at this point in time unknown) vision.
However, first a sketch of the actual situation must be drawn.

AUSTERELY BUT EFFICIENT

For those not of Dutch origin it is important to understand the Calvinist background of Dutch society, leading to a rather strict and ascetic political demarcation (“sober maar doelmatig”) of the way we deal with our elementary schools. The expression “austerely but efficient” has a boarding-house smell. The current situation is very well described by Jeroen in ’t Veld, Yasmine Hamdan and Emile Barendregt (2010). They have started their analysis from three aspects: the quality of the current buildings for schools, the quality of the process of establishing new schools and the quality of the organizing context (jurisdiction and legislation, financing and budgets and policy) the following conclusions are drawn up.
A key problem in the provision of buildings for primary education as well as the after-school child care is the lack of information. This is not only a huge hurdle while researching the subject, but most of all for a proper development process. Even very basic figures like numbers of buildings and their age are missing.

Based upon the information which is available most buildings do meet the basic requirements. However these requirements are shaped as utterly minimum. For e.g. inner climate, cleaning and maintenance even these very basic requirements are not always met. The requirements as a set do not lead to buildings meeting the expectation of the people of the sector.
The processes for establishing the buildings are inefficient and not productive. The omission of the obvious party taking the lead, especially where multifunctional accommodations are concerned, is disruptive.

The actual legislation and financial system is outdated and designed for a situation with only educational buildings. Act on primary education (WPO) declares the responsibility of the municipality towards realization and building maintenance on a global level. The actual detailed instructions are given in the model by-laws of the Association of Netherlands Municipalities (VNG). Municipalities are not obliged to use the by-law but usually do treat them as law. All the directives to m^2 and budget become rules. Separately there is a Act on Child-Care with additional directives of the Ministry of Social Affairs. Rules for buildings are laid down in the Building Decree with reference to standards. The municipality is responsible for permits of use, all of course fit to the Act on Spatial Planning.

Although the political ambitions may be clear, and again changing with new rounds of elections, the legal and organizational system below is very layered and diverged. It takes more to work out completely the consequences of policy adjustments then to take new directives. The result is a rather unstable complexity in which participants hardly dare to move. The financial component is even more interwoven. On top of the pyramid both the Ministries of the Interior and Education, Culture and Science) are providing funds for realization and maintenance of buildings for primary education and after-school child care. The first cash flow goes through the Fund of the Municipality towards this municipality and the second by lump sum financing to the school. At that point a 'dialogue' is foreseen between the school and municipality if there is a need for an addition to the school stock. The traditional way is along the act on primary education in which the municipality is responsible and using the by-law for the appropriate instructions. The municipality builds. However there is an alternative by which the school can get a yearly amount for realisation and maintenance of the building. The municipality will keep its ultimate responsibility for the provision of education and care.

Probably this diversion of financing is done for historically well thought arguments, but the result is a focus on investment costs for the municipality and cleaning costs and other maintenance for the schools. The value of the investment is hardly steered by the process while all insights on the need to steer on life cycle costs in order to work on more sustainable solutions is basically neglected due to the way the process is set up.

Even more alarming is the fact that during the years a clear demand can be established, the administration and bureaucracy takes a very long time, in which a whole range of temporarily measurements has to be taken, rather often resulting in a situation in which temporarily buildings become definitive solutions, due to the fact the system cannot provide the right terms the system need to move from a temporarily status to a definitive status. Where the important values of these school buildings are missed, municipalities do react heavily on vacancies; schools have to cooperate on sharing (building) resources, logically argued on 'societal costs'. Also in the presented alternative (Veld, Hamdan et al. 2010) this obsolescence is used as an argument for new approaches into the direction of the combination of primary education and after-school child care.

The budget for both primary education and after-school child care is above all a political choice. Therefore it is worrying that although in the different political programs the essential benefits of collaboration between primary education and after-school child care are widely spelled, the whole idea is presented too as a way of economising within the system itself. The loss of the current system is quantified to € 55.000,- per school on simplifying the preparation process, € 16.500,- per school per annum on additional occupation (and removing redundancy and obsolescence) and € 4.000,- per school per annum on life cycle optimisation.

These numbers can be related to 150 new projects and 100 renovations on a yearly base for the preparation costs and about 7.500 schools for the per annum figures.

As acknowledged by In het Veld (2010) it is in this perspective very positive that even with the given bureaucracy the involved people and parties, including the municipalities, are succeeding in the establishment of reasonable buildings after all. The response of the bureaucracy, the Association of Netherlands Municipalities (www.vng.nl) is rather conservative with the proposition a change of system in order to prevent bureaucracy will create additional bureaucracy.

STUDENT RESEARCH



Figure 1: *The Hague (above), Biggekerke (below left) and Amsterdam (below right)*

The first case is a new development in The Hague on a VINEX-location (Leidschenveen). A VINEX-location is an area designated in the Supplement to the Fourth National Policy Document on Spatial Planning as large-scale housing development area, and therefore an example of monoculture development. The second case is almost the opposite, a redevelopment in a small village in the more rural parts of the Netherlands which areas are confronted with shrinkage. Although the demand on pupil places is getting smaller, the integration with after-school child care requires adjustment of the building. The third case is a new development in a brown field area in a larger city. Due to its size there is a large variation in population.

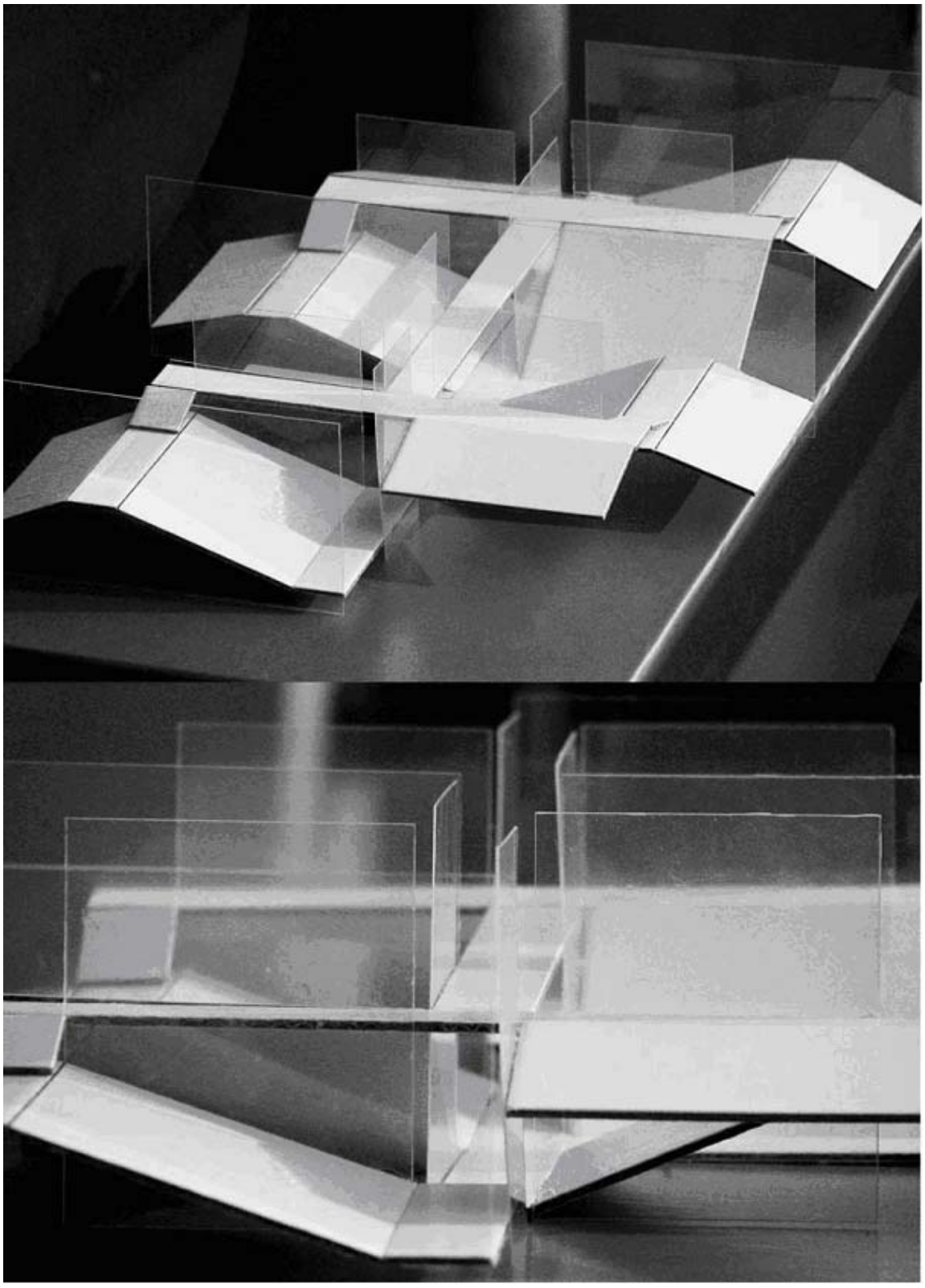


Figure 2: *Transport between rooms is always done through another room since all the horizontal transport area is skipped. Bram van Hemmen Group 1 – Growth and transformation.*



Figure 3: *Considering the use of the building during the day. Jeannette Bisseling Group 2 – New town and transformation.*



Figure 4: *Central hall as meeting place Bob van Rooijen Group 3 – Shrinking city and transformation*

When grouped together like this, it becomes clear the neighbourhood development starting as a VINEX will end someday as a shrinking village. The relation with urban dimensions can give some relieve, depending on the regional impact of such facilities. The answer to these kind of adjustments over time is hardly researched by this research approach. As can be drawn of the examples below, in case of architectural research by design, the complexity of the daily flexibility takes already all the focus of the researcher – designer - student.

The PO-council, a sector organisation concerned with financing, employment and policy for elementary education asked for new ideas from an architectural perspective. The basic

question for the research by design assignment was to give solutions for the combination of elementary schools and after-school child care in case of shrinking cities, new towns and reuse in inner cities.

The student research fulfilled its primary goal. The students did have a steep learning curve on the complexity and possible architectural solutions. However the way this research by design is shaped, students are only confronted with the first flexibility requirement: to find solutions for the optimal use of space during the day by giving room to the primary school with their class rooms in which learning is the issue and the after-school care with places for playing, food and resting in which caring is the matter.

In this research approach the outcome is not to find solutions for primary schools in combination after-school child care in a new town, transformed after some time and again two decades later when the town is shrinking again. So it is not about the need for flexibility over time due to changing quantitative requirements. It is also completely not about variations in qualitative requirements.



Figure 5: *Same project, after care playing options in zones between functions*

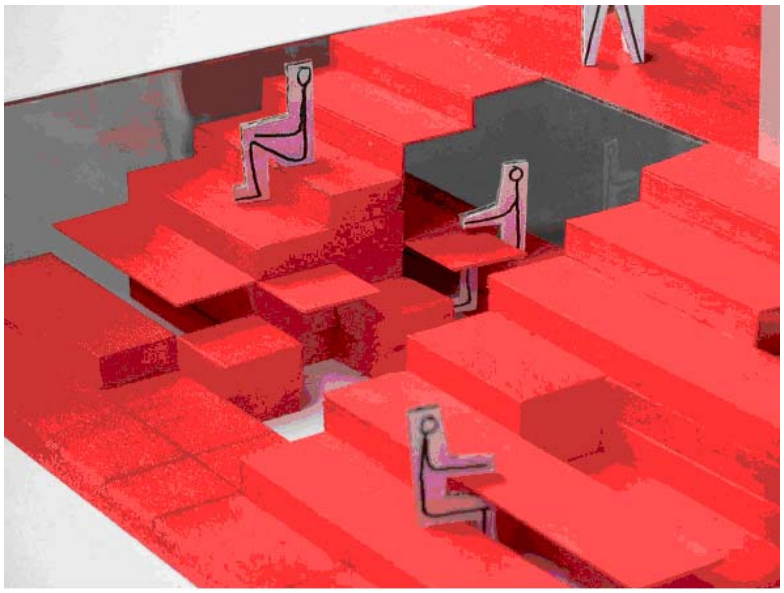


Figure 6: *Soft gradient zoning (from creative to playing), stairs as presentation platform Martijn Aling Group 4 – Growth and transformation.*

INSIDE OUT OR OUTSIDE IN

Both the discussion on the running operations and the research by design are illuminating that it is only very partial an architectural solution. As far as school buildings can contribute to the system, and the idea is of course the appropriate buildings do, the process of establishing these buildings can make the difference, both for the build result as for the process which has to take place in the building.

The solution is to be found in a demand driven system in which the user is holding the central focal point (Veld, Hamdan et al. 2010), a flexible model taking care of the utmost efficient investment of means. Without calling it by its name, the report gives a continuation of what is embraced in the current political climate as the agreeable free market processes. The same privatizing causes besides benefits also plenty disadvantages. Like similar discussions in health and public transport it is disputable if and until which extent such central elements in the society are save in the hands of the market, or depending on someone's stand, to be trusted to the authorities. At least it is clear such processes go in fits and starts.
Several conditions are elaborated, which are probably rather essential, like a guarantee fund in order to keep financing within limits. The necessary knowledge has to be mobilised in this field to keep control over the quality level, support of users and schools has to be developed and maintained, and sufficient consideration has to be given to implementation of such a system modification.
So the free market is not seen as an universal remedy in advance. Nevertheless a small excursion outside the discipline to the office market is needed. Offices are built for centuries, like schools. Take the prototype in Florence in 1580 as an example to see its history. Nowadays it is rather obvious offices are established by developers, whenever possible in close consultation with future tenants, after which the buildings becomes the property of an investor and is rented by the final users. But for the larger part of the previous period between 1580 and today it was rather standard for end users to be the owners. These owner-occupiers took the initiative and were responsible for repair and maintenance. It took a long time before

the insight was gained by these companies to acknowledge the specialism of the specialists, and to see the benefit of stalling risk by those who can deal with it.
Decisive response on market changes is more difficult for companies if they have to maintain accommodation in the ancient way. In the end accommodation is not the only thing you rent but also the service around it. For those reasons the majority opts for rent.
It may seem less logical to take offices as an example in the Netherlands, since there is a good deal of obsolescence, created by this free market (2011). It is to be expected most of this obsolescence will be seen again in societal costs. The public demand for measurements on a national level is increasing, since it is still an option for developers to add to the stock of vacant office buildings while earning a personal profit. This kind of arrangements are declined by the developers but more and more embraced by the investors. At the same time these investors are searching for new forms of real estate investments. Dwellings are becoming a more interesting market. Indeed the possible yields seems substantially lower, yet the risks are within limits too. An investor is looking for the appropriate balance between the return and the risk, where at the moment the risk is playing a slightly more important part. Along this renewed focus on dwellings also other categories become of interest for investors, of which societal real estate is the most promising. New companies and forms of participation are evolving, leading to new sustainable answers.

The previously observed obsolescence in the schools and the supposed benefits additional occupation are missing the awareness of office developers, knowing a certain minimal of vacancy needed for a working market (Remøy 2010). Just like the demand for office space is not changing in building volumes and some small change is needed for dealing on such a market, these types of additional occupation will not work on the single square meters. Aiming at a zero vacancy rate is not realistic.

The need for accommodation in elementary schools in combination with after-school child care can be solved by the market. Unlike complicated Public Private Partnership constructions, in which the authorities are basically coping with risk-avoiding behaviour while trying to keep full control, a more laid back approach of the municipalities seems needed to see what the developing parties are offering. The risk the market is not establishing the kind of building the schools are needing is in this perspective the risk of this market, and they will mature quickly enough to make what is wanted. At the same time the municipality can, as sketched by In ‘t Veld (2010), organise a guarantee fund in order to create the right balance between risk and return, in order to enable this market for investors and developers.
Today it takes years (12 year on average) after the acknowledgement of the need and initiative for a new school. Assuming the market can respond much quicker, the best gain is to be found in these first years, where the demand is best known and the ‘new’ school will fit the original requirements. This can be seen as the best years, which can make the difference between austerely development and quality development.

However the flexibility in the long term still suggest a wider scope on the elementary schools in combination with after-school child care. In order to cope with the demands over time additional functions seem to be the solution, especially in case of shrinking societies.

Analysis of the required space of four programs of demand of multifunctional accommodations did show that almost every combined use of area is related to similar functions and activities. This multifunctional use does not allow any change in use of rooms in order to fulfil different functional needs. As one can learn from the chapter ‘Student Research’ such frequent adjustment are not helping the process.

This observation is confirmed by initiators of multifunctional accommodations (e.g. municipalities), giving ‘tips and tricks’ for improved multifunctional accommodations (2010). “Main points with respect to flexibility, multi-purpose nature and standardisation, are essential to achieve long-lasting, durable and payable housing concepts. These main points stand however in many cases perpendicular on user expectations and wishes; for users a tailor-made approach and identity strengthening services and facilities are important”. This quote and the remaining `tips and tricks' indicates that initiators and users are more concerned with the performance at this instant, instead of future use. Even though motivations for multifunctional accommodations are (cost) efficiency and social appreciation.

With an experimental fictive model we like to show the advantage of considering a multifunctional approach (including a perspective beyond the first user). The experimental fictive model shows not an financial truth nor punctuality, but a thought. We do this by combining two social topics: Shrinking and including-education. Including-education as a second-user can use the without relative large adaptations (care-spaces and extra bathrooms) this second-user can fit in the vacancy of primary and secondary education, as an result of shrinking (notice: the conclusion of student work, page x and program of demands, page x).
The experimental fictive model contains data collected of four municipalities in shrinking area’s (schools and cost indicators) and cost-indicators from a including-education foundation.

This content creates a fictive real estate-file, which contains:
- Around 5.100 students in 2010;
- A reduction of 1.275 to 1.350 students in 2040;
- 23 Primary educations (circa 22.000 m²);
- 6 (secondary) special educations (circa 12.000 m²);
- 5 secondary educations (circa 12.000 m²);
- Estimated building operation cost: €58 per m²
- Estimated taxi-cost special education: €2.500 (cost indicator)
- Reconstruction each 40 years (instead of 60 years ordered by VNG)

Introducing (secondary) special education to primary and secondary education leads in the model to a reduction of 50% vacancy (€0,4 million building cost each year for municipality and school boards). Current ground attitude of special education with became unnecessary can be solved (€P.M). In contrast with primary and secondary education were selling half buildings and ground is much less attractive. An assumption is made that there is 10% less taxi-use can be realised for children in special education, because they can join education in their hometown. This leads to a reduction of €0,2 million taxi-cost each year for municipalities. When these numbers are capitalise, it is possible to purchase an credit around 10 to 14 million + P.M income of ground attitude (note: a part of this funds are needed to realise the integration of special education).

In comparison the scheduled investment cost in this real estate-file is circa 5 to 6 million. Although there are a lot of practical and ideological comments on this experimental fictive model. The comparison shows that financial and social advantage can be realised when the correct social themes are combined with the second of third user.

CONCLUSION

Reviewing the references will show a 100%-Dutch research on a 100%-Dutch case. The Dutch Calvinism is unique in the world, and so will be every idea coming out of it. However neighbouring countries have to deal with similar economic restrictions. Maybe for different reasons elementary schools are lacking the same quality. And above all economising is the main argument for after-school child care. At the same time it is clear this article is not dealing with big time shrinkage like e.g. Detroit is confronted with.

Although the student research did generate plenty ideas on how to combine elementary schools with after-school child care, it has to be acknowledged these ideas are not mature enough yet for being a response to the first flexibility. There is still a lot to improve on these designs where there is hardly a budget to do this professionally. Renewal of the way these kind of projects could be developed using new market mechanisms seems to be an answer to the second flexibility but very depending on the context in which still a lot of hurdles have to be taken. The third kind of flexibility discussed here, involving additional communal functions to create durable 'multifunctional community centres on care and education', resistant to obsolescence is with the increasing complexity far from being guaranteed. If the proof of the pudding is in the eating, it is advisable to start with a small portion. Still there are mountains to climb already to enable experiments into this direction, since many rules in school development are preventing experimental approaches. Probably the appropriate start for any renewal is to deal first with the 'austerely but efficient' directive. These schools are the place where our children do have to spend an important part of their youth, so 'ideally' should be the objective instead of 'ascetically'.

It is the observation of the average quality in office buildings feeding the believe in the free market to be able to create the schools we want and the schools we need. Given the right balance between risk and return, todays developers and investors are not only equipped for such developments, it also fits in their schemes of changing focus to other non-office markets. The suggestion by some of the market parties towards the development of multifunctional accommodations is both promising and still rather unsecure. Thinking on the sequential users of accommodations is new and like many aspects of sustainability, the proof of the pudding takes time, since such projects depend on a long term approach and the results are only to be seen after the first satisfied user has left the building.

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EXTENDED CONSTRUCTION SUPPLY CHAIN MANAGEMENT: RELATIONSHIPS, REWARDS AND RISKS

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Abstract
Over the past decade, the UK construction industry has sought to exploit the rewards of supply chain management practice. This paper explores construction industry capability to implement an extended construction supply chain culture. Where commercial solidarity prevails and integrated supply chains, including small and mediums sized enterprises (SME's) vie for construction projects and economic advantage.
Despite recent advancements in construction supply chain management many barriers continue to inhibit the realisation of fully extended construction supply chains. Economic, social and cultural conventions require to be investigated to appreciate the complexity associated with the strategic alignment of extended supply chain stakeholders' interests.
Drawing on a model of supply chain maturity, the practicalities of extended construction supply chain relationships, rewards and risks are reviewed. Given the current structure of the construction industry, it is proposed that the attainment of extended construction supply chain management practice will require key industry stakeholders to develop innovative collaborative policies that will be progressive, organisationally supportive and commercially attractive to SME's.

Keywords: Supply Chain Management, Maturity, Integration, Relationships, Construction Industry.

INTRODUCTION

Supply chain management is an emerging theme within construction management theory and practice (O'Brien et al., 2009). Advocates of supply chain management now suggest that enlightened organisations within the UK construction sector may seek to take advantage of improved supply chain solidarity. Envisaging a scenario where extended supply chains, rather than discrete companies, compete and tender for future building projects (Tan, 2001). However, considerable critical debate has been directed at the apparent hesitancy of the construction industry to capture the opportunities afforded by supply chain management principles (Akintoye et al., 2000, Dainty et al., 2001a). Proponents are quick to suggest construction has failed to keep pace with contemporary management of supply chain practice, learning and innovation (Bankvall et al., 2010, Lonngren et al., 2010, King and Pitt, 2009). Many reasons for the lack of progress have been expressed. The most common criticisms include fragmentation (Saad et al., 2002), SME scepticism (Briscoe and Dainty, 2005), temporary relationships, short-term projections (London and Kenley, 2001), opportunism, an

infrequent client-base and particularly pertinent in a difficult financial climate, economic uncertainty. All of which individually and collectively conspire to undermine the efficacy of construction supply chain management when contrasted with the highly controlled environments of the automotive and retail sectors (Cooper and Ellram, 1993). It is, however not unexpected that the utility of construction supply chain management is benchmarked against the successes charted in the institutional homelands of supply chain management. In common with most key performance indicators, assessment requires careful interpretation. For some scholars, industrial context is crucial (Green et al., 2005). Context creates a spatial awareness (Jepperson, 1991) that formulates and frames our understanding of the developing situation.

The supply chain maturity model proposed by Lockamy III and McCormack (2004) offers a generic performance criteria against which current practice and future aspirations of construction supply chain management may be evaluated and discussed. Five stages of supply chain maturity are depicted, ranging from stage 1: immature (ad-hoc) to stage 5: mature (extended). Its usefulness is not necessarily comparison with other sectors per se, but a contextually rooted appraisal of what may or may not be realistically 'achievable' within the strict confines of UK construction supply chain management practice.

It is in this area of supply chain maturity and extended supply chain management practice in particular that the paper wishes to make a positive contribution and stimulate constructive debate. The discussion is arranged as follows. The supply chain maturity model is introduced with consideration given to the positive attributes as well as some inherent limitations and assumptions. The following section outlines the importance of the construction industry to the economic and social well-being of the UK. This is supported in the subsequent section with an overview of contemporary supply chain management practice within a construction context. The discussion concentrates on apparent levels of construction supply chain maturity with particular reference to the notion of an extended supply chain as depicted in the supply chain maturity model. Three key themes are identified and debated; relationships, rewards and risks. Finally, the conclusion comments on the likelihood of extended construction supply chain management practice as defined by Lockamy III and McCormack (2004).

SUPPLY CHAIN MATURITY

According to Lockamy III and McCormack (2004), the extent of supply chain management development, integration and experience may be evaluated and expressed in terms of a numerical grading by applying their supply chain maturity model. The model defines five stages of supply chain maturity;

Stage 1 - Ad-hoc: An unstructured and ill-defined approach to supply chain management. If the term supply chain management is employed it is highly likely in response to management practice witnessed elsewhere and in this context represents mere tokenism.

Stage 2 - Defined: Whilst the implementation supply chain management has structure and key supply chain facilitators are in place, working practices remain largely unchallenged and resolutely traditional.

Stage 3 - Linked: Supply chain management takes on a strategic orientation, focusing on business objectives and customer satisfaction. Collaboration between supply chain stakeholders begins to cultivate an atmosphere of trust and 'budding' team spirit.

Stage 4 - Integrated: Supply chain management principles become embedded in the commercial process, over-riding traditional practices in favour of

greater inter-dependency and commercial solidarity. Corporate investment in supply chain management principles begin to benefit from increasing levels of efficiency and effectiveness.

Stage 5 - Extended: Supply chains compete against other supply chains. Asset specificity is likely to be high and commercial interests are inextricably extended to the success of the collective supply chain participants.

A maturity classification of supply chain adaptation and application draws specific attention to key characteristics associated with various incarnations of supply chain management in practice (Morledge et al., 2009). Explicit within Lockamy III and McCormacks' (2004) interpretation is that ever-greater displays of maturity will generate superior levels of commercial performance. For example, as companies gradually pass through predetermined 'staging-posts' on a supply chain maturity continuum, organisational experience, trust, confidence and predictability in supply chain stakeholder behaviour will evolve.

Whilst a continuum may be well suited to charting key developmental stages of supply chain maturity, the exploitation of the continuum concept exhibits a number of intrinsic limitations and assumptions. A continuum, defined as continuous array of barely discernable points located in succession between two bipolar extremes (Pearsall, 2002) often fails to adequately capture economic, social and cultural idiosyncrasies (Boisot and Child, 1996). Thus a continuum may be perceived as *"too quiescent and mechanical"* (Powell, 1990). This limitation is compounded by an underlying assumption of continuous improvement regardless of context. Yet as stated earlier, context is increasingly recognised by critics as a central tenet to the efficacy of construction industry adaptation of supply chain management principles. Construction industry context will constrain supply chain management ideology with a fit-for-purpose pragmatism. It is therefore not necessarily automatic or 'natural' that supply chain participants would wish to progress to the next stage, even if their experience, learning and supply chain know-how is ideologically sound.

Limitations aside, simple classification of supply chain maturity may be useful as a barometer of stakeholder commitment to supply chain management policy, structure and custom. For some industry commentators the key to successful construction supply chain management is appropriateness (Cox, 2004, Cox et al., 2004); appropriateness to the commercial exchange, appropriateness to the parties involved and appropriateness to the cultural context in which it is enacted. A 'horses-for-courses' contention augments a pluralist supply chain management interpretation of the supply chain maturity model. For example, contingent upon the situation encountered; stage 1: ad hoc supply chain maturity may be wholly appropriate, conversely; stage 3: linked supply chain maturity may be best suited to a contrasting set of circumstances. Either way the policies, systems and procedures can be evaluated against the five distinctive criteria disclosed by the supply chain maturity model.

CONSTRUCTION INDUSTRY BACKGROUND

The importance and complexity of the UK construction industry cannot be underestimated (Thompson et al., 1998, Cox and Ireland, 2002, Ireland, 2004). Both a vibrant and volatile sector, the construction industry is defined by the Department for Business Innovations and Skills (BIS) as an eclectic assortment of construction service and product providers (BIS, 2010a). The economic and organisational structure of the construction sector has some distinguishing features. Construction output, in terms of monetary value is dominated by relatively few very large construction companies. In stark contrast, construction output measured in terms of volume is carried out by a considerably larger number of small and medium (SME's) sized specialist and general contractors (Cox and Thompson, 1997, Morton,

2002). Over the past three years construction activity across all but a few sub-sectors has declined at an unprecedented rate. Down from £110 billion in 2007 to an estimated £95 billion for 2010, representing a 14% downturn in construction output (Experian, 2009b) While construction output had grown steadily in the period up to 2009, the rate of growth failed to match the corresponding increase in UK GDP, indicating that construction industry share of the UK economy as a whole had been contracting (Experian, 2010).

Post second world war, the construction industry has been the subject of numerous Government sponsored reports (Murray and Langford, 2003). To a greater or less extent the consensus of opinion is that the UK construction industry requires reformation in the way in which it conducts business (Latham, 1994, Egan, 1998, Strategic_Forum, 2002, BIS, 2010b). In the wake of the 'Egan Change Agenda' the latest Government review, 'Never Waste a Good Crisis' remains somewhat under whelmed by industry achievement. Whilst acknowledging limited progress, Wolstenholme (2009) pinpoints a lack of supplier integration in the supply chain as an ongoing barrier to continuous improvement in the construction delivery process (Wolstenholme, 2009). In a challenging economic environment, construction service and product providers are looking towards their pre-selected network of supply chain companies to deliver ever greater levels of efficiency (Knutt, 2010).

SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION

With dedicated journal publications and professional recognition of supply chain practitioners, supply chain management has made a notable impact on contemporary management theory and practice. Central Government have endorsed supply chain management as a vehicle designed to deliver enhanced quality of construction services and products (Latham, 1994, Egan, 1998, Strategic_Forum, 2002). As a consequence, the term supply chain management is now commonplace within construction management jargon. Despite increasing popularity, a universally agreed definition of supply chain management remains shrouded in a fog of semantic ambiguity. The complexity of the debate is compounded by confusion over its suitability and utility to a construction sector that exhibits quite unique characteristics when directly compared with the manufacturing heritage of supply chain management theory and practice.

Some commentators refer to an abstract interpretation citing the need for an "integrative philosophy" (Cooper and Ellram, 1993). Other supply chain management experts adopt a more corporate perspective, using terms such as supply chain strategy and structure (Alder, 2009). The Council for Supply Chain Management Professionals (CSCMP), the pre-eminent institute for supply chain practitioners, offer a long drawn-out definition capturing a wide-range of management functions associated with the provision of service and product not only across organisational boundaries but also internally between organisational subsidiaries (CSCMP, 2009). The subsequent lack of universal exactness may be perceived as a both a hindrance and an opportunity. A hindrance with regard to potential misunderstandings with other management fashions of the day such as, partnering and lean manufacturing (Gruneberg and Hughes, 2004). On the contrary, the lack of terminological precision presents an opportunity to root a definition of construction supply chain management within the strict context in which it is being enacted.

To date, much of the practice in construction supply chain management has focused on two distinct supply chain configurations; project and organisational supply chains (King and Pitt, 2009). Both of which are short, bilateral arrangements. The project supply chain relationship is the dyadic relationship between the client and first tier main construction contractors. This configuration has a patently client centric focus and is typified by contemporary procurement

arrangements such as partnering and framework agreements. Driven by the construction client, a project coalition is established with a few pre-selected principal supply chain partners (PSCP) for a predetermined duration. Although there are few restrictions within the private sector, public sector clients must adhere to EU and UK procurement legislation. Typically four years with the option of a further two years (4 + 2) for framework agreements (OGC, 2008).

The organisational supply chain is a bilateral relationship between the main contractors and second tier service and product providers. Driven by the main contractor, the relationship has a distinct business orientation and usually manifests itself as a list of preferred sub-contractors and suppliers. The main contractor would audit prospective sub-contractors and suppliers and grade them against a business criteria sympathetic to their own corporate values, such as predictability, financial security, health and safety, sustainability and in light of the recent investigation by the OFT, ethics.

Drawing on Lockamy III and McCormack's (2004) supply chain maturity model to review construction supply chain management practice, it may be contested that performance levels equate to stage 1, 2 and 3. Stage 1 (adhoc) is representative of traditional contracting practice whereas stage 2 (defined) and 3 (linked) illustrate working practices commonly encountered via contemporary procurement routes such as partnering and framework agreements. Stage 4 (integrated) and 5 (extended) remain at present largely hypothetical.

DISCUSSION: RELATIONSHIPS, REWARDS & RISKS

Analysis of extended construction supply chain relations with second, third and fourth tier suppliers and manufacturers have been comparatively limited. Many economic, social and cultural conventions require careful exploration to comprehend the inherent complexity associated with the strategic alignment of multifarious supply chain stakeholders. Sponsors of supply chain management contend that the construction industry must modify its default cultural disposition. Only by addressing deep-rooted traditions and customs can construction take advantage of the economic opportunities afforded by greater integration and commercial solidarity (Latham, 1994, Egan, 1998). However, it is essential that the adoption and adaptation of construction supply chain management respects the professionalism and intuitive observations of experienced industry practitioners. Environmental agencies will invariability fashion stakeholder perception and construction management enactment of the transactional arena. The following discussion highlights three avenues of supply chain interest integral to the concept of extended supply chain management, namely; relationships, rewards and risks.

Relationships

The dynamic contribution of the UK economic climate to the ongoing construction supply chain management debate needs to be readily acknowledged. It is widely conceded that commercial behaviour in the UK construction sector is largely driven by economic forces (Wolstenholme, 2009). In terms of business and commerce, neoclassical interpretation of transactional exchange remains the dominant economic model in Western society (Biggart and Hamilton, 1998). Broadly perceived as an asocial and largely autonomous interpretation of the marketplace (Biggart and Castanias, 2001, Hirschman, 1970), neoclassical economics promotes a lowest-cost mind-set amongst consumers. The core values of an orthodox economic policy and the fierce competition promoted by free-market values is believed to be both pro-market and pro-consumer (OFT, 2001). However, it is generally recognised even among advocates of neoclassical doctrine that neoclassical economics is an

oversimplification of trading relations (Granovetter, 1985, Uzzi, 1997). In other words, despite a dogged adherence to neoclassical values it is illogical to wholly exclude social reasoning from the economic calculus.

The challenge for the construction stakeholders is to craft the correct balance of economic and social interplay appropriate for the optimal exchange of goods or services. In relation to the bilateral arrangement between construction client and main contractor (Project Supply Chain) the procurement selection by the client is pivotal to the ongoing construction relationship. Hitherto, the Joint Contracts Tribunal (JCT), the construction industry's foremost suite of contractual governance has exploited the values of an orthodox, asocial, autonomous, fiercely competitive marketplace. Although traditional contracting remains the most popular procurement route in UK construction (RICS, 2006, RICS, 2010), the practice has been repeatedly censured for being adversarial, fragmented and short-term (Briscoe and Dainty, 2005). Over the past decade alternative procurement routes have become more commonplace (RICS, 2010). Contemporary procurement routes such as partnering, framework agreements and more recently the Scottish Futures Trust (SFT) initiative have sought to instil a greater emphasis on relations contracting between construction client and first tier service and product providers. Contractual agreements popular with contemporary procurement such as Project Partnering Contract 2000 (PPC2000) and the New Engineering Contract 3 (NEC3) are calculated to engender values of trust and mutual respect in accordance with industry best practice initiatives (NEC, 2005). That said, uptake in contemporary procurement practices is unlikely to result in a cultural sea-change however it is anticipated to induce behaviour modification.

Recent examples of public sector framework procurement in conjunction with NEC3 contracting have created an alternative project environment conducive to greater integration of the supply chain. Whilst the Health Frameworks in England (Procure 21+), Wales (Design for Life, Building for Wales) and Scotland (Framework Scotland) conform to the requirements of EU and UK procurement legislation, each framework agreement differs slightly to accommodate characteristics unique to national circumstances. Arguably, in terms of Lockamy III and McCormacks' (2004) supply chain maturity model and within the context of the NHS procurement, the Welsh NHS framework agreement presents the most advanced example of construction supply chain integration. It is mandatory for NHS Trusts in Wales to procure major capital construction projects (total costs exceeding £6 million) via the framework agreement (WHE, 2010). Three principal supply chain partners (PSCP) have an integrated supply chain that includes architects, health planners, cost managers, building services engineers, civil and structural engineers, building services installers, FM advisors and CDM Consultants (WHE, 2005). All participants have exclusivity within their integrated supply chain, creating a 'squad' of service and product providers with 'teams' selected for each project (WHE, 2010). As a result, 'squad members' are wholly dependent on the success of their PSCP for future workload. It may be contended that the Welsh Health Estates pro-active management of the NHS framework agreement have initiated 'project' supply chain characteristics representative of a stage 4 (integrated) classification on Lockamy III and McCormacks' (2004) maturity model.

A key feature of construction activity is the high level of subcontracting (Hartmann and Caerteling, 2010). A typical construction project may witness up to 90% of its total value outsourced to an array of specialist and general subcontractors (Dubois and Gadde, 2000, BERR, 2004). A statistic that may suggest construction stakeholders are ideally placed to benefit from greater integration of the supply chain. At present the main contractor driven organisational supply chain remains short. Corporate preoccupation is typically focused on the development of a second tier preferred suppliers list. Second tier subcontractor and supplier information is centralised on a company database and formal auditing procedures are

put in place to evaluate the strategic nature of the ongoing commercial ties. From the resultant inquiry the main contractor will establish an inventory of validated subcontractors and suppliers within key construction disciplines. Subcontractors and suppliers cannot tender for work unless 'validated' via corporate supply chain protocol. Preferred suppliers will be continuously monitored on a criterion of predetermined key performance indicators (KPI's) complete with feedback loop. Whilst it remains rare for main contractors to proactively manage relations with third and fourth tier members of the supply chain, 'pinch-points' could on occasion jeopardise project deadlines. Consequently, the main contractor may be required to adopt a more 'hands-on' approach to 'downstream' supply chain management to protect their business interests.

Rewards

The benefits of supply chain management have been extensively extolled in management literature. Commercial solidarity has potential benefits for all the participants. The client secures a reliable and trustworthy construction provider who understands and appreciates the trials and demands of the client business. During period of economic growth the client has also insulated the provision of major construction services and products from inflationary price hikes due to demand outstripping supply. The client also benefits from project learning and information sharing throughout the supply chain. Challenging entrenched practices where organisational learning is usually at the expense of the client without either the client or the main contractor benefiting from the project experience (Strategic_Forum, 2002).

Industry ingenuity may also have an opportunity to thrive in an extended supply chain environment. Modern methods of construction (MMC) may be prototyped, developed and refined via supply chain collaboration. Minimising the financial risk of implementation and increasing the rewards for successful innovation. For example, off-site building techniques challenge the predominately craft approach to the traditional building processes. Although MMC are widely believed to improve construction productivity (Goodier and Gibb, 2007), it requires considerable capital and human investment plus economies of production to justify a business case. From a supply chain management perspective, the advancement in industrialisation and assembly processes will also begin to mirror the applications used in manufacturing supply chain management. Second, third and fourth tier construction providers will benefit from a near continuous stream of work. Alleviating excessive fluctuations in demand and supply that construction companies often find difficult to adequately manage (Hartmann and Caerteling, 2010).

Other rewards are less obvious. Health and safety, for example is a prime concern for all parties engaged in the building process. Off site working coupled with increased assembly processes and strong supply chain leadership can help facilitate an incident and injury free working environment (Doherty, 2008). Reducing near misses and accidents not only reduce otherwise hidden costs but also sets a standard of working and performance that transgresses from the exceptional to the norm. Sustainable working practices will also reap benefits from MMC. Embedding working relationship within the supply chain increases both formal and informal communications channels. Efficient dialogue among stakeholders will mitigate project risks via comprehensive risk register, especially in high profile, complex construction projects. Integral to the communication and information sharing is the development of ICT channels. This will not only improve communication but depending on the sophistication of the communication and information exchange systems the prerequisite for capital investment may act as a barrier to market entry for those organisations outside the supply chain coalition (Powell, 1990).

Risks

Engaging in extended supply chain management within a construction context is not without risk. Inextricably linking business interests with the success or possible failure of other discrete organisations may mitigate risks on the one hand but on the other if the failure is catastrophic then there will undoubtedly be collateral consequences for the extended supply chain participants. It is possible that due to the fragmentation of the industry and high incidence of insolvency (Chevin, 2010) within the construction sector that construction firms remain wary of high levels of interdependency. A narrow relationship portfolio may be detrimental to their self-interest over the longer-term. Over embeddedness within a supply chain may also be accompanied by corporate lethargy. The competitive edge may be compromised by an over-reliance on collaborative arrangements that insulate the organisation from the competitive pressures of the free market. There is an inherent risk, as with most administrative tasks that supply chain management practice and procedures become victim of increasingly bureaucratic processes, the sharpness of the supply chain enterprise blunted by an administrative encumbrance.

Whilst relationships are stable and the informal social contract remains intact, the efficiency of the commercial solidarity is likely to mitigate corporate tendencies to merge. However, there remains an ever-present operational and commercial risk that irreconcilable differences between supply chain partners may trigger dysfunctional behavioural patterns and a return to adversarial relations. Consequently, a breakdown in trust and mutual respect will necessitate that economic and social ties are either; relinquished or alternatively, contingent upon ongoing commercial commitments an acquisition may be appropriate (Granovetter, 1985).

The potential futility of engendering social relationships within a construction project environment should also be carefully measured. The transient nature of production (Akintoye et al., 2000) necessitates a nomadic construction workforce (Trajkovski and Loosemore, 2006). Therefore building personal relationships over many years of social networking may be unexpectedly dissolved due to company or individual circumstances. Investing considerable time developing social capital may create business opportunities mutually conducive to the participating parties but within the context of construction, ties remain tenuous and the terms of social contract ill-defined.

Within the construction contracting community, subcontractors and suppliers remain sceptical of main contractors' motives for developing alliances (Dainty et al., 2001b). Small and medium sized enterprises (SME's) in particular continue to question the value of strategic alliances. Often believing that strong business ties with one or a few main contractors may endanger business opportunities with other construction providers. Even industries with a history of successful supply chain management it is somewhat inevitable that during periods of economic hardship the suppliers are subjected to cost cutting measures, commonly referred to as the *'squeeze'* (Blake et al., 2003). Construction clients and main contractors are unlikely to behave any differently. Evidence from the private sector already suggest that blue chip construction clients are turning their back on framework agreements (Wright, 2010). Consequently any ambition of 'extended' relations within construction supply chain management is likely to be compromised by an enduring faith in orthodox economic thinking, driven by self-interest, competition and supply and demand.

CONCLUSION

This paper has shown that the concept of extended supply chain management (stage 5) as illustrated by Lockamy III and McCormack's (2004) supply chain maturity model remains an aspiration within the context of the UK construction industry. Exemplars of extended supply

chain management witnessed in the manufacturing sector bear little semblance to the highly institutionalized setting of a project-based, craft orientated, geographical dispersed construction industry. Construction supply chain management, like the construction industry is unique. Ingrained construction operating practices (Dainty et al., 2001a) interlaced with complex environmental agency conspire to undermine the innocent ambitions of a manufacturing supply chain management ideology.

The supply chain maturity model does offer a benchmark of adaptation and application against which construction supply chain management may be evaluated and current practice discussed. However, progress on the notion of extended construction supply chain management will require key industry stakeholders to develop innovative collaborative policies that will be progressive, organisationally supportive and commercially attractive to SME's. As with all transactional and social relationships, risk will need to be offset against the rewards. Given the structural characteristics of the construction industry and a preoccupation for competitive tendering procedures it remains fanciful that construction supply chain management will attain a stage 5 (extended supply chain management) category of supply chain maturity.

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A CRITICAL ANALYSIS OF RISK MITIGATION MEASURES FOR TARGET COST CONTRACTS IN CONSTRUCTION INDUSTRY

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Abstract
A scarcity of empirical research has been observed on risk mitigation measures for those construction projects procured by guaranteed maximum price contracts (GMP) and target cost contracts (TCC) worldwide. This paper aims to seek and examine the risk mitigation measures associated with GMP and TCC (GMP/TCC) construction projects through an industry-wide empirical questionnaire survey launched in Hong Kong. Survey respondents were invited to delineate their levels of agreement on 18 individual risk mitigation measures identified from reported literature and in-depth interviews, and the views of client group were compared with those of contractor group. The survey results manifested that both the client group and contractor group are in general consistent in their views towards the risk mitigation measures for GMP/TCC contracts. However, the Mann-Whitney U Test revealed that they held different perceptions on 4 out of the 18 risk mitigation measures, and the findings may stem from different roles involved in the projects. The research findings are useful in providing industrial practitioners with valuable pointers towards effective risk mitigation measures of applying GMP/TCC schemes at an early stage of project delivery.

Keywords: Guaranteed maximum price contracts (GMP), Target cost contracts (TCC), Risk mitigation measures, Construction industry, Hong Kong.

INTRODUCTION

Traditional adversarial relationships are often encountered between employers and contractors within the construction market, primarily because various project stakeholders tend to focus mainly on the success of their individual own businesses instead of the overall project itself. By linking the individual own financial goals of the contractors with the overall

project objectives, both the Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) schemes are often applied as effective means to motivate contractors in achieving better value for money and more favourable project outcomes (Construction Industry Review Committee, 2001). GMP/TCC schemes can add value to project delivery only if the key risk factors are carefully identified, analysed, shared and managed (Trench, 1991; Walker *et al.*, 2000).

Although both GMP and TCC contracts have been in use for several years, not all of these projects were successfully completed and some of them resulted in a high level of risk or an uneven apportionment of risks. For example, Roja and Kell (2008) found that the final construction cost of 75% of public school projects based in the northwest of the United States cost more than the contract GMP value at completion, while the same phenomenon was observed in about 80% of public non-school projects. Hence, it is essential to seek ways to mitigate the potential risks which may be detrimental to the overall project performance of GMP/TCC contracts. This study serves as an attempt to fill up the gap of research in the area of risk mitigation measures for GMP/TCC schemes.

DEFINITIONS OF GMP/TCC

Carty (1995) defined GMP as "Both the contractor and owner agree that the contractor will perform an agreed scope of works (defined as best as possible) at a price not to exceed an agreed upon amount, the guaranteed maximum price (GMP) …… if these costs and the agreed upon contractor's profit are less than the GMP, the owner and contractor will share the savings in cost based upon an agreed formula. If the costs exceed the GMP without any changes to the defined scope, the contractor must solely bear the additional cost."

The National Economic Development Office (NEDO) (1982) suggested TCC to be "Target cost contracts specify a 'best' estimate of the cost of the works to be carried out. During the course of the works, the initial target cost will be adjusted by agreement between the client or his nominated representative and the contractor to allow for any changes to the original specifications. Any savings or overruns between target cost and actual cost at completion are shared between the parties to the contract."

HIGHLIGHTS OF RESEARCH STUDIES ON GMP/TCC

An extensive review of published literature has sought a bunch of research studies in relation to GMP/TCC schemes over recent years. Matthews and Howell (2005) reported on a case study of a central chilled water plant in Orlando of the United States which was procured with a GMP arrangement and achieved a cost saving of around 10% because of the partnering efforts of the project team. Pryke and Pearson (2006) carried out three European case studies and advocated the application of a GMP arrangement to be an effective means to transfer risks to the employer associated with design development at post-contract award stage. Kaplanogu and Arditi (2009) explored the practice of pre-project peer review process of GMP of contractors in the United States via an empirical questionnaire survey. Puddicombe (2009) established a regression model to explain the variations of project performance of applying different compensation schemes including GMP, cost-plus and lump sum contractual arrangements.

Badenfelt (2008) launched 16 interviews with the Swedish clients and contractors to identify the important factors influencing the selection of sharing ratio under TCC. Another recent study by Badenfelt (2010) revealed that a business relationship solely built on mutual trust appears to be rare in Sweden, and more attention should be placed by contracting parties to trust-nurturing actions to facilitate a smooth delivery of TCC. Lahdenpera (2010) examined the problem with late involvement in design of contractor in TCC, and proposed a two-stage target cost arrangement to combine early contractor's involvement and price containment.

Despite plentiful literature about the application of GMP/TCC contracts in construction, there seems to be a shortage of empirical research looking into the "risk aspect", especially the risk mitigation measures for GMP/TCC schemes which are generally perceived to be applicable to projects with high levels of complexity and risks. This observation has paved the way for conducting this study with the purpose of generating useful insights into risk mitigation strategies under the GMP/TCC umbrella towards industrial practitioners for reference and implementation.

DEVELOPMENT OF SURVEY INSTRUMENT

A comprehensive review of relevant materials from textbooks, academic journals, professional journals, conference proceedings, research reports, previous dissertations and internet information was first undertaken to capture background knowledge about the application and risk mitigation of GMP/TCC contracts worldwide. The literature review helped establish an overall framework for the research study and to prepare for the template of the survey questionnaire.

A total of seven semi-structured face-to-face interviews were carried out between June and July of 2008 with senior industrial practitioners with direct hands-on experience in procuring GMP/TCC construction projects in Hong Kong (Chan *et al.*, 2010a) to glean their opinions on key risk factors, risk allocation and risk mitigation measures for implementing GMP/TCC projects. Then an empirical survey questionnaire was compiled according to the findings from literature review (Chan *et al.*, 2010b) and those in-depth interviews. An industry-wide questionnaire survey was subsequently launched from March to April of 2009 to solicit the opinions and perceptions of relevant industrial practitioners on risk identification, risk assessment, risk allocation and risk mitigation associated with GMP/TCC construction projects in Hong Kong.

The survey form was made up of four major sections. The first section was about the respondents' general personal profiles. The second section was concerned with the risk identification and assessment of 34 listed key risk factors in relation to GMP/TCC construction projects. The third section focused on the risk mitigation measures for GMP/TCC contracts in which respondents were invited to rate the effectiveness of 18 possible risk mitigation measures as postulated by the interviewees with a five-point Likert scale, where 1 indicated "least effective"; 3 "effective" and 5 "most effective". The fourth section was optional and the respondents were requested to show their personal preference on future development and application of GMP/TCC contractual arrangements with their supporting reasons. It should be stressed that only the survey findings in relation to the risk mitigation measures are reported and discussed in this paper due to length limitation. The results of other sections will be duly documented and disseminated in other publications in

near future, for example, on the first section of the development of a fuzzy risk assessment model (Chan *et al.*, 2011).

Altogether, 300 self-administered blank survey forms were delivered to individual construction professionals and project stakeholders in Hong Kong through both postal mail and electronic mail between March and April of 2009. The target survey respondents were first determined from previous research studies on GMP/TCC procurement strategies in Hong Kong undertaken by the authors (Chan *et al.*, 2007). A total of 94 valid and duly completed survey forms were returned in June of 2009 for further statistical analysis. The 94 respondents either have acquired direct hands-on experience in participating GMP/TCC projects or they declared to have basic understanding of the underlying principles of GMP/TCC schemes even though without the direct exposure to GMP/TCC contracts before (Chan *et al.*, 2010b). Since all of the major active practitioners in applying GMP/TCC had been included in the list of target respondents of the questionnaire survey, it was discerned that their opinions and perceptions could substantially represent the GMP/TCC project pool in Hong Kong over the past decade of 1999-2009. Hence, the chosen sample was perceived as representative of the survey population given the limited number of construction projects completed under GMP/TCC schemes in Hong Kong (about 20 as cited by Chan *et al.*, 2007).

Table 1 serves as a summary of the profiles of the 94 respondents. More than 80% of the respondents have already derived working experience of at least 5 years within the construction industry, their opinions and data collected from the survey are regarded as representative and reliable. The collective opinions from all of the survey respondents will be presented in this paper, and the views of client group will also be compared with those of contractor group because they are the key players in driving the GMP/TCC procurement process. A four-level data analysis framework (Chan *et al*., 2010b), including descriptive statistics, Kendall's concordance test, Spearman's rank correlation test and Mann-Whitney U Test, will be applied to investigate the intra-group agreements and inter-group comparisons for this survey.

Table 1: *Personal profiles of survey respondents*

Category	Respondents	
	Frequency	Percentage
Grouping by role in the project		
Client	33	35.1%
Contractor	27	28.7%
Consultant (i.e. architects, engineers, quantity surveyors, project managers, etc)	34	36.2%
TOTAL	94	100%
Experience level in construction		
Below 5 years	17	18.1%
5-10 years	11	11.7%
11-15 years	11	11.7%
16-20 years	12	12.8%
Over 20 years	43	45.7%
TOTAL	94	100%

PRESENTATION OF SURVEY RESULTS

Overall ranking of the risk mitigation measures for GMP/TCC projects

The mean scores of each of the 18 listed risk mitigation measures as rated by all respondents were calculated and they were ranked in descending order of the mean scores as reported in Table 2. The mean values for the 18 measures ranged from 2.60 to 3.90. Since all the mean values are above 2 (fairly effective), the respondents believed the suggested risk mitigation measures to be effective and feasible in general but with different levels of agreement only. Item 16 "Right selection of project team" was ranked as the most effective risk mitigation measure for GMP/TCC construction projects. Chan *et al.* (2010c) advocated that the selection of a competent project team is crucial to overall project success of a target cost contract, as inexperienced or claim-conscious contractors may jeopardise the smooth implementation of the GMP/TCC procurement process. Gander and Hemsley (1997) also concurred the recruitment of an experienced project team as crucial to the success of a GMP/TCC project since an inexperienced one could generate a lack of clarity for his roles and obligations.

The respondents ranked Item 3 "Clearly defined scope of works in client's project brief" as the second most effective risk mitigation measures. Since "change in scope of works" was regarded as the most significant risk in the same survey (Chan *et al.*, 2010b), it is not astonishing that respondents indicated that a clear definition of scope of works at project commencement could effectively mitigate risks inherent with GMP/TCC projects during site construction. This finding is in line with that in a recent study from the United Kingdom (Olawale and Sun, 2010), suggesting that clear distinction between a design change and a design development item well at the outset of a construction project could reduce the potential risks arising from subsequent design changes. Thus, it is essential to define the scope of works as detailed and accurate as possible at the initial project stage and to keep scope changes or necessary variations to a minimum.

The third most effective risk mitigation measure was Item 12 "Mutual trust between the parties to the contract". It is found that partnering concepts were introduced in parallel in a number of GMP/TCC construction projects in Hong Kong (Chan *et al.*, 2007). The methodology of TCC is usually applied in projects with high risks (Wong, 2006), so mutual trust between the employer and the contractor would be necessary to cope with the risks associated with the projects. Moreover, because of the unique arrangement of the target cost contracting approach based on joint determination and agreement between the client and the contractor on the allocation of major risks, the client recognised the essence of realistic target cost estimates, which would include appropriate risk contingencies under the pain-share/gain-share mechanism (Chan *et al.*, 2010c). Mutual trust and close working relationship are thus essential in reducing the possible risks under a teamwork culture.

Table 2: *Rankings and results of Kendall's concordance test of risk mitigation measures for GMP/TCC construction projects*

ID	Risk Mitigation Measures for GMP/TCC	All respondent group			Client group			Contractor group		
		N	Mean	Rank	N	Mean	Rank	N	Mean	Rank
16	Right selection of project team	60	3.90	1	33	4.00	1	27	3.78	1
3	Clearly defined scope of works in client's project brief	60	3.73	2	33	3.79	2	27	3.67	6
12	Mutual trust between the parties to the contract	60	3.70	3	33	3.67	4	27	3.74	3
6	Confirming a contract GMP value or target cost after design documents are substantially completed	60	3.63	4	33	3.70	3	27	3.56	11
4	Prompt valuation and agreement on any variations as they are introduced	60	3.58	5	33	3.52	5	27	3.67	6
14	Proactive participation by the main contractor throughout the GMP/TCC process	60	3.57	6	33	3.48	6	27	3.67	9
15	Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor	60	3.55	7	33	3.42	9	27	3.70	4
8	Early involvement of the main contractor in design development process	60	3.53	8	33	3.39	10	27	3.70	5
17	Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of works involved and necessary obligations to be taken in the project	60	3.50	9	33	3.42	7	27	3.59	10
11	Sufficient time given to interested contractors to submit their bids for consideration	60	3.47	10	33	3.24	12	27	3.74	2
2	Clearly stated circumstances in which agreed GMP value or target cost can be adjusted in contracts	60	3.45	11	33	3.27	11	27	3.67	6
18	Establishment of adjudication committee and meetings to resolve potential disputed issues	60	3.39	12	33	3.42	7	27	3.35	13
5	Proper risk register with responsible parties assigned and agreed	60	3.17	13	33	3.24	12	27	3.07	16
7	Development of standard contract clauses in connection with GMP/TCC schemes or methodology	60	3.12	14	33	3.00	15	27	3.26	15
1	Application of price fluctuation clause in the contract	60	3.07	15	33	2.82	16	27	3.37	12
13	Open-book accounting regime provided by main contractors in support of their tender pricing	60	3.03	16	33	3.09	14	27	2.96	17
10	Implementation of relational contracting within project team	60	2.97	17	33	2.69	17	27	3.30	14
9	Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage	60	2.60	18	33	2.36	18	27	2.89	18
	Number (N)		60			33			27	
	Kendall's coefficient of concordance (W)		0.124			0.175			0.109	
	Actual calculated chi-square value		122.149			95.221			48.284	
	Critical value of chi-square from table		28.870			28.870			28.870	
	Degree of freedom (df)		17			17			17	
	Significance level		<0.001			<0.001			<0.001	
	H_0 = Respondents' sets of rankings are unrelated (independent) to each other within each group Reject H_0 if the actual chi-square value is larger than the critical value of chi-square from table									
	Note: Items were rated on a 5-point Likert scale (1 = Least effective; 2 = Fairly effective; 3 = Effective; 4 = Very effective; and 5 = Most effective).									

Results of Kendall's concordance analysis

The second step of data analysis is to perform a Kendall's test of concordance to gauge the agreement of different respondents on their rankings of the risk mitigation measures for GMP/TCC within a particular respondent group (*Chan et al*., 2010b). As the number of

attributes (i.e. risk mitigation measures) considered was larger than seven, the chi-square value would be used as a near approximation instead of the Kendall's coefficient of concordance to measure the agreement of different respondents on their rankings of risk mitigation measures for GMP/TCC as a whole based on the mean scores. According to the degree of freedom (18 - 1 = 17) and the allowable level of significance (5%), the critical value of chi-square from table was found to be 28.87 (Siegel and Castellan, 1988). For all respondents, the actual computed chi-square value of 122.149 was much greater than the critical value of chi-square of 28.87. This result indicates the null hypothesis that "Respondents' sets of rankings are unrelated (independent) to each other" has to be rejected. Consequently, there is sufficient evidence to conclude that there is significant degree of agreement among all respondents on the rankings of the risk mitigation measures for GMP/TCC. The same result (actual calculated value of chi-square larger than critical value of chi-square) is found in both the client group and contractor group. This concordance test ensures the data and opinions collected from the questionnaire survey to be valid and consistent for further analysis.

Results of Spearman's rank correlation test

With the purpose of comparing the perceptions between the client group and contractor group, the next step of data analysis is to conduct a Spearman's rank correlation test. The Spearman's rank correlation coefficient is a statistical tool to test the strength of relationship between the rankings of two respondent groups (Olawale and Sun, 2010). The level of association between the client group and contractor group on their rankings of the 18 risk mitigation measures for GMP/TCC schemes was gauged by the Spearman's Rank Correlation Coefficient (r_s). The coefficient, r_s , ranges between –1 and +1. A value of +1 indicates a perfect positive correlation, while a value of –1 indicates a perfect negative correlation (Fellows and Liu, 2008). If the Spearman's rank correlation coefficient (r_s) was statistically significant at 5% significance level, the null hypothesis that "No significant correlation on the rankings between the two groups" can be rejected. It can then be concluded that there is significant association between the two groups on the ranking exercise.

The level of agreement amongst the respondents on the ranking exercise was tested via the Spearman's rank correlation test as portrayed in Table 3. The results reflected that the null hypothesis that no significant correlation on the ranking between the client group and contractor group is rejected at 1% significance level. This results in significant correlations in general on the rankings of risk mitigation measures between the two respondent groups and they shared similar perceptions on the ranking exercise as a whole (e.g. Item 16 both ranked as the 1st, Item 7 as the 15th and Item 9 as the 18th).

Table 3: *Results of Spearman's rank correlation test on the risk mitigation measures for GMP/TCC construction projects between client group and contractor group*

Comparison of Rankings	r_s	Significance Level	Conclusion
Client's ranking vs Contractor's ranking	0.625	0.006	Reject H_0 at 1% significance level

H_0 = No significant correlation on the rankings between the two groups
H_a = Significant correlation on the rankings between the two groups
Reject H_0 if the actual significance level (p-value) is less than the allowable value of 5%

Results of Mann-Whitney U Test

The final step of data analysis is to detect any differences in perception on individual risk mitigation measures by means of the Mann-Whitney U Test. The Mann-Whitney U Test is a non-parametric statistical test which is applied in hypothesis testing involving two independent variables (Gibbons and Chakraborti, 2003). It is performed to test if there is any statistically significant difference in the median values for each attribute under study between any two respondent groups. This same technique was adopted in a recent research by Wibowo and Mohamed (2010) to test whether there was statistical difference between perception towards criticality of risks of regulators and operator in water supply projects in Indonesia. This test is used because it is distribution free and thus requiring no assumption of normality of data sets (Wibowo and Mohamed, 2010). The Mann-Whitney U Test was applied in this study to test the null hypothesis that "There is no significant difference in the median values of the same risk mitigation measure between the respondents from client group and contractor group" and the medians can be represented by mean ranks (Sheskin, 2007).

Level of significance (α) for testing these hypotheses was set at 5%. The results can be interpreted by the Z-value and p-value. When the actual calculated p-value is less than the pre-defined significance level of 5%, then the null hypothesis (H_0) can be rejected. Thus, it can be concluded that there is a significant difference in the median values of that risk mitigation measure between the two respondent groups (Sheskin, 2007).

The results of Mann-Whitney U Test are shown in Table 4. It can be seen that the two groups of respondents had statistically different perceptions towards 4 out of the 18 risk mitigation measures. The contractor group considered Item 1 "Application of price fluctuation clause in the contract" more important than the client group. This finding may stem from the fact that there was a significant increase in the materials price when the survey was conducted (i.e. first half of 2009). The contractors suffered a lot for such increase in materials price if the price fluctuation clause was not applied. So the contractor group would believe the price fluctuation clause to be very effective in mitigating risks in GMP/TCC schemes.

The two groups of respondents also held different views towards Item 9 "Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage". This risk mitigation measure is similar to that found from those interviews undertaken in the United Kingdom by Olawale and Sun (2010) that employing a design manager to manage the design process and review related information as it comes in. Again, the contractor group perceived this risk mitigation measure as more effective than the client group did. Perhaps, the contractor group may advocate that the lack of buildability of project design would unnecessarily delay the overall project duration and affect the progress of subsequent portions / phasing of works. The contractor's resources may be wasted in preparing for works which is actually difficult to construct, due to the deficient initial project design.

Table 4: *Results of Mann-Whitney U Test between the client group and contractor group on the risk mitigation measures for GMP/TCC construction projects*

Risk Mitigation Measures for GMP/TCC	Respondent Group	Mean Rank	Significance Level
1. Application of price fluctuation clause in the contract	**Client**	**26.42**	**0.036***
	Contractor	**35.48**	
2. Clearly stated circumstances in which agreed GMP value or target cost can be adjusted in contracts	Client	27.59	0.128
	Contractor	34.06	
3. Clearly defined scope of works in client's project brief	Client	31.45	0.622
	Contractor	29.33	
4. Prompt valuation and agreement on any variations as they are introduced	Client	29.73	0.688
	Contractor	31.44	
5. Proper risk register with responsible parties assigned and agreed	Client	31.94	0.457
	Contractor	28.74	
6. Confirming a contract GMP value or target cost after design documents are substantially completed	Client	31.15	0.734
	Contractor	29.70	
7. Development of standard contract clauses in connection with GMP/TCC schemes or methodology	Client	28.58	0.326
	Contractor	32.85	
8. Early involvement of the main contractor in design development process	Client	28.36	0.273
	Contractor	33.11	
9. Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage	**Client**	**26.58**	**0.044***
	Contractor	**35.30**	
10. Implementation of relational contracting within project team	**Client**	**25.16**	**0.013***
	Contractor	**35.74**	
11. Sufficient time given to interested contractors to submit their bids for consideration	**Client**	**26.59**	**0.043***
	Contractor	**35.28**	
12. Mutual trust between the parties to the contract	Client	29.88	0.752
	Contractor	31.26	
13. Open-book accounting regime provided by main contractors in support of their tender pricing	Client	31.52	0.606
	Contractor	29.26	
14. Proactive participation by the main contractor throughout the GMP/TCC process	Client	29.08	0.457
	Contractor	32.24	
15. Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor	Client	28.95	0.429
	Contractor	32.39	
16. Right selection of project team	Client	32.47	0.305
	Contractor	28.09	
17. Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of works involved and necessary obligations to be taken in the project	Client	28.95	0.419
	Contractor	32.39	
18. Establishment of adjudication committee and meetings to resolve potential disputed issues	Client	30.80	0.670
	Contractor	28.98	

* Risk mitigation measures with a significance level of less than 0.05 which indicates significant statistical differences

The contractor group also rated Item 10 "Implementation of relational contracting within project team" higher than the client group did. According to Chan *et al*. (2007a), partnering spirit is essential to the overall success of GMP/TCC projects. The partnering spirit incorporated in relational contracting enhances the willingness to achieve co-operation between the contracting parties and ensures a smooth operation of the projects.

Finally, the two respondent groups shared different views on Item 11 "Sufficient time given to interested contractors to submit their bids for consideration". This finding is not surprising since it is the contractor to submit the bids, the client may like to have the overall project duration as short as possible and may be less concerned about the tendering period. A reasonable tendering period would allow interested contractors to gain a basic understanding

of the special features and contractual requirements of the project such as the methodology of GMP/TCC contractual arrangements (Chan *et al*., 2010a). The tenderers would probably recognise potential risks involved in the projects concerned before contract award, and this would certainly reduce the risks such as change in scope of works at the post contract award stage.

CONCLUSIONS

An empirical questionnaire survey was launched on some risk mitigation measures for GMP/TCC schemes which are still at a germinating stage of development in the construction industry of Hong Kong. The three most effective individual risk mitigation measures as perceived by those industrial practitioners are: (1) Right selection of project team; (2) Mutual trust between the parties to the contract; and (3) Clearly defined scope of works in client's project brief.

Following the descriptive analysis of the survey results, the Kendall's concordance test indicates that the responses in both the client group and contractor group are in general consistent within their respective groups. The result of Spearman's rank correlation test further suggests that the rankings of risk mitigation measures between the two groups are also consistent statistically as a whole. The Mann-Whitney U Test shows that the contractor group perceived 4 out of the 18 risk mitigation measures as much more effective than the client group did in the survey.

With the survey results of this study in mind, industry leaders and decision makers have secured sufficient evidence and useful pointers to determine whether to adopt GMP/TCC contracts in future projects or not. It is hoped that this research study could be served as a first step towards generating valuable solutions for mitigating potential risks associated with the GMP/TCC contractual arrangements which are discerned to be suitable for projects with high risks (Wong, 2006). Further research could be undertaken in future via case studies to confirm the applicability and effectiveness of those suggested practical strategies for mitigating the potential risks inherent with GMP/TCC schemes worldwide.

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CULTURAL HERITAGE IN URBAN REDEVELOPMENT PROJECTS: A FRAMEWORK TO ANALYSE COLLABORATIVE STRATEGIES

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Abstract

Due to technological, economic and spatial developments, various inner-city industrial areas have lost their former use and their original economic value. Many of these areas have elements of cultural-historical value. Preserving this cultural heritage means managing it for the benefit of current and future generations, and –by doing so - contributing to a sustainable development. Governments, private parties, citizens and interest groups are often convinced of the desirability of preserving the cultural heritage. However, the presence of cultural heritage entails extra complexity. Hence, public and private parties are searching for new methods, processes and instruments to embed cultural heritage in urban redevelopment projects. In this paper we present a framework to study strategies used and their implications for balancing costs and benefits. To develop this framework, we analyzed five Dutch urban redevelopment projects with cultural heritage and confronted the results with literature. We then argue that value creation, through collaborative efforts in finding new uses, and value claiming, by negotiating on the costs and benefits involved, go hand in hand. From this perspective, value creation and settlements regarding costs and benefits of cultural heritage depend on how stakeholders handle this tension.

Keywords: cultural heritage, urban redevelopment, collaborative strategies, balancing costs and benefits, negotiation

INTRODUCTION

One of the key concepts of sustainability is preserving the environment for future generations (Nijkamp and Riganti, 2008). Developments should meet the needs of the present generation without compromising the ability for future generations (World Commission on Environment and Development, 1987). However, many urban areas were developed in a period when sustainability was not really an issue. In recent decades technological, economic and spatial developments caused that many urban industrial areas lost their original economic value or the use was not considered socially desirable anymore at the specific location. Without a new use, these areas will fall into decline. Buildings will slowly deteriorate and the areas can become a spot for crime. Such areas can cause serious economic, social, political damages to

society (Yousefi et al., 2007). As spatial developments will increasingly consist of inner-city redevelopment projects, a big challenge is to transform these areas. This contributes to a sustainable environment. Re-use of (parts) of buildings saves demolition waste, buildings will become more energetic, and inner-city redevelopment makes greenfield development elsewhere superfluous.

In contradiction to greenfield development, urban redevelopment has to a greater extent take into account its economic, physical, social and environmental context. This includes the context of the surrounding urban area, but also the characteristics of the redevelopment area itself. An important characteristic of these projects is that they often include buildings which are considered to be of cultural-historical value. Although the added value of this cultural heritage for urban redevelopment is generally acknowledged, in practice successful transformation seems hard to attain. Based on an analysis of five Dutch urban redevelopment projects in which transformation of cultural heritage plays a significant role, we will explain the challenges and bottlenecks in more detail. We confronted the findings from the empirical analysis with literature on planning and negotiation. We end this paper by presenting a general framework to study collaborative strategies and the implications of these strategies on settlements regarding the costs and benefits to effectively transform of cultural heritage in urban redevelopment. In the following section, we first pay attention to cultural heritage in an urban redevelopment context.

CULTURAL HERITAGE IN URBAN REDEVELOPMENT

Cultural heritage in urban areas is often seen as the physical representation of the identity of a certain community (Nijkamp and Riganti, 2008). More specific, cultural heritage comprises a whole of various things, like (art) collections, archaeological heritage, individual buildings, city views, landscapes, industrial complexes and waterworks with cultural, social and economical value (Coccossis and Nijkamp, 1995). An area can be appointed as cultural heritage, like UNESCO world heritage sites, or individual buildings can be officially registered (like national protected monuments) or generally be considered as such.

In urban redevelopment, the presence of cultural heritage can offer opportunities for social-economic development, such as the development of tourism, recreation, leisure and other kinds of cultural activities (Bizarro and Nijkamp 1997). Cultural heritage gives an area a specific identity and generally improves the satisfaction of people living in the neighbourhood (Aarsen et al., 2010; Linssen, 2009). Preserving cultural heritage means managing it for the benefit of current and future generations. In this way, preserving and transforming built cultural heritage into new uses, contributes to a sustainable development (Nijkamp en Riganti, 2008).

Governments, private parties, interest groups and citizens are often convinced of the desirability of preserving and re-using the valuable cultural-historical buildings. Besides interests like perception of a certain identity and historical conscience, there are also other material and immaterial considerations to preserve cultural heritage: aesthetical, ecological, social and economical interests. However, urban redevelopment projects tend to be complex in general and even more when cultural heritage is involved. Urban redevelopment projects are characterized by high contextual and organizational complexity; mutual dependencies among actors, as the investments needed are generally too high and the project too complex for a single actor; the need for collaborative interaction between private and public parties;

and a long time frame (Bult-Spiering, et al. 2005). The presence of cultural heritage entails extra complexity. It is often a challenge to find new appropriate uses for these buildings which are also financially feasible.

In this paper we focus on transformation of built cultural heritage as a part of a wider urban area development. These projects often concern former industrial or military complexes.

A well-known example of a successful transformation of a former urban industrial area is the so-called Westergasfabriek in Amsterdam. Constructed in 1883, this factory was once the largest coal plant of the Netherlands (14 ha). The plant closed down in 1967. Most of the remaining buildings were officially acknowledged as cultural heritage 30 years later and became successfully used for temporary creative and cultural activities. This was the start of a redevelopment project in which many of the buildings were renovated. Nowadays, these buildings are used for events, or as a gallery, office, theatre, bar or restaurant. The industrial buildings and surrounding area are transformed into a characteristic place to work and play.

The complexity of the projects implies that straight-forward planning is not possible. The great number of actors and interests in area developments makes planning processes slow and complicated. Especially financial agreement seems hard to attain when plans have to be made effective. Although various studies (Ruijgrok, 2004; ABF Research, 2007; a.o.) show that the presence of cultural heritage adds value to an area, quantifying and allocating the increased value is often very difficult. As a consequence, a number of parties profit from investments to preserve and or transform cultural heritage without contributing in the costs. For collective goods this is known as the problem of free-riders.

In previous years, governments usually subsidized non-commercial elements, like cultural-historical values, as an incentive for urban redevelopment projects (Aarsen, Brons et al. 2010). As government funds are decreasing and more emphasis is put on efficient use of public money, opportunities to capture the increased value are searched for. Governments, market parties, citizens and interest groups have a need to cooperate (Ministries OCW, LNV, VROM, V&W, 1999) to prevent cultural heritage buildings to disintegrate and embed them in the urban redevelopment projects. However, a major bottleneck in the efforts to transform cultural heritage buildings in urban redevelopment projects appears to be the lack of transparent system for balancing the corresponding costs and benefits between actors involved.

BALANCING COSTS AND BENEFITS IN CULTURAL HERITAGE PROJECTS

Balancing of costs and benefits can be seen as acknowledging the fact that additional value of commercial elements, like houses or offices also depends on the granted subsidy for non-commercial elements (Ministry of Finance, 2001). Boeve (2006) defines it as “the transfer of rights, risks, financial or qualitative values, between profit making and non-profit elements in order to make a coherent programme possible".

In recent years a lot of attention is paid to the balancing of costs and benefits in area development projects, both in policy documents (Ministries VROM, V&W, EZ, LNV and Finance, 2003; Ministry of VROM, 2004 en 2001; a.o.), as by interest groups of the private sector. A distinction can be made between voluntary balancing of costs and benefits and the use of governmental instruments to enforce contributions of private parties. Within the

current Dutch institutional context - contrary to some other countries – the legal possibilities to capture the added value due to public investments are very limited. The applicability of a recently introduced law on land exploitation is limited to a contribution in the costs of certain public facilities, instead of focussing on capturing increased value. Besides, investments in preserving cultural heritage or cultural facilities are not listed cost categories of public facilities in this law. As institutional changes go beyond the scope of our research, balancing costs and benefits in transformation projects is primarily based on (voluntary) negotiation. In urban development practice, balancing costs and benefits usually takes place in the context of an agreement between public bodies, property developers and landowners. Therefore, we focus on the collaborative strategies of actors and the implications of these strategies regarding settlements of costs and benefits.

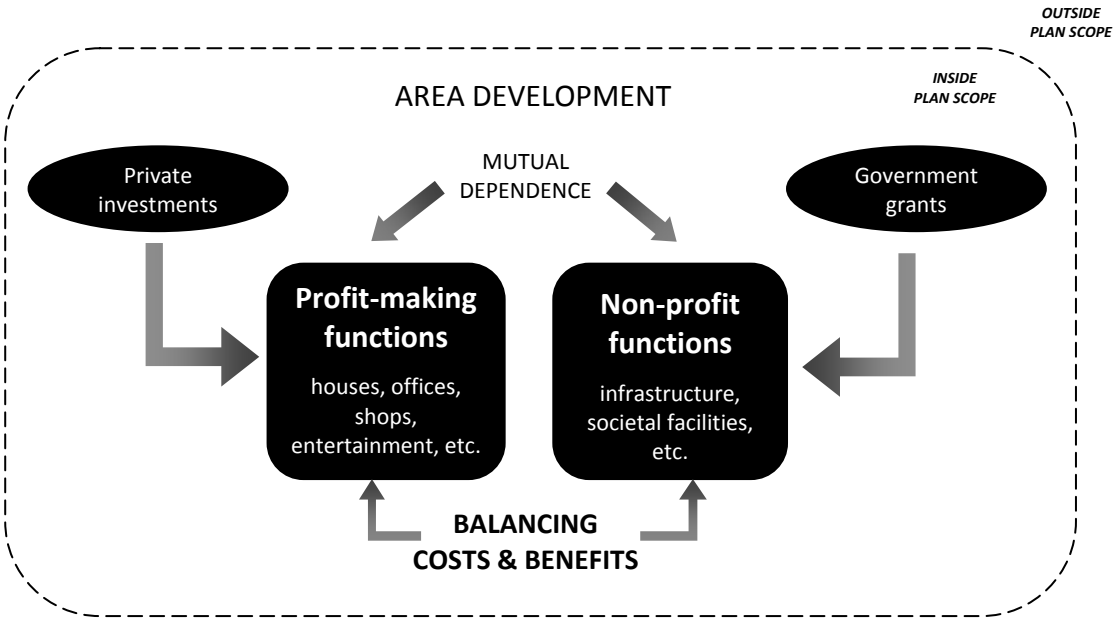


Figure 1: *Balancing costs and benefits*

RESEARCH METHOD

A premise of our research is that there is a strong relation between spatial quality, finances and process. In other words: preservation and re-use of cultural heritage adds quality to urban redevelopment projects, but requires substantial investments. To find the money needed, possibilities to integrate various uses and involve more actors are searched for during the planning process. In that way new value can be created for locations which have lost their old value and costs and benefits can be balanced. The question is then which collaboration between governments, developers, financers, users and people living in the neighbourhood contributes to fair settlements on costs and benefits and how this influences effective transformation of the cultural heritage. Therefore, the emphasis in our research is on the collaborative strategy used.

To develop such strategy we adapt the design oriented- approach, developed by Van Aken (2004). The design approach is pragmatic and the knowledge is to be applied by practitioners (Van Aken, Berends et al. 2007). The results of the design approach are so-called technological rules (van Aken, 2004) *"if you want something like x, in setting z, than do y"*. In our research: 'x' would be the effective transformation of cultural heritage; 'z' is the

network of actors in an urban redevelopment project, and ‘y’ is the collaborative strategy to make financial agreements to balance costs and benefits. To reach greater understanding of the relation between x, z, and y, a first step is to gain insight in the specific characteristics of urban development projects with cultural heritage and the bottlenecks experienced by stakeholders in the process to transformation. For this purpose we analysed five urban redevelopment projects in the Netherlands, in which the re-use of cultural heritage plays an important role.

These projects were selected based on the following criteria: 1) redevelopment of an entire area instead of a single object; 2) multiple functions, the aim is to develop several different new uses (not only housing) in mutual coherence; 3) one or more buildings in the area are considered to be of cultural-historical value and the aim is to re-use these buildings; 4) the area has to be urban, located inner-city or at the border of a city, and 5) the project should be in the planning stage, thus in other words, plans for redevelopment are being made but stakeholders are (for some parts of the project) still searching for appropriate new uses that are financially feasible. Side conditions were access to project documentation and the willingness of the project managers to participate in interviews.

To study how the processes in these projects develop towards settlements on costs and benefits we chose to vary the context as less as possible. Therefore, we only studied projects in the Netherlands. So, in this research institutional factors do not have the status of variables which can be optimized to attain agreements on costs and benefits. The first four criteria are related to the context of the projects. The last criterion is important as we aim to identify the current substantive bottlenecks and interaction processes among actors. The projects we selected are Wagenwerkplaats (Amersfoort), Spoorzone (Tilburg), Hart van Zuid (Hengelo), Hembrugterrein (Zaanstad) and 't Vaneker (Enschede).

For each of these projects, we conducted at least two face-to-face interviews. The interviewees were the project managers of the leading organisation for transformation of the cultural heritage. Besides, four meetings with the project managers were held to discuss the findings. For each project we also carried out a document analysis. Among others, master plans, official decision documents of the city council, studies of the cultural-historical elements, progress reports and (initial) agreements among parties were analyzed. The analysis gave insight in the physical-spatial characteristics of the projects, the stakeholders and organizational setting, and the bottlenecks experienced with transforming cultural heritage. We confronted this data with literature on planning. Together, these provide the building blocks for a framework to be used in a more in-depth analysis of strategies for balancing costs and benefits of cultural heritage.

PROJECT DATA

Project description

The Wagenwerkplaats in the city of Amersfoort (145.000 residents) is a former maintenance area for railway carriages of the Netherlands Railways Company (NS). The area with two maintenance buildings, the boilerhouse and the smithy, was build in 1908. In 2000 NS closed down their maintenance workplace and the area lost its use. NS is now developing and realizing a vision to create an area of commercial cultural activities. Some buildings have already been restored and are currently used by an architect company, the CliniClowns education centre and a theatre.

Spoorzone Tilburg, in the city of Tilburg (205.000 residents), is another former railway workplace. The central area, where various buildings of cultural historical value are located, is part of a large urban restructuring project that is to be realized around the central railway station. The redevelopment should result in a dynamic, playful multifunctional area for arts, theatre, education and living, with an old industrial atmosphere.

Hart van Zuid is a former industrial area just south of the city centre of Hengelo (75.000 residents). In 1854 Stork and Dikkers settled their headquarters in the area and produced, among others, large engines and pumps. In the 1980's the economic growth stopped and the company moved a part of its production processes to other countries. Currently, most of the buildings are not in use anymore and there is a opportunity for the municipality to strengthen this part of Hengelo and create an area of added value to the city. One of the heritage buildings is already in use as a large scale educational centre.

Hembrugterrein is a former military area in Zaanstad (150.000 residents). From 1895 till 1970s the area and the buildings were used for producing, testing and storing ammunition. The area has a green character with 62 registered monuments (of 120 military buildings in total). Besides built heritage, also a stretch of woods to muffle explosions of ammunition tests and former gas pipelines are indicated as monuments. In 2003 all activities stopped and the area was abandoned. Although actors agree that it is a unique area with many opportunities, all planning attempts failed so far. Recently, a start is made by creating opportunities for creative artists and companies to temporarily hire buildings and opening the area for public.

't Vaneker is also a former military area, situated between the Airport of Twente and the city centre of Enschede (157.000 residents). There is an old fenced military complex, called "Het Zuidkamp", which was build in 1940. The municipality is developing this area to a high quality living area in the specific green landscape of Twente.

Physical-spatial characteristics

	Wagenwerkplaats	Spoorzone Tilburg	Hart van Zuid	Hembrugterrein	Het Vaneker
Location	Inner-city	Inner-city	Inner-city	City outskirts	City outskirts
Size (ha)	18.9	55	60	43.5	90
Former use	Railway workplace	Railway workplace	Industrial	Military	Military
Cultural heritage	Buildings. 5 are official registered as monuments.	Buildings. Not registered as monuments. 4 buildings are explicitly pointed out to be of cultural historical value	Buildings. Not registered as monuments. Main parties signed covenant how to deal with valuable buildings.	62 official registered monuments: buildings, stretch of wood, small elements	Buildings. Not registered as monuments.

***Table 1**: Physical-spatial characteristics*

The cultural heritage - officially registered or considered to be of cultural historical value - gives these areas a unique character and identity. The unique character and the apparent opportunities keep attracting new ideas of governments and developers. However, many

redevelopment attempts fail. Appropriate new uses have to be found for the buildings to be able to preserve them. This requires high investments, while the benefits are difficult to express in financial terms and – due to environmental issues – are often in a far future. Besides, the presence of monuments in most projects entails additional regulations. These characteristics make transformation of cultural heritage in urban redevelopment projects a complex challenge.

Organizational setting

In all projects multiple stakeholders are involved in the planning process. Resources needed to redevelop the areas are divided among various parties. A person or group who has a vested interested in the success of a project and the environment within the project operates is called a project stakeholder (Olander and Landin, 2005). As mentioned before, in urban development practice, balancing of costs and benefits usually takes place in the context of an agreement between public bodies, property developers and landowners. They own, decide, invest and/or have the knowledge and other resources to develop the area. Therefore, we focused primarily on the roles of these parties.

	Wagenwerkplaats	Spoorzone Tilburg	Hart van Zuid	Hembrugterrein	Het Vaneker
Leading role (project management)	Private developer (NS Poort)	Municipality	Municipality & Private developer	Central government	Municipality
Landowner(s)	NS Poort	Municipality	Multiple	Ministry of Defence	Municipality and Province
Public authority	Municipality	Municipality	Municipality	Province and Municipality	Municipality
Property developer	NS Poort	Volker Wessels	Van Wijnen BV	X	X
Cooperation agreement?	No, Informal deliberations between NS Poort, municipality and citizens that live near the plan area	Yes, A Public Private Partnership of the municipality and Volker Wessels	Yes, A Public Private Partnership of the municipality and the Van Wijnen Group	No, Informal steering committee of central government, municipality and the province	No, Municipality prepares and sells the land primarily for housing

Table 2: *Organizational setting*

It appeared that the roles of various types of stakeholders vary substantially. In some projects, the municipality is the leading actor, while in others they are only involved as public authority. Land ownership and the perception of urban development possibilities seem to be the important influential factors for the differences in roles.

Landowners, public bodies and property developers contribute to the costs of transformation in different ways. Their benefits are also quite different. Besides, they have different interests. In general, public bodies strive for societal benefits, while property developers have financial gain as their primary goal. Table 3 provides an overview of the division of costs and benefits among stakeholders.

	Wagenwerkplaats	Spoorzone Tilburg	Hart van Zuid	Hembrugterrein	Het Vaneker
Costs of maintaining the cultural heritage (before redevel.)	Private developer (NS Poort)	Municipality	Private owners (Stork e.a.)	Central government	Municipality
Risk-bearing investor in cultural heritage	NS Poort	Municipality VolkerWessels	Municipality VanWijnen	Not yet known	Future buyers
Actors who subsidize	Province Ministries	Province Ministries	Ministries	Municipality Province Ministries	None
Actors who (financially) benefit	NS Poort and surrounding neighbourhoods (housing corporation)	Municipality, Volker Wessels, surrounding real estate owners	Municipality, Van Wijnen surrounding real estate owners	Not yet known	Unknown
Current balancing costs and benefits	Indirect as NS Poort is both landowner as developer.	Indirect in PPP construction	Indirect in PPP construction	Still too many uncertainties.	No expected free rider behaviour
Perceived bottlenecks for balancing costs and benefits	Environmental regulations; Planning in phases; Accessibility of the plan area	Current market situation; No feasible new uses yet; Ground pollution	Current market situation; No feasible new uses yet	Environmental regulations; Ground pollution; Many cultural heritage buildings in decrepitude; Inflexibility of municipality	No appropriate financially feasible new uses yet

Table 3: *Overview of the division of costs and benefits among stakeholders*

Uncertainties and complexity in transformation

The analysis shows that all projects have to deal with quite similar difficulties in the process towards effective transformation of the cultural heritage. Firstly, although in the long term returns on investments are generally expected to be positive, the initially needed financial investment are often far higher than in a situation without cultural heritage (Saris, Dommelen et al., 2008; Bade and Smid, 2008). The former industrial or military activities frequently caused heavily polluted ground. This pollution needs to be cleaned up to make new use possible. The costs for sanitation are high. Furthermore, there is often substantial uncertainty, as these costs can only be calculated precisely after the sanitation started. This uncertainty makes initial agreements more difficult. One of the involved actors states: *"due to the ground pollution, the project keeps stagnating"*. Costs to make re-use of the cultural heritage buildings possible are also high. For example, only conserving a (large) building costs about a million. This includes as much as repairing the roof so the building will be wind- and waterproof. Even more investments are needed to adjust the buildings to the current standards of working and living.

Secondly, not all possible new uses are considered appropriate and the ones that contribute to the unique character of the areas are often non-commercial. A manager of one of the projects states "*For some parts of the area it is really hard to find a suitable new use, that does justice to the cultural historical character and is, at the same time, financially feasible"*. Regulations for officially registered monuments limit the possibilities for adapting the buildings. Housing

is often excluded due to environmental regulations of noise, air quality, dust, smell and external safety in the specific areas. As housing is one of the most commercial new uses, these limitations make returns on investment uncertain. Furthermore, non-commercial uses contribute positively to the specific character of the industrial heritage buildings. For example, these buildings attract budding artists for a studio but they cannot afford high rents.

Thirdly, the tangible and intangible returns are uncertain as the added value of the transformation of cultural heritage can rarely be expressed in financial terms alone (Linssen, 2009). The interviewees were asked what their perception of success was of the urban redevelopment project. One project manager said: "*You can look at success in such a project in two different ways: as an accountant who will define success as selling the area for a good price. However, you can't run an area like this as an accountant. You need vision and inspiration. It has to become a beautiful urban neighbourhood, where you can feel the former atmosphere, and still see history".* Another project manager described success as: *"the project is a success when my children walk through the developed area and say that they are proud that their dad took care of saving the historical buildings."* All the interviewees stated that preserving gives additional quality to the area. "*Investments in cultural heritage will make the rest of the area attractive and will strengthen the image and identity of the project".* However, the end users determine what "atmosphere", "identity" or "history" is worth. They have to be willing to pay more for the additional quality by preserving the cultural heritage buildings. In most of the projects they do. One interviewee states: *"For example, the prices in the surrounding neighbourhoods are already rising. Before, the municipality did not invest in these areas as it wasn't profitable, but now there are even private development initiatives. The story sells".* However, what future users are willing to pay extra is difficult to determine beforehand. So, the value of cultural heritage is difficult to express in financial terms and 'believing' in the added value of the transformation is vital.

Summarizing, transforming cultural heritage in urban redevelopment project is complex as 1) initial investments needed are far higher than in greenfield development; 2) finding feasible new uses that contribute to the ambition to preserve the unique character is difficult and; 3) the tangible and intangible benefits are uncertain at the start of the process and are hard to express in financial terms. Current economic developments make financing urban redevelopment projects even more complex. Risk adverse behaviour of financial institutions and decreasing government funds especially endanger these projects. Subsidizing non-commercial elements is less an option. The situation is described by one of the interviewees "*the market situation makes development difficult. The budget may not be enough. We ask ourselves, do we need to slow down the project? But this is not desirable. Currently, the municipality is in hard negotiations. Developers knock on our door for subsidies. How can you develop now? […] How can investors have financial returns? If you cannot make benefits because you preserve the cultural heritage, no developer wants to invest."*

TOWARDS AN ANALYTICAL FRAMEWORK

As previously indicated, collaboration resulting in balancing costs and benefits between actors involved helps to preserve and transform cultural heritage in urban redevelopment projects. *"Success of the project depends on the possibilities to balance the costs and benefits of the total urban development project, including the investments needed to transform the cultural heritage".* Balancing of costs and benefits is indicated as a crucial instrument. "*Balancing of costs and benefits is the only option to preserve cultural heritage. It stimulates*

the right development and should be seen as a kind of loan beforehand". However, settlements regarding costs and benefits are not easily to attain. The projects are characterized by many uncertainties in costs, new-uses, and benefits. Hence, a straight forward answer to the question what strategies will realize effective transformation of cultural heritage cannot be given.

The complexity is mainly causes by the mutual dependency of the actors in the urban redevelopment projects. Knowledge, resources and authority are fragmented and dispersed, so planning decisions on what to do with the cultural heritage and how to make arrangements on costs and benefits involved require interaction among multiple actors. They have to make decisions about their abilities to act and their commitment to future actions that will satisfy their (financial) interests (Forester 2006). However, the actors in these projects cannot command other actors whose cooperation is vital, so negotiation to reach decisions regarding the content of the plan and (financial) settlements is needed (Koppenjan and Klijn, 2004). Thus, planning for these projects is essentially joint decision making, which is in turn inherently transactional (negotiated) (Shmueli et al, 2008). In literature four key elements of negotiation are distinguished (Lax and Sebenius, 1986) 1) mutual dependency among actors to realize their objectives; 2) some perceived conflict, as competing claims; 3) opportunistic or strategic behaviour of the actors, and 4) the possibility of agreement which is mutual beneficial. These four conditions are present in urban redevelopment projects in which re-use of cultural heritage is an important component.

In general, negotiation consists of both cooperating and competing elements, which makes it difficult to create mutual gains. At a certain point in the process, created value - for example by redeveloping the cultural heritage for new use - has to be divided and a claim on the increased value by one party implies there will be less for others. This tension between creating and claiming value is called the *negotiators dilemma* (Lax and Sebenius 1986). Value creators are the actors who are inventive and cooperative, in search for a win-win situation. This behaviour is contrary to value claiming behaviour in which actors try to convince the other actor of their own right. Leeuwis (2000) distinguishes two broad categories negotiation processes: distributive and integrative negotiation. In a distributive negotiation process the various stakeholders hold on to their own perceptions and positions, and basically use negotiations to divide the added value. The source of conflict remains intact, which leads to an unstable compromise. The result is a win-lose situation; the gains of one party represents the losses of another. For example, the developer’s goal is to get the highest possible return on his investments in the commercial real estate, while the municipality wants to capture (a part of) this return as their investments in the cultural heritage adds value to the developer’s real estate. If the municipality gives in, they have to fully bear the costs for preservation of the cultural heritage. If they do not give in and the developer is not willing to contribute, the realisation of the complete urban development might be endangered. In case of integrative negotiation, the stakeholders develop new (and often) wider problem definitions. Through interaction the actor learns about the nature of the problem, the possibilities for (joint) problem-solving and about other actors (Koppenjan and Klijn, 2004). They change perceptions on the basis of a creative collective learning process, resulting in the identification of so called win-win solutions. The result is similar as is intended with participatory processes (Leeuwis, 2000). For example, the municipality and the developer learn about the value of cultural heritage from both actors' perspective. Instead of negotiating on who has to contribute what, they search for possibilities to combine functions and for other actors to join the process. Communicative and strategic action is in many ways two sides of the same coin. Learning and negotiation are intertwined "effective social

learning is unlikely to happen if it is not embedded in a well-managed negotiation process. At the same time, effective negotiations are impossible without a properly facilitated social learning process" (Leeuwis, 2000).

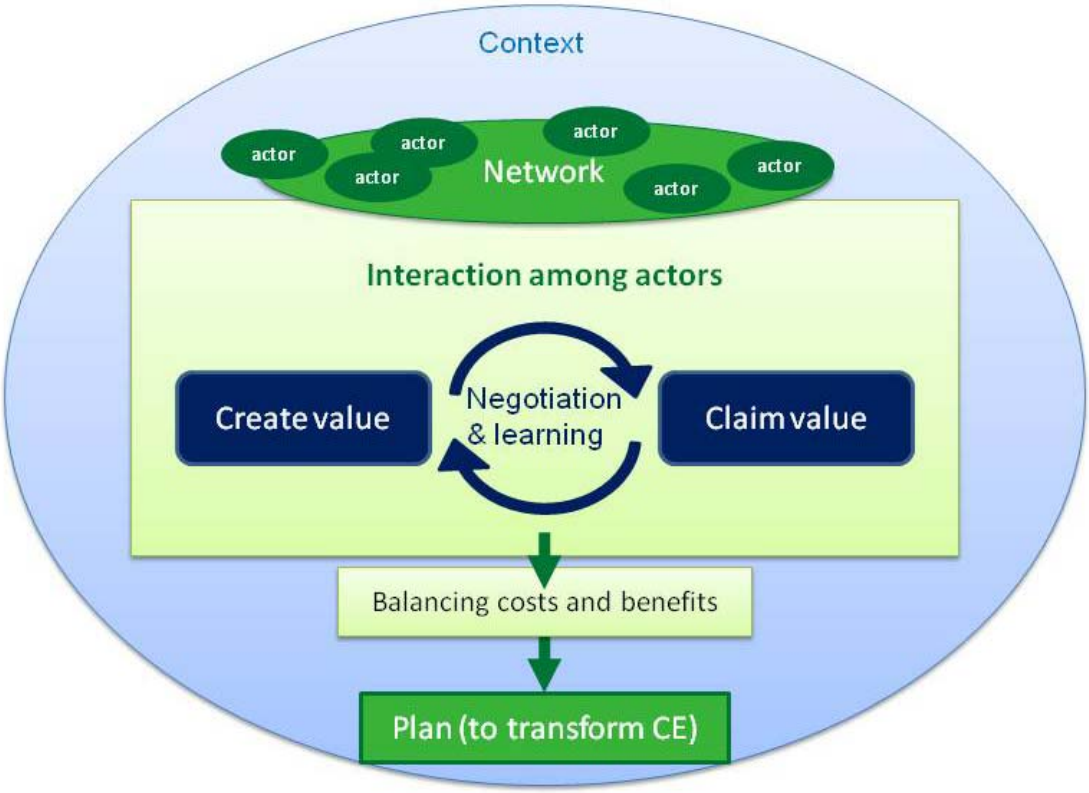


Figure 2: *Framework for analysis of the process to transform cultural heritage*

In conclusion, in order to effectively transform cultural heritage in urban redevelopment, a win-win situation is needed. In cultural heritage projects, a win-win situation can be considered as a mutual beneficially agreement on costs and benefits between actors involved, whereby the cultural heritage is preserved by transforming it for new use. During the planning process, actors will negotiate and learn. We argue that learning and negotiation, or creating and claiming value, go hand in hand, as stakeholders in these projects cooperate and compete with each other at the same time. In this 'game' of interaction actors try to deal with the uncertainties of the project. The context of the project, the network of mutual dependent actors, the actors´ characteristics and the interaction among the actors determine the plan-making process (De Kort, 2009). Together, these elements influence the possibilities to re-use cultural heritage in urban redevelopment project. They form the basic building blocks of a general framework to be used in a more in-depth analysis of strategies used to redevelop cultural heritage.

DISCUSSION

In this paper we presented the characteristics of five urban redevelopment projects with built cultural heritage and the difficulties stakeholders in these projects have to tackle in the plan-making process, in order to achieve effective transformation of the heritage for new use. Based on the empirical data and a study of literature on planning and negotiation we presented a general framework to be used for further analysis. The next phase of our research

will consist of a more in-depth study of the five cases in order to understand the negotiation processes and how these processes develop towards arrangements on costs and benefits. This requires that the building blocks of our framework are further made operational. For that some dilemma's have to be overcome.

Firstly, it is hard to measure performance in urban redevelopment projects in general. Often used performance criteria in planning projects are: efficiency, effectiveness and relevance (Walter and Scholz 2007). Efficiency refers to the relation between means and outcomes. Effectiveness is related to how well the proclaimed objectives of the project are attained. Relevance indicates the accuracy of a solution to the targeted problem. As urban restructuring projects have a long time frame and objectives will change during time, measuring these criteria will be difficult as the projects will not be finished in the next 10 years. Furthermore, proclaimed objectives are abstract and probably there will be no consensus on operational level. In a context of interdependencies, performance partially depends on the perception of actors (De Bruijn and Ten Heuvelhof 2008). Performance indicators that can be used, are: actor satisfaction; solved problems of the actors involved; learning, as the actors were confronted with new issues and information; lasting relations and; a fair process with equal chances and respect to core values (De Bruijn and Ten Heuvelhof, 2008; De Graaf 2005; De Kort 2009). In the projects, the sum of perceived performance of individual actors will not be – by definition - the performance of the total project. Therefore, to evaluate the performance of the transformation projects, we plan to use process (actor satisfaction, solved problem, learning) and project (expected efficiency and effectiveness) criteria.

Secondly, distinguishing creating or claiming behaviour in the process is difficult. We argue that negotiation and learning are intertwined and creating and claiming go hand in hand. However, as we want to gain insight in the relation between the used strategy and the performance, we need to measure these aspects somehow. From literature, we can define conditions which have to be met for creating or claiming value behaviour to occur and then study these conditions in the projects. Another possibility is to use a more grounded approach. In an open interview interviewees describe the main events in the process, their actions and the effects of their action. Afterwards, the data will be analysed and coded to link their stories to creating and claiming value. In this way we will be able to define creating and claiming value.

We hope that this paper contributes to a more profound discussion on the transformation of cultural heritage in urban redevelopment. We welcome feedback on this paper and suggestion to cope with the presented dilemmas for further research.

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A COMPREHENSIVE STUDY OF SOUTH AFRICAN CONSTRUCTION DATA SOURCES

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Abstract
This paper examines published construction data sources available to researchers, construction professionals, clients and government policy makers in South Africa. The paper explores whether the authenticity of these data sources are reliable and accurate because there are assumptions and processes behind the computation of the data sources which are unknown. The rationale for the examination of these documented construction data sources stems from the argument put forth by scholars that a significant number of these data sources have loopholes and black holes and therefore need to be verified. The paper intends to identify authentic South African construction data sources which can be used in construction data analysis and propose possible methods that should be used in preparing valid construction data sources for publication.

Keywords: Construction Data, Data Sources, Cost Indices, and Industry Performance

INTRODUCTION

According to Ofori (1990) construction is considered to be a sector comprising a number of industries. Sawhney, Walsh and Brown IV (2004), opined that the construction industry consists of a vast array of contractors, sub-contractors and suppliers, resulting in a very complex supply chain. According to Sawhney et al (2004), there are no formalized industry structures that represent all of its stakeholders and its primary output is a series of projects, each resulting in a unique constructed facility. The United Nations (1998) in Ruddock (2002) defines construction activity when used in the compilation of construction statistics as an economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature and other such engineering constructions as roads, bridges, dams and so forth. Data is regarded as a measurement scale consisting of information, facts and statistics such as cost information used for reference or analysis (Agresti, 2007 and Ofori, 1990). Construction data can therefore be said to mean the information, facts and statistics used in the industry in which fixed assets are erected, renovated, repaired or extended.

The aim of this paper is to explore whether the assumptions and processes behind the development of the published construction data sources available to researchers, construction professionals, clients and government policy makers in South Africa are authentic, reliable

and accurate because according to Patil (2010) and Mc Cabe (2002), there are assumptions and processes behind the computation construction data sources, which are unknown. Furthermore, Ruddock (2002) opined that the ability to provide full conformity with the International Standard Industry Classification (ISIC) is lacking to varying degrees in different countries.

Ofori (1990) noted that owing to the large number of geographically scattered sites from which data needs to be collected, the multiciplicity of enterprises involved and their often transient nature, the widespread practice of subcontracting and the risks of omission and double counting that that involves, and the difficulty of defining the boundaries of the industry, statistics on the construction industry are seldom accurate. This view is further corroborated by The World Bank (1984) publication cited in Sawhney et al (2004) which observes that the construction industry is typified by temporary, contract-driven relationships between participants of a given project, and this condition makes characterization and collection of national statistics for cross-country comparison very difficult to satisfactorily achieve. While, Lopes (1998) in Ruddock (2002) referred to the inadequacy and rudimentary nature of data on the construction industry in developing countries pointing out the lack of input-output data in such construction sectors. There is also the added problem of several agencies within a country collecting data on the construction industry in different formats and in relation to different criteria, even where the subjects are similar, leading to unnecessary processing problems (Ofori, 1990 and Ruddock, 2002).

In order to examine the assumptions and processes behind the development of the various data sources available to the construction industry in South Africa and to determine their authenticity, reliability and accuracy, this paper firstly presents the holistic methods used in the compilation of construction data – including definitions and descriptions of the data. Secondly, the paper identifies the published construction data sources and information available to users in South Africa. Thirdly, the paper reviews the assumptions and processes used in compiling the construction data in South Africa and the limitations of the data if any in order to establish the authenticity, reliability and accuracy of the available sources. Finally, the paper proposes possible methods that could be used in preparing valid construction data sources.

HOLISTIC METHODS USED IN THE COMPILATION OF CONSTRUCTION DATA

The construction data to be used in the paper will be mainly related to the resource costs, construction cost indices, all in rates of major items of work, labour cost, national statistics such as GDP, income per capita, construction industry performance indices and so forth. The focus on cost (quoting O'Brien and Al-Soufi (1993)) is due to the fact that it continues to be the dominant dimension in construction with its use of competitive tendering, commodity suppliers and sub-contractors.

According to Ofori (1990) there is a wide range of sources used to gather construction data including direct reporting by contractors, federal government regulatory agencies, and federal, state and local government agencies engaged in construction activity. He further stated that construction data can be obtained in surveys, on a sample basis with estimates made for enterprises not responding to the questionnaire and those not surveyed. In some cases, Ofori (ibid) noted that the data relates only to major conurbations and sometimes only to certain category of projects – location e.g. cities, government construction units, new construction,

value, and method of procurement – e.g. traditional, size of establishment by number of employees, licensed and registered construction establishments, tax inclusion or exclusion.

The accuracy of the compiled data has been a topic for consideration before now. Remer and Buchanan (2000) quoted in Sawhney, Walsh and Brown IV (2004) indicated that as much as 50% variation between estimated and actual construction cost has been found to exist depending on the level of effort expended as measured by the cost of the estimation preparation process. As a result, Sawhney et al (2004) observed that wealthier nations are likely to be willing and/or able to devote the effort required to obtain accurate estimates for a standard project and that less wealthy nations may not be willing or able to do so, and as a result, may develop less accurate estimates.

To improve the quality of international (and national) data provision generally, Lievesley (2001) in Ruddock (2002) in his suggestion noted the fact that, although the term 'quality', when applied to official statistics is difficult to define, the following components should apply: (1) validity, (2) reliability, (3) currency, (4) clarity and transparency with respect to known limitations and (5) comparability through adherence to internationally agreed standards.

Construction data according to Sawhney et al (2004) should have the following important characteristics:

- A relatively shortlist of items, in order to minimize the effort required to collect the data
- Incorporation of productivity and the labour/equipment tradeoff into the result
- Items on the list should be representative of construction work performed in each country, meaning that they should be things that actually occur routinely rather than items with artificial pricing due to scarcity of use or lack of demand, and
- Items on the list should be comparable between countries, meaning that they should be as equivalent in objective and perceived value as possible in every country.

Methods used in the compilation of construction data as presented by Sawhney, Walsh and Brown IV (2004) and Mc Cabe, O'Grady and Walker (2002) include: -

- Standard Project Methods which incorporates output indices
- Basket of Goods and Services Approach which incorporates the input indices, and
- Construction component/hybrid based approach

Standards Projects Method (SPM)

According to Sawhney et al (2004), the Standard Projects Method (SPM) was pioneered by Eurostat, and adopted by the United Nations as part of the International Comparison Program (ICP) around 1970. In this method, around 20 standard construction projects are identified for the three basic construction types, i.e. for residential buildings, non-residential buildings and civil engineering works. The projects are documented with a complete set of construction drawings, construction specifications, and bills of quantities for each of the projects. The Bill of Quantities (BoQ) lists basic work items from which the standard project is comprised, and is used in the pricing process (United Nations, 1992 in Sawhney et al, 2004). Pricing of the standard project is done with the help of government and professional quantity surveyors, architects, cost estimators, or civil engineers with some regional modifications. The SPM can be used in gathering output indices. Output indices measure the total cost of construction of a completed structure in each location (Mc Cabe et al, 2002).

The limitations of output indices and the SPM method is that it is a highly complex data collection process and it is extremely difficult to collect the information, usually requiring significant estimating resources (Sawhney et al 2004 and Mc Cabe et al, 2002). Furthermore according to Sawhney et al (2004), it requires specialized knowledge and knowledge of the wide variety of construction tolerances and acceptable quality that exists between nations. The advantage of this approach is that measurement of prices is at the output level and therefore includes productivity differences and the implications of the equipment/labour trade off in its calculation, and the fact that these indices more accurately represent the real costs of construction and reflect local conditions including labour skill, availability and productivity (Mc Cabe et al 2002).

Basket of Goods and Services (BOG) Approach

According to Sawhney et al (2004), the ICP utilizes a basket based on a comprehensive nationwide sample of goods and services on which money is spent in a country. Biru (1998) quoted in Sawhney et al (2004) notes that all expenditure components of GDP including purchases of capital goods and outlays are represented in the basket. The BGS approach is similar in content with the Input method reviewed by and Vermande and Van Mulligen (1999), who stated that the input method is based on the weighting of statistical input data (wages, materials and productivity) that is, a factor cost approach. While Mc Cabe et al (2002) viewed the input indices as representative of the construction process inputs such as common materials, equipment and trade labour hours.

The limitations of the BGS method were noted by Sawhney et al (2004) to include its inability to capture productivity very well and that even in cases where the basket includes labour items in most instances, the cost of a fixed number of hours of labour is reported, as it removes the labour/equipment trade-off from the results because no consideration is given to the degree to which some of the trades performed by labour are simplified by equipment use, and also representativity concerns. They opined that existing baskets in common use seem to concentrate on structural elements (concrete and steel principally), which may be appropriate. However, the advantages of input indices as noted by Mc Cabe et al (2002) include the fact that they are the simplest to produce and contain the least error and are useful if labour productivity can be assumed to be similar between the locations or if a general cost of construction comparison is desired.

Construction-Component Based Approach/Hybrid Index

According to Vermande and Van Mulligen (1999), the component method is applied in Germany, Austria, Luxembourg and Canada. They stated that the components, which constitute the basket for the statistical index, specify similar work operations as the building items of the Eurostat bills of quantities. Mc Cabe (2002) notes that the focus of the Hybrid index is on the smaller, more manageable building elements such as foundation walls, insulation or roof membranes to exploit the ease of input index development and the reliability of output indices.

Sawhney et al (2004) opined that it is important to develop a system that can be used to identify component contributions towards final construction output in the nation's GDP in order to establish weightings for the contents of a conceptual model to be called the basket-of-construction components (BOCC). According to them, the proposed model would require pricing of relatively few construction components, and the labour or equipment required to put them in place. As a result, material, labour and equipment costs could be inherently incorporated to whatever degree in a given nation.

PUBLISHED DATA SOURCES AND INFORMATION AVAILABLE IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

The South African construction data sources and information reviewed below were used only because they were readily available to the authors. Most of the data reviewed are easy to access except for Quantec SA where access may need to be negotiated. While every effort has been made to provide a comprehensive study of the available construction data sources in South Africa, it is inevitable that some sources will have been unintentionally left out.

Statistics South Africa (Stats SA)

Statistics South Africa (Stats SA) is the national statistics agency in South Africa and it is mandated by government to undertake surveys, collect and process data and produce official statistics that will provide the private and public sector with reliable and relevant information. According to Barnes et al (2007), Stats SA's mission is to provide relevant, timely, reliable and accurate body of statistics to inform users on the dynamics in the economy and society through the application of internationally acclaimed practices.

From 1998/99, Stats SA has been developing a set of social statistics. Social and population projects such as the annual October Household Survey and the Population Census have been run to provide Government with critical data for planning and monitoring socio-economic development. According to Stats SA (2010), Stats SA has also emphasized improving the work processes, methodologies and technologies for generating key economic statistics by for example ensuring the compliance of statistical series with the International Monetary Fund and the United Nation's Standards.

Stats SA produces a variety of vital construction data including, GDP on both sectors and inflation, Consumer Price Index (CPI), Producer Price Index is calculated using specific formulas to determine the price escalations for the construction industry. Stats SA also gives a holistic overview of Employment Statistics through its published results of the Labour Force Survey. The Labour Force Survey, which was introduced in year 2000 to track poverty and labour market dynamics, are based on representative probability samples drawn from the South African population. Consequently, all estimates are subject to sampling variability.

South African Reserve Bank (SARB)

Through the South African Reserve Bank's (SARB) Quarterly Bulletin; one can access the National Account's Gross Fixed Capital Formation (GFCF) and the infrastructure spend on private and public sector projects on the Residential, Non-Residential, Machinery, Equipment and Construction Works. The economic data collected by Stats SA and SARB are prepared at various levels of aggregation. This may be illustrated using the CPI which is available at the national level as macrodata.

Industry Insight

Industry Insight offers a wide range of construction business intelligence and customized services these include; Project Database, State of industry reports, Statistics, Forecasts, Newsletters, Provincial Reviews, Preferred Supplier Trade Surveys, Price Indices, Electronic library. In partnership with other willing stakeholders; Industry Insight hosts a series of Focus Forums, in these Focus Forums industry players meet and discuss issues that affect the industry and this also serves as a platform to network and explore other industry opportunities that may be available for the stakeholders.

The Bureau for Economic Research (BER) Building Cost Index

According to Cruywagen (2010), the original BER Index was developed in 1966 by Brook, a quantity surveyor who was at the time responsible for research and development in the quantity surveying division of the Department of Public Works in Pretoria. Segalla (1991) cited in Cruwagen (2010) stated that the original Brook index was based on a variation of the cost items of a single storey, 100m^2 quasi-house.

Brooke (1974) cited in Cruywagen (2010) explains that the basic logic to the background of the development of the BER index involves the assumption that the total building cost will move in correspondence with the cost of the specific items selected for the purpose. The accuracy of the index will accordingly, depend on the degree to which the items are representative of the most common, and therefore the most widely used, construction and finishing materials. To this end, he stated that the items have been selected in such a manner that the resulting index will be indicative of relative cost levels not only for various types of buildings but also for various regions in the Republic of South Africa and also South West Africa (now Namibia).

Twenty-two cost components including excavation of footings, mass concrete footings, reinforced concrete in slabs and reinforcement were selected and expressed as quantities. These components are then weighted based on the proportions to the role played by each in the total cost, in which consideration had been given to the incorporation of basic design criteria which vary from the simplest one of the fundamental ratio of light or window area to the more complicated criterion of a predetermined floor loading in respect of the ratio of formwork, steel and concrete floor slab component.

By using the quantities (or weights) assigned to the components, an index is calculated for each specific project by multiplying the applicable weights with a rate supplied on a quarterly basis by quantity surveying firms, who submit BER calculation sheets for completed projects. The total amount obtained for each project is then expressed as a percentage of the amount obtained in the base month (Cruywagen, 2010). According to him, these project indices are then used to calculate the overall building cost index.

Davis Langdon Africa Region Property and Construction Handbook

Davis Langdon Africa Region Property and Construction Handbook (2010) highlighted the fact that construction cost estimation is complex and comprehensive exercises based on detailed accurate information are required to achieve reliable levels of comfort, for various undisclosed reasons however, it was revealed that decisions are often based on inclusive rate estimates i.e. rate per m^2 of construction area or rate per unit in number. It was emphasized that the list of approximate building cost rates for various buildings types in South Africa, which are available in the publication are purely of an indicative nature and should be used with circumspection, as they are dependent on a number of assumptions which were not given. The rates given are said to include the cost of appropriate building services, e.g. air-conditioning, electrical, etc but exclude costs of site infrastructure development, parking, any future escalation, loss of interest, professional fees and VAT. The area of the building expressed in m^2 is said to be equivalent to the 'construction area'.

Building cost for the purpose of the handbook is deemed to mean the tender price (or negotiated price) submitted by the building contractor. The handbook explains that the words building cost depends on the application thereof in context. A building contractor, for

example, may refer to building cost as the cost of labour, material, plant, fuel and supervision while in contrast, a developer may refer to building cost as either the tender price from the contractor or to the ultimate cost of the project, which could include professional fees, plan approval fees, escalation, loss of interest etc.

The Handbook allowed for regional variations. It explains that construction costs normally vary between different provinces of South Africa and that for example, costs in the Western Cape and KwaZulu-Natal, specifically upper class residential, are generally significantly higher than Gauteng due to the demand for this accommodation.

Support Programme for Accelerated Infrastructure Development (SPAID) Infrastructure Expenditure Tracker

Lockwood (2010) explains that in an effort towards the attainment of the public sector infrastructure programme's objectives, the Business Trust – with the Presidency as a strategic partner – established the Support Programme for Accelerated Infrastructure Development (SPAID). SPAID's goal is stated as being to provide focused support to mobilize an increased private sector contribution to meeting the Accelerated Shared Growth for South Africa (ASGISA) infrastructure targets, while its developmental objective is to ensure that underserviced communities have access to infrastructure.

The tracker includes comprehensive data on the level and composition of infrastructure spending in South Africa. Unpublished data was obtained from the South African Reserve Bank that enabled the estimation of the effects of fixed capital spending on the real value of the fixed capital stock, and the quantification of the consumption of fixed capital. Standardized industry data, which was used to assess trends in employment in the construction sector, in terms of both number and skills level was obtained from Quantec (Lockwood, 2010). Multipliers – also obtained from Quantec – were used to estimate the impact of public infrastructure spending on the wider economy in respect of indicators such as value added, remuneration and employment.

Typical information found within the body of the SPAID Infrastructure Expenditure Tracker includes the actual and projected infrastructure spending by the public sector, detailed breakdown of spending on different project types within each province, major projects by types, estimated cost, implementing agent and project completion date, changes in employment in the construction sector among others.

cidb Construction Industry Indicators (CIIs)

Though, the paper will mainly focus on resource costs due to the fact that it continues to be the dominant dimension in construction, mention need to be made about significant construction data being compiled on an annual basis by the cidb.

Construction Industry Indicators (CIIs) were developed by the Department of Public-Works and the cidb with the assistance of the Council for Scientific and Industrial Research (CSIR) in South Africa (Marx, 2009) to play a useful role in developing a sustainable industry and to be adopted as a tool for improving performance in the South African construction industry.

The cidb CIIs has been documented since 2003 and the variables used by the cidb to measure performance of the South African Construction Industry include: client satisfaction with project milestone dates achieved, construction costs versus budget, contractors' performance,

consultants' performance and the quality of materials used in construction. Figure 1 shows the Client Satisfaction results of the Construction Industry Indicators (CIIs) survey for 2009.

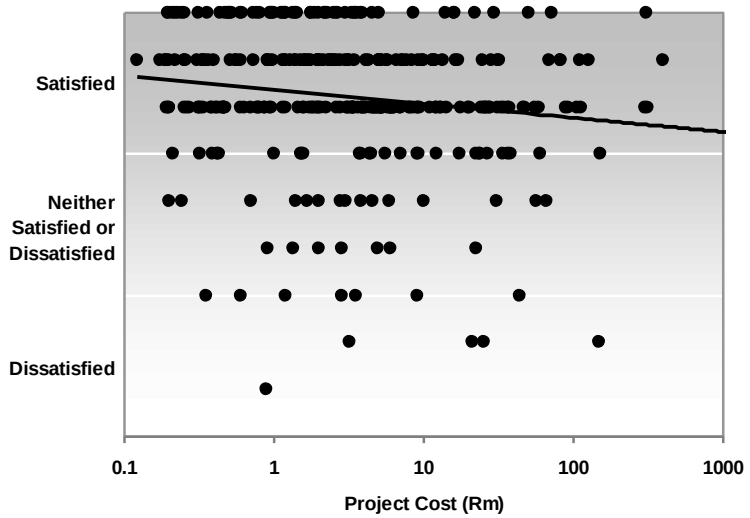


Figure 1: *Client Satisfaction (CIIs, 2009)*

cidb SME Business Conditions Survey

The SME Business Conditions Survey measures contracting business conditions amongst cidb registered contractors in Grades 3 to 7. The Survey measures, amongst others, the business confidence, and construction activity, tendering competition, employment and labour constraints amongst cidb registered contractors at a provincial level and in various contractor grades. The Bureau for Economic Research (BER) undertakes the SME Business Conditions Survey for the cidb.

The cidb has been undertaking Construction Industry Indicator surveys for the past three (3) years. The trends emerging from these surveys are used to initiate interventions in support of contractor development and the improvement of the overall contracting capacity in the country. Recently, the cidb initiated a quarterly registers monitor to study the registration trends across South Africa.

The cidb SME Business Conditions Survey aims to validate the findings of the internal surveys and provide deeper understanding of the business environment and needs of SMME contractors in order to develop responsive interventions. It must also measure access to work opportunities and the types and value of investments emerging contractors are making in their business across the different provinces. Where possible, the business confidence survey should correlate these to the overall economic climate in the provincial building and construction industry.

Fig 2. Below demonstrates the data that is captured on cidb SME Business Confidence.

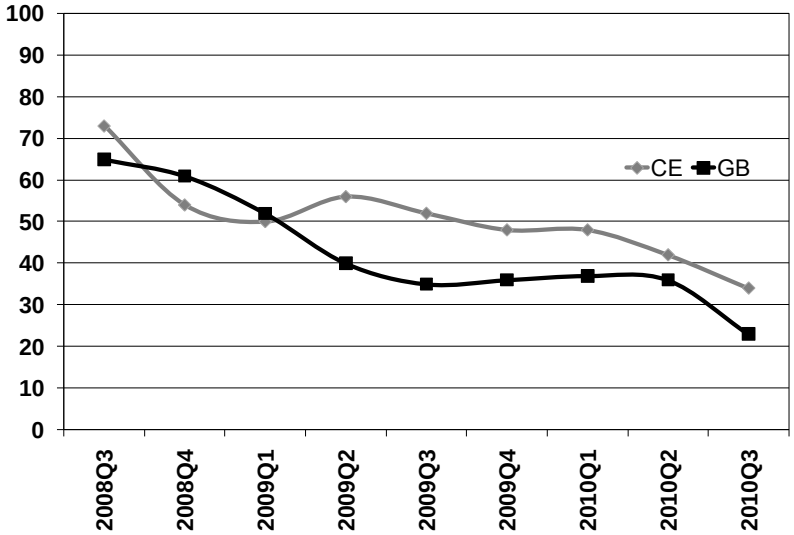


Figure 2: *cidb SME Business Conditions Survey (2010)*

cidb Quarterly Monitor

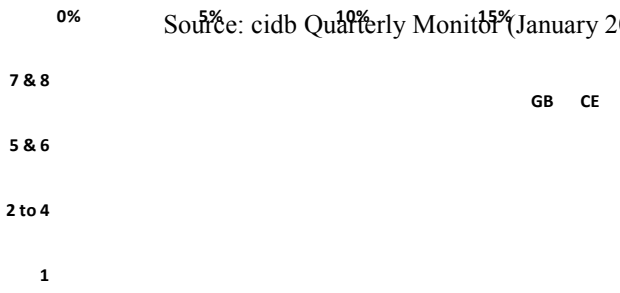
The cidb Quarterly Monitor provides an overview of the state of contractor development in South Africa as input to developing targeted development intervention strategies in support of the National Contractor Development Programme (NCDP). The Quarterly Monitor focuses on public sector supply and demand at a provincial level, and deals only with the General Building (GB) and Civil Engineering (CE) cidb Class of Works.

Included in the cidb Quartely Monitor is the ratio at which the contractors are Upgrading on the cidb Register of Contractors as shown in Table 1 and Figure 2.

Table 1. Contractors Upgrade on cidb Register of Contractors

Upgrades; 201001 to 201004							
From/To	2 to 4	5 & 6	7 & 8	9	Total	Registrations	%
GB							
7 & 8	0	0	11	0	11	280	4%
5 & 6	0	51	51	0	102	1 117	9%
2 to 4	228	193	6	1	428	3 511	12%
1	687	69	4	0	760	59 162	1%
Total	915	313	72	1	1 301	64 070	2%
CE							
7 & 8	0	0	16	10	26	300	9%
5 & 6	0	69	44	0	113	1 248	9%
2 to 4	234	205	9	0	448	2 866	16%
1	484	73	0	0	557	22 225	3%
Total	718	347	69	10	1 144	26 639	4%

Source: cidb Quarterly Monitor (January 2011)



Total	915	313	72	1	1 301	64 070	2%
			CE				
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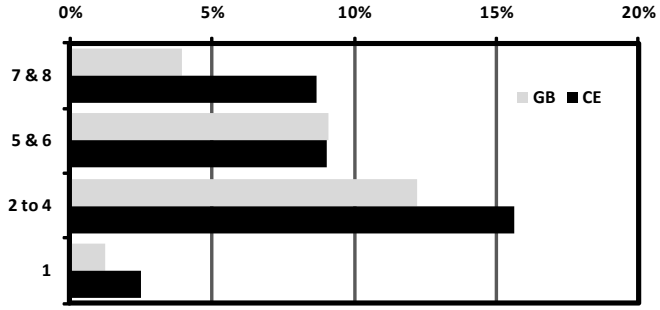


Figure 3: *Contractors Upgrade on cidb Register of Contractors*
Source: cidb Quarterly Monitor (January 2011)

Quantec SA

Quantec SA discusses the availability of the South African construction industry indicator time-series database that provides disaggregated and consistent long-term view of South Africa's economic structure by industry. The data is compiled by combining a consistent input-output framework spanning three decades with a comprehensive set of industry and national account indicators. The emphasis of the database is on the input and output indices.

SUMMARY OF DATA SOURCES

Table 2 summarizes the characteristics of the available construction data sources in South Africa. It gives an indication if the data types are input, component/hybrid, output or industry performance indices. It also indicates the level of aggregation of the data sources, and if the data provided can be compared along location indices and regions in South Africa. Other variables tabulated are the source of information whether from private or public agencies and the possibility of expressing the data compiled as a time series with a view to facilitating comparisons.

Data Source	Data Type						Location Indices	Availability of Time Series
	Labour (Input)	Materials (Input)	Equipment (Input)	Components (Hybrid)	Projects (Output)	Industry Performance Index		
BER Cost Index (Govt)				√				√
StatsSA (Govt)	√	√					√	√
SARB (Govt)					√		√	√
Davis Langdon					√		√	√
SPAID (Govt)	√				√		√	√
cidb CIIs (Govt)					√	√		√
cidb Quarterly Monitor (Govt)					√	√		√
cidb SME Business Confidence Survey (Govt)					√	√		√
Quantec SA	√	√	√		√		√	√
Industry Insight	√	√	√	√	√		√	√

Table 2 shows that only three private data sources - Davis Langdon Africa Property and Construction Handbook, Industry Insight construction management services and Quantec SA

are available to the construction industry in South Africa. Davis Langdon handbook, Stats SA, SARB, SPAID, Quantec SA and Industry Insight provide sources of construction data with location indices, though that of Davis Langdon handbook is not comprehensive in nature. It is important to consider location because South Africa covers a very wide expanse of land and that building costs are likely to differ across the republic due to social factors such as population, demand, income levels among others.

LIMITATIONS, AUTHENTICITY, RELIABILITY AND ACCURACY OF THE PUBLISHED DATA

Certain limitations were revealed in the compilation of the readily available construction data sources. For example, although the BER uses the component based hybrid method advocated by Sawhney et al (2004) in the compilation of data, researchers including Martin (2006) quoted in Cruywagen (2010) has expressed concern about the age of the index and that best practice is not followed any more in compiling the index. An indication that the BER is also worried about the correctness of the index is the fact that it commissioned an independent organization in 2005 to investigate whether the index measures changes in the cost of construction in South Africa correctly (Marx, 2005 cited in Cruywagen, 2010). Other major areas of concern regarding the BER index include the current item descriptions and the fact that the items are not in line with the latest version of the Standard System for Measuring Building Work – 6th edition as published by the Association of South African Quantity Surveyors, some of the materials referred to in the descriptions such as Asbestos roof covering and ceiling are outdated and the relative low number of projects sampled (Cruywagen, 2010).

The degree of accuracy of the rates provided in the Davis Langdon Handbook must be considered to be in direct proportion with the amount of research and study undertaken to establish the rate for the building (Sawhney et al, 2004). Furthermore, the publishers of the Davis Langdon Data Source emphasized the fact that the rates presented are purely of an indicative nature and should therefore be used with circumspection, as they are dependent upon a number of assumptions. This statement in itself has cast a doubt on the accuracy, authenticity and reliability of the Davis Langdon Data Source.

Stats SA and SARB make use of reliable methods in the compilation of the construction data sources published. Stats SA specifically makes use of representative probability samples drawn from the whole South African Population and ensures compliance of the statistical series with the IMF and UN Standards. The data presented is representative of all participants in the economy and for all levels of data aggregation

The construction data published by Industry Insight, Quantec SA and SPAID, rely heavily on the primary data obtained from Stats SA and SARB. The only inputs in these documents are the additional reports and insights provided based on further analysis and interpretation of the data obtained. The extent of reliability of their published data will therefore depend to a large extent on the authenticity of the data obtained from primary sources.

Methods used to obtain the data compiled in the cidb publication tend to be reliable and accurate, and based on information from a representative sample of contractors on the cidb Contractor Register and classes of works. The survey carried out by the cidb relates to

contractors who are mainly involved with government projects and it might not entirely represent unregistered contractors who are only involved in private projects.

Limitations identified on a global scale by Vermande and Van Mulligen (1999) is the difficulty with pricing of building specifications. According to them, building cost experts sometimes are not familiar with particular items, work operations or materials specified in the bills of quantities. Prices given can therefore be completely wrong. The case of the Eurostat surveys is considered to be more serious by Vermande and Van Mulligen (1999), due to the hybrid composition of a 'basket of building types' which has to be representative of all EU-countries, and due to the fact that Eurostat statisticians perhaps have too little construction experience.

CONCLUSION

Ruddock (2002) opined that if the national system cannot provide efficient access to micro-data bases, both business and governments will come to depend increasingly on private proprietary databases, and the advantages of an overall integrated system will be lost. The scenario in South Africa is such that a significant number of the available construction data sources are provided by the government and even the private data source obtains a significant part of its information from the government data sources thereby attempting to integrate the public and private sources of construction data suggested by Ruddock.

Seemingly therefore, there appears to be no visible loopholes and black holes in the computation of the investigated data sources in South Africa and all the data sources can be said to be authentic having made use of standard practices, save only for that of Davis Langdon handbook, wherein the fact was emphasized that the rates presented are purely of an indicative nature and should therefore be used with circumspection and the BER index of which scholars have expressed concern about the practice used in its compilation.

As a guide to construction data compilation in South Africa, it is recommended that samples should be used that will reflect the diversity and size of the country using accepted standards such as input, composite/hybrid and output methods.

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LOCALISING THE SUPPLY CHAIN

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Abstract
The UK committed in 2008 to reduce its greenhouse gas emission by 80% by 2050. The construction industry is a key contributor to the greenhouse emissions and future legislative adjustments for the built environment are well underway. The industry will face many challenges and it is expected that its profile will be very different by 2050. The scenario that there will be pressure for the supply of labour, materials and components to be much more localised due to increased energy costs is very likely. In turn, supply chains, which currently are becoming increasingly long as the demands of projects become increasingly complex, will inevitably have to face the localisation challenge.
The long supply chains provide the increasingly high levels of technical input relating to design, manufacture, installation and servicing in the context of an industry anxious to maintain flexibility in the face of uncertain levels of workload and investment. These tall contractual hierarchies contain a massive amount of expertise but the contractual hierarchy constrains the effective management of knowledge and innovation through excessively long network paths, containing multiple, perversely incentivised, network bridges and gate keepers. Contractual relationships, knowledge management and information exchange networks define the localised supply chains and important work needs to be done to examine the potential for these networks to be established and be maintained. Social network analysis can be employed to map existing supply chains and to provide predictive models for local supply chains in 2050.
The paper discusses how to best examine what the capabilities of the local supply chains today are and what their capabilities would be if they were specifically enhanced to meet 2050 challenges. These capabilities inform supply chain management targets which mainly focus on continuous improvements of the supply chain increasing value and stimulating knowledge sharing and innovation. Sustainability targets are yet to be fully incorporated in the value equation, which is what the 2050 challenge requires; therefore particular attention is paid to it. It is suggested that exploring the location of intellectual capital in construction supply chains, demonstrating how the use of BIMs and vertical integration of the supply chain might be exploited to provide interfaces between local supply chain actors and end-users, examining the logistics and embedded energy, comparing the today's logistical demands with a 2050 localised supply chain scenario, is a starting point in developing the concept of the localised supply chain as a successful approach to the sustainability problem.

Keywords: Sustainability, Localisation, Supply Chain, Knowledge Management, Information Exchange Networks

INTRODUCTION

The UK‟s commitment to reduce greenhouse emissions by 80% from 1990 levels by 2050 has been the driving force for legislative changes; it has also raised issues associated with sustainable development and its meaning. Sustainable development has three dimensions; economic, environmental and social. Changes to accommodate the demanding environmental targets by 2050 have to deal with the forces opposed to the economic and social dimensions. It is generally perceived that the relationship between the economic and environmental dimensions require the negotiation of trade-offs, which is not always true because many of their objectives can be found to be perfectly aligned creating a win-win relationship (Quariguasi Frota Neto et al., 2010).

Increased public awareness and governmental regulations are imposed on various industries and as result many organisations and brand companies like Xerox, IBM, and Sony have initiated significant reforms in the entire supply chain systems (Lu et al., 2007). Supply chains not only get extended to include the end-of-life phase of products but also Supply Chain Management (SCM) principles are facilitated to improve the environmental performance of the manufacturing processes with suppliers and of products with customers (Lu et al., 2007). This is leading the most recent concept of Sustainable Supply Chain Management (SSCM), which advocates the integration of sustainability within SCM for successfully achieving the implementation of sustainability targets at business strategic level (Adetunji et al., 2008). The construction industry, which encompasses the design, construction and operation of the built environment, plays an important role on both the growth of the economy and the rate at which resources are being used. It is responsible for almost half the UK‟s carbon emissions (HM Government, 2008) and a similar proportion of its energy consumption (Miller, 2001). Legislative adjustments for the built environment are well underway and the industry is expected to face many challenges. Its profile will be very different by 2050. However, SCM‟s appropriateness, scope and ways of implementation in construction is still debated (Pryke , 2009) and only a few major clients and contractors have successfully implemented it in their business strategy for procuring projects (Adetunji et al., 2008; Pryke, 2009). The construction industry is lagging behind in its focus on SSCM because the debate is still on going on about sustainability and SCM as separate concepts and integrating them considerably increases the complexity of any discourse (Adetunji et al., 2008).

Supply Chain Localisation (SCL) could be considered as a bottom-up approach as its starting point is the study of transportation concerns and logistical implications for the greening of supply chains with the ambition to move towards the issue of SCM and SSCM. In other words, starting at an operational level to inform strategy. For that reason, the focus of the research might appear to be limited to solely the environmental implications and some associated economic factors. Construction supply chains might however be regarded as social networks, which affect and are affected by their surrounding environment.

This paper aims to introduce an alternative approach to the problem of making construction supply chains sustainable by advocating the importance of localisation. Presenting the paper in MISBE is considered the first step into refining the research problem posed and the appropriateness of the proposed method for future empirical data collection and analysis. Therefore, no empirical data or results are currently available.

WHY LOCALISATION? BACKGROUND

The consumption of natural recourses is a problem of two dimensions. One is the cost of the resource and the other its efficiency and therefore the price is a primary determinant of behaviour (Barrett et al., 2008). As the price of energy is expected to rise in the future it is highly possible that the supply of labour, materials and components will be significantly affected by it. For construction materials and components, particular attention must be given to the notion of embodied energy - the energy impacts of material and component production. The energy embodied in a material due to its transportation in most cases is small when compared to its total embodied energy and its quantification is typically oversimplified (Miller, 2001). This point is returned to later. It is, however, the transportation of labour that causes greater concerns. Efforts to reduce passenger transport by road have been made through traffic management approaches or land use changes requiring planning policy support (Barrett et al., 2008). Raising urban densities, which would result in shorter journey length and possibly replacing the use of cars with the use of public transport or even the use of non-mechanised transport such as walking and cycling (Barrett et al., 2008), is considered to be a move towards localisation or enhancing the supply of labour at local level.
Interestingly although many efforts are made to enhance the energy performance of operations and products, the demand for energy continues to rise (Barrett et al., 2008) and with it energy emissions. Through SCL, there is a need to consider increasing energy use performance but more so minimising the supply chain‟s dependence on energy. This could be achieved by identifying energy consuming processes and activities that could be omitted or replaced with others that require less energy.

SUSTAINABLE SUPPLY CHAINS AND THEIR MANAGEMENT

Focusing on the supply chain as a vehicle for accumulating value and improving efficiency is becoming increasingly important. Equally, the challenge to incorporate sustainability into business strategy has led many organisations to look at the activities of all supply chain actors in increasing detail (Lu et al., 2007). Therefore, consideration is given to the integration of sustainability and supply chains (Linton et al., 2007; Adetunji et al., 2008) in order to create sustainable supply chains. Sustainable development requires the triple bottom line of economic, environmental and social dimension to be satisfied (Linton et al., 2007; Quariguasi Frota Neto et al., 2010; Adetunji et al., 2008) and when integrating sustainability in supply chains their complexity increases significantly (Adetunji et al., 2008; Quariguasi Frota Neto et al., 2010).
Sustainable supply chains are extended supply chains, which include and integrate issues beyond the ones traditionally considered. These are product design, manufacturing and during product use by-products, product life extension, remanufacturing, products end-of-life and recovery processes at end of life (Linton et al., 2007). Their management moves from being reactive in the sense of monitoring general environmental management programmes to a more proactive direction through the implementation of energy/resource efficiency or reduction, re-use, rework, refurbish, reclaim, recycle, remanufacture and reverse logistics (Quariguasi Frota Neto et al., 2010). The end-of-life phase of the product life cycle has attracted particular attention and interest because this approach not only minimises waste but also captures any remaining value (Linton et al., 2007). This indicates a trend for sustainable supply chains to be „closing the loop" with the introduction of reverse logistics (Figure 1).

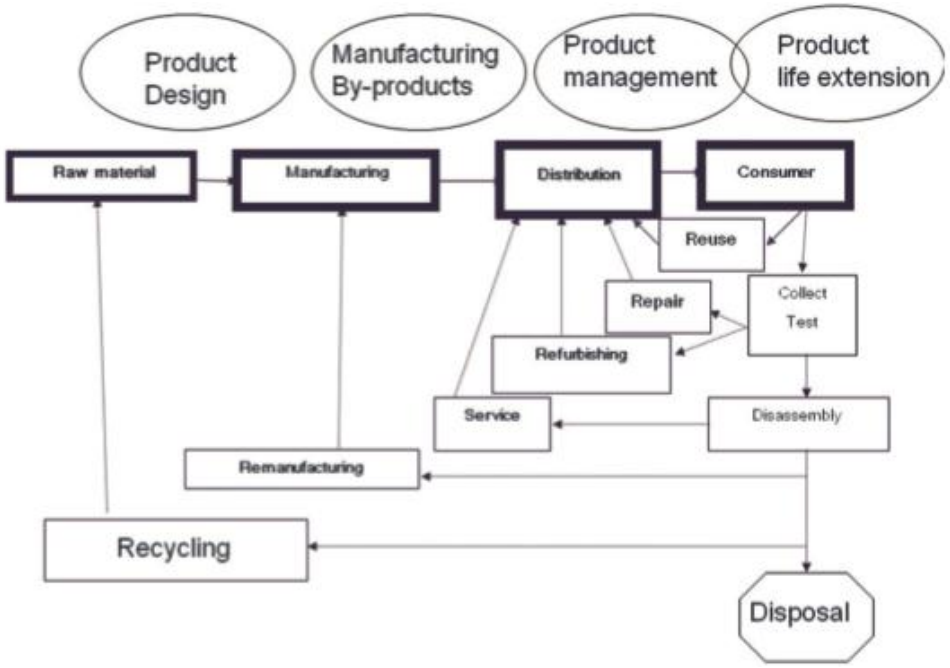


Figure 1: General framework of a closed-loop (sustainable) supply chain.
Source: Quariguasi Forta Neto et al., (2009), pg. 4465

Including the end-of-life phase, recycle and recover larger quantities of material are assumed to be proven measures to reduce the supply chain‟s environmental impact but this does not necessarily make it sustainable (Quariguasi Frota Neto et al., 2010). This is because energy consumption levels are not the same at the various phases of a product‟s life cycle and significant energy emissions do not always occur during the manufacturing process. Quariguasi Frota Neto et al. (2010) debated the sustainability aspect of closed-loop supply chains through the study of different electronic products‟ life cycles. Figure 2 illustrates how different the energy consumption profiles of products in an industry can be.

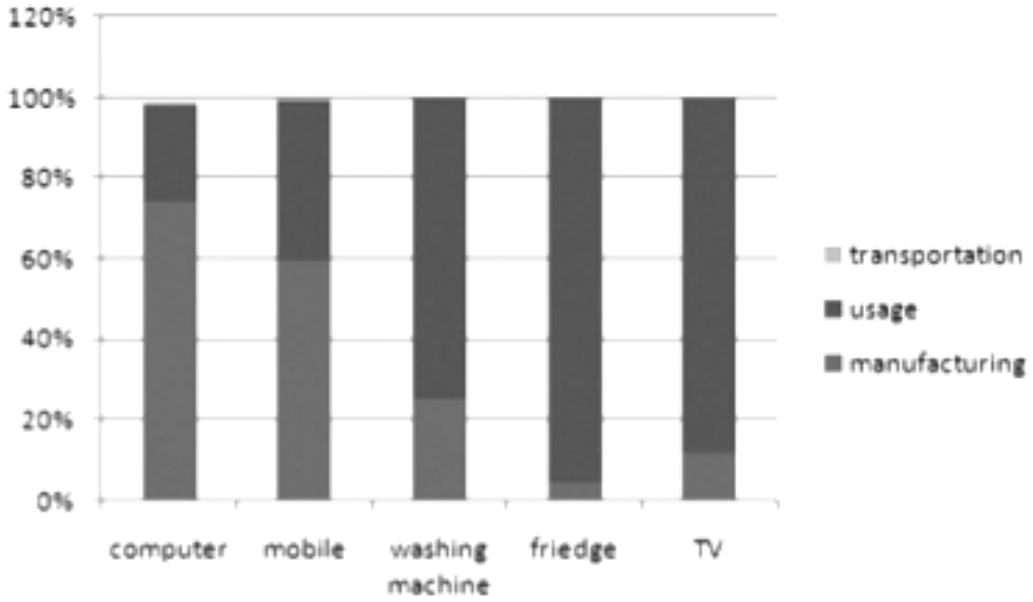


Figure 2: Energy consumption profile for PCs, mobiles, washing machines, fridges and TVs.
Source: Quariguasi Forta Neto et al., (2009), pg. 4470

The different consumption profiles prove that the scope of closing the loop of all supply chains might not be the most effective way of creating a sustainable supply chain. For the products that have high energy consumption levels during manufacture, the scope of closing the loop is very high. However, an alternative would be to extend the product‟s life cycle (Quariguasi Frota Neto et al., 2010), which is a product design consideration. For products with low manufacturing energy consumption, little improvement can be obtained via the adoption of end-of-life decisions (Quariguasi Frota Neto et al., 2010), and the maintenance service supply chains could be the focus for improvement to support the products efficient use of energy during its operation.

Energy consumption due to transportation is treated as negligible when compared to the total energy used for the production and operation of products and buildings. However, it is recognised that it is a significant source of cost in the supply chain and that, in extreme cases it can consume up to 8% of the energy needed over the entire life-cycle of a product (Quariguasi Frota Neto et al., 2010). Transportation is required for both the forward and reverse directions of the supply chain, and although it might be negligible in the forward direction, its energy consumption levels at the reverse direction become critical (Miller, 2001).

Buildings are responsible for almost half the country‟s emissions, about one third of landfill waste and use one quarter of all raw materials (HM Government, 2008). Efficiency in design, managing construction waste through increasing reuse, recycling or incineration, and reducing landfill waste are the main foci of the efforts aimed at making construction supply chains sustainable. The consideration of the energy consumption due to transport is almost non-existent as in common practice the energy embodied in the winning and manufacturing process is considered, which excludes the final delivery to the construction site (Miller, 2001). However, relative proportions of transport energy can vary greatly for different projects, which require different material and supply chains (Miller, 2001). The energy consumed in the delivery of materials can attribute 1.5% of the total embodied energy of materials for a new build project and up to 20% of the total embodied energy of recycled materials (Miller, 2001).

WHAT IS A LOCAL SUPPLY CHAIN?

Localisation in the context of this study is perceived in two dimensions, which should both be considered in the efforts of localising the supply chain. The first is the obvious dimension of geographical/ spatial location, which aims to shorten travel distances and stipulate local sustainable growth. However, this dimension is vulnerable to the energy efficiency of the transport modes available to the geographic area. Transport modes vary in their cost and impact with rail being 3.4 times more efficient than truck, barge 2.5 times more efficient than rail and 8.7 times more efficient than truck (Kendall et al., 2010). The second dimension is when supply chains are viewed as networks of production processes and localisation in this sense refers to the partial supply chains that are part or make-up the whole (global) supply chain (Albino et al, 2002). This dimension is highly relevant to construction because construction projects in addition to the construction (forward) and demolition (reverse) supply chains also require a Facilities Management (FM) supply chain. Also, construction supply chains require technical input of knowledge and expertise. Knowledge and information exchange networks can therefore be considered as partial supply chains. Localisation in that respect, therefore, allows for the efforts to minimise energy consumption at a local/ partial level of the supply chain. The importance lies into establishing localised

boundaries, which would effectively be different for professional services, materials, plant and labour.

THE SCOPE OF LOCALISING CONSTRUCTION SUPPLY CHAINS

As in the case of electrical products (Figure 2), different building types have different emissions profiles during their life cycle. Figure 3 present the percentages of embodied carbon and operational carbon for offices, warehouses, supermarkets and houses.

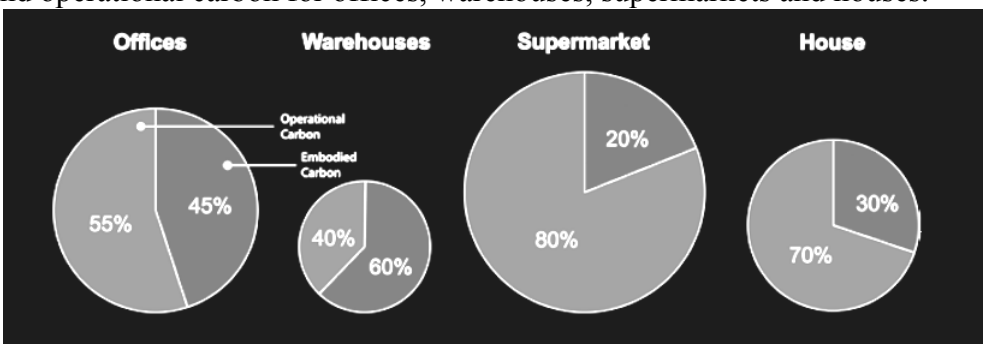


Figure 3: Typical different whole life Carbon splits for different types of buildings
Source: Sturgis & Roberts, (2010), pg 12

This can be treated as a guide on the construction phase‟s impact in comparison to the overall life cycle. It appears that SCL, in both geographical and at the construction/demolition partial supply chain dimensions, has a great scope for industrial buildings, where the embodied carbon percentage is much higher than the other building types. Having material production or recycling units in an industrial area does not raise particular planning implications, which could massively benefit the energy performance of the construction of new warehouses.
There is also scope for FM supply chains to become localised in areas where the demand for their services is high. FM is essential in maintaining the designed levels of energy efficiency of buildings. Therefore, for the building types where energy efficiency during operation is critical and more challenging to be achieved (e.g. offices), FM services, which in turn should minimise energy consumption, are expected to be in demand.

Key Themes	**Principal issues**
Economic sustainability 1.1 Improved project delivery	– Improved productivity
Environmental sustainability 2.3 Transport planning 3.1 Improved energy efficiency 3.2 Efficient use of resources	– Green transport plan of sites and business activities – Use of local suppliers and materials with low embodied energy – Use of recycled/ sustainability sources products
Social sustainability 4.2 Working with local communities & road users	– Contributing to local economy through local employment and procurement – Delivering services that encourage local environment – Building long-term relationships with local suppliers

Table 1: Key sustainability construction themes
Source: Adetunji et al., (2008), pg 166

However, the scope of localising the construction supply chain extends when considering the key sustainable construction themes. Table 1 lists the themes and the principal issues that relate directly to the issues discussed in this paper.

PROPOSED METHOD

Exploring the potential of SCL is extremely challenging due to its scope vagueness and as well as its interdisciplinary nature. This interdisciplinary nature is not only evident at the policy and industry level but also at a theoretical/academic level. The policy level initially requires for the issue to be considered as a critical adjustment in order to minimise energy demand but still maintain growth. However, an adjustment that requires moving away form the principals of globalisation to localisation raises implications of economic nature in addition to planning policy and social implications. The industry level requires cooperation and co-ordinated action by committed clients, design professionals and construction experts within a supporting policy framework. The industry and policy levels paint the picture for the vast number of theoretical/ academic disciplines, which are required to develop in an environment of cooperation. For the construction industry field of research some of those disciplines are planning, design (per design discipline), construction management and supply chain management including waste management, project management, economics of construction, facilities management etc.

Social Network Analysis (SNA) is proposed as a method to investigate the problem of localising the supply chain. Construction projects/ programmes/ enterprises can be seen as Social Networks (SNs). A particular characteristic of SNs is that they not only encompass information exchange networks but also value and resource flow networks. This allows non-social aspect of construction activity (Pryke, 2008) and organisations to be explored in conjunction with social aspects. Although, the use of SNA in the study of construction supply chains is not unknown, its application in the sense of concurrently investigating social and non-social aspects, which is proposed as bridging the economic, environmental and social dimensions of sustainable developments, is innovative.

Resource/value flows and logistics, knowledge management, contractual relationships, performance incentives and information exchange networks define the supply chains that are required to deliver construction services. These networks have a geographical dimension, which is considered in addition to the relationships between the supply chain actors listed above The existing energy demand profile of sustainable developments can be investigated by mapping current supply chains through SNA, starting at project level and expanding at programme or portfolio levels. The size and capacity, technical expertise, the geographical location of the supply chain as well as the location of the intellectual capital in it should be investigated in order to make a viable proposal about SCL. This would involve proposals on which local supply chains need to be enhanced, how best to enhance them and how the use of BIMs and vertical integration of the supply chain might be exploited to provide interfaces between local supply actors and end-users.

In summary, investigating the issue of localising the supply chain involves:

- Defining SCL.
- Investigating SCL"s input in dropping energy demand (define the scope for its adoption as a model).
- Investigating how to implement SCL through the industry"s cooperation and supporting policy.
- Investigating the viability of existing local supply chain infrastructure and its relevance and evolution over the coming decades.

PLANNING POLICY AND TECHNOLOGY DEVELOPMENT

Although SCL due to its strong dependence on the study of logistics and transport, appears to be an operational issue for the management of sustainable supply chains, instead of a strategic one (Srivastava, 2007), it actually finds its place in the heart of "the problematic bifurcation of sustainable construction into two exclusive agendas: the construction technology agenda and the urban sustainability agenda" (Moore & Rydin, 2008, pg 233). Moore‟s & Rydin‟s (2008) paper raises the issue of lack of integration between the two agendas, how it leads one agenda to be odds with the other and the detrimental effects on delivering mechanisms for sustainable construction that satisfy the technological imperative as well as the goal of sustainable urban development. Rydin (2010) raises the issue that „the planning system is facing new challenges in which the nature of its engagement with technology is a driving force" (Rydin, 2010, pg 256). This is based on the observation that the sustainability agenda has created a shift in the society that puts technology at the centre and planning debates are evolving around the need to focus on technological issues.
SCL has undoubtedly planning implications and requires supporting policy for its implementation. Its scope, however, appears to depend on the technological advancements available. Investigating any potential benefit that SCL might bring is expected to also inform the problem between the technology and urban development agendas.

CONCLUSION

The main objective of this paper is to highlight that the issue of localisation appears to have been neglected in the discussion of sustainable supply chains. Starting from questioning the impact of transport in the total energy consumption of supply chains, and by attempting to impose those concerns on the management of sustainable supply chains the notion of localisation presents two dimensions; geographical and procedural. It is advocated here that both dimensions should be considered for successfully SCL and its scope in construction is briefly presented.
Localising the supply chain is being introduced as potentially an effective approach to achieving a sustainable reduction to the energy demand levels required by construction projects. Emissions from transporting construction materials and labour appear to be overlooked in the study of sustainable construction despite the fact that they are arguably more important than many of the factors currently regarded as central. They could be a reflection of the construction sector‟s reliance on energy, which in turn leads to increasing costs and contributes to greenhouse emissions. Questions centred on transport and logistics management, which are considered as processes that are heavily energy demanding, provide a starting point for a discussion on the definition of SCL and its scope for development and implementation.

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THE MANAGEMENT OF REQUIREMENTS: WHAT CAUSES UNCERTAINTY IN INTEGRATED DESIGN APPROACHES?

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Abstract

Although a substantial amount of literature advocates the integrated collaborative design processes for construction projects, very little explicit knowledge exists about the impact of the integrated processes on project uncertainty. In contrast with construction site processes, which can in most cases be organized as a sequence of tasks mutually interlinked by technological interconnections, design is a highly interdependent and iterative process that needs different management approaches. To manage the complex interdependencies of design, managers need to make sense of how far-reaching the impact of addressing a particular requirement will be on project outcomes.

By using the theoretical dichotomy of wicked and tame problems, this paper conducts a study on a design and engineering mega-project to induce the shortcomings of traditional project management applied to complex design problems. This study develops a cognitive map of how a requirement propagates through the entire scope of an ill-structured design problem and contends that the traditional design management techniques do not capture the ill-structure of the design sufficiently. The paper finally develops a list of theoretical propositions and an accompanying set of practical recommendations that are based on the notion that design should be managed on the basis of distinguishing between wicked and tame parts of the problem. The study contributes to design management literature with an early normative framework for managing complex construction design.

Keywords: construction design, requirements management, systems thinking, uncertainty, sensemaking.

INTRODUCTION

During the last two decades, the Architecture, Engineering, and Construction (AEC) sector has witnessed the emergence of a number of management concepts with the sole aim of reducing the fragmentation for which the sector has traditionally been considered notorious. More specifically, the fragmentation within the industry comes not only at the traditional boundaries of architecture, engineering, and construction; it is also a matter of internal fragmentation within each of the disciplines (see, for instance, Latham 1994; Egan 1998). *Integrated project delivery* is a common methodological umbrella to cover different approaches if reducing this fragmentation to make the industry more efficient (AIA 2007). One of the most popular approaches of integrating project delivery is to use the design/build method where the contractor assumes responsibility for the entire scope of work starting with client's project requirements (e.g., Anumba and Evbuomwan 1997). The focus of this type of integration is, however, limited to constructability of the design and does not encompass integration within each of the included disciplines extensively enough. Furthermore, design/build contractors tend to be organizations specializing in construction because the total costs of construction significantly exceed those of design activities (see, for example, Eldin 1991). As a consequence, what is considered integrated at the design/build interface, as a rule, can be oftentimes considered relatively disintegrated within the boundaries of design and engineering.

The most common approach to designing complex systems is by using systems engineering reasoning, where the total system is subdivided into hierarchies of subsystems (NASA 1995). The main assumption of systems engineering is that by managing the parts, one is also managing the whole. Indeed, the only way to manage a project of any scope is by using a subdivision-based reasoning and organizing the dependent units into separate tasks to be assigned to different project teams for execution. However, the resulting interdependency is a source of great complexity that needs to be addressed in the subsequent execution of the project. This complexity underlies every project decision in the form of uncertainty that accompanies project decisions. The essential problem is, therefore, to identify such interdependencies between parts of the design, which will enable the process to be organized as a set of independent tasks and tasks that need continuous process-level integration (see, for example, Thompson 2003).

This paper is an attempt of early inductive theorizing to present the interdependence and complexity in construction design. The main aim of the paper is to argue that organizational integration at the level of processes, not contracts, is the key characteristic of integrated delivery approaches. To accomplish its aim, the paper begins with a theoretical overview of design management concepts and techniques in the AEC context. After the theoretical overview, the paper continues with presenting a case study of an integrated engineering design from which it extracts a series of issues in the form of a cognitive map. From the case study findings, the paper finally induces a set of theoretical propositions and practical recommendations.

BACKGROUND THEORY

Designing a new product (or artifact) with an engineering content is normally defined as the activity of producing information about the system that embodies the functions necessary for fulfilling the set of requirements set forth by the client (e.g., Pahl et al. 1996; Cross and Knovel 2000). In the case of facility design, these requirements need to be mutually negotiated between the stakeholders and the project coalition (Winch 2010). This significantly complicates the design decision-making process as interests of the client, the stakeholders, and the project coalition diverge. Additionally, the elicitation of requirements for the designed system is a tremendously challenging task because the requirements are often changing through time. For all these reasons, the process of facility design is *ill-structured*.

The dichotomy between the *ill-structured* or *wicked* problems in contrast to *well-structured* or *tame* problems was first introduced by Rittel and Webber (1973) who argued that design problems are impossible to define and therefore no optimization in the traditional mathematical sense is possible for such problems. Some of the most obvious differences between tame and wicked problems are that the former are describable and determinate, whilst the in the latter, problem definition incorporates solution and only indeterminate solutions can be achieved (see, for instance, Winch 2010)

Wickedness and ill-structure have, to date, remained considered the fundamental property of design. In a more recent discussion about the subject, Coyne (2005) corroborates evidence for the ill-structured nature of design and extends the debate by stating that:

> *"Wickedness is the norm. It is tame formulations of professional analysis that stand out as a deviation."*

In contrast with the theoretical discussions about design, most known techniques used in design are by and large deterministic in that they disregard the wickedness of the design problem. Some of the most famous of such methods in the AEC sector include the likes of: *Quality Function Deployment*, *Design Structure Matrix, and Process Models* (e.g., Austin et al. 2000; Ahmed et al. 2003; Tzortzopoulos et al. 2005). In Coyne's terms, all of these methods are tame formulations of the wicked problem and, therefore, have a limited value.

To come up with more realistic representations of the wicked problem and to develop better methods for managing it, first the traditional positivist paradigm of :the rational man" needs to be replaced with an interpretive paradigm that acknowledges the subjective and relative nature of decision-making (Simon 1955). Following this cognitive concept, contemporary scholars in construction project management (Winch and Maytorena 2009) contend that decision making in such highly-uncertain conditions, as the ones that appear in design, can be classified more reliably as *sensemaking* under bounded rationality than as rational economizing as advocated by hierarchical breakdown structures from traditional project management literature. Sensemaking is the process of retrospectively assigning meaning to past events and thereby shaping the organizational context for present and future events (Weick et al. 2009).
Using the cognitive concept of sensemaking, we will argue, is a step forward towards describing the decision making process in complex problems of integrated construction design.

RESEARCH DESIGN

To learn more about interdependencies in the complex design project, we chose to conduct a retrospective study because the decisions that affected the project events can only be evaluated *ex post*. The traditional project setting for decision making relies on management procedures that only deal with identifiable contingencies, thus, they belong into the realm of tame problem solving and hard systems thinking. The project normally deals with uncertainty only through risk management procedures that are, again, limited in their predictive potential. We, therefore, chose to trace the processes resulting from decisions in a fast-paced and complex design-build railway engineering project. In a retrospective process-tracing setting, we hoped to encapsulate the uncertainty that would have not been possible to address with ongoing project events.

There are several additional reasons why we chose a large contractor-led design and build engineering project for analyzing interdependency in construction design. Firstly, most design and build projects are characterized with a relatively fast pace with a possibility of overlapping design with construction. Due to the pace of such projects, many design activities are planned in parallel rather than sequentially, which causes additional fragmentation and complexity of the design process. Secondly, because design and build contracts are undertaken relatively early and they are based only on the clients' requirements; there is an inherent uncertainty concerning the scope of the project. The deliverable dates, however, often do not change in such projects, which calls for a robust organization that is capable to adapt to sudden changes in scope and still deliver the job on time. Thirdly, the geometry and size of the constructed facility, along with the multidisciplinary contributions, accentuates the importance of design integration across numerous project interfaces. All these project properties highlight the need for tracing the interdependence in the design system to reduce consequences of uncertainty. Finally, since we wanted to make generalizations from this study at the project level, we chose a project that we believe makes a suitable unit of analysis for an exploratory study.

During a one-week stay in the project offices, the first author used extensively interviewed five representatives of the owner's project management and the contractor engineering organization using ethnographic techniques (Spradley 1979). For the purpose of this study, only accounts by the contractor's engineering organization were further analyzed, thus setting the level of analysis to the contractor's system sensemaking. The aim of the data collection by interviews was to uncover the managerial sensemaking process retrospectively, by having all the relevant data after the project had finished (Weick et al. 2009; Winch and Maytorena 2009). In contrast with the process maps as the result of the ongoing project, here our aim was to develop a cognitive map of the traced processes according to the managers' sensemaking and, finally, induce conclusions of theoretical validity from the single-case study (Eisenhardt 1989; Yin 2003).

Apart from fixing the interview framework to issues in the design management processes, the interviews were open-ended, allowing the subcategories of the topic to naturally emerge during the one-hour long interview interactions with each informant. This unstructured interview setting enabled us to better understand the scope of the complex inter-organizational arrangements in the supply chain and their influence on design. We triangulated the data obtained from the interviews with relevant internal project documentation (project reports, schedules, organizational diagrams, etc.) and with publicly available material from press coverage of this public-funded project. After having analyzed the data from open-ended ethnographic interviews and project documentation,

we then carried out two follow-up telephone interviews that were structured around several topics identified in the initial research session. The aim of the follow up interviews was to get more in-depth information about specific instances of design issues. Following the open ended and structured interview sessions, we tried to induce theory by tracing the processes of how the project design was unfolding in an attempt to establish causal relationships between the events and their consequences occurring in the project (George and Bennett 2005). We finally coded the structured follow-up interviews with all instances of unforeseen uncertainty cause by complex interdependence.

CASE CONTEXT

The case project involved extending a section of a rapid transit urban railway system and incorporating it into the suburban rail system of a congested European metropolitan area. The scope of works comprised partial extension of tracks, replacement of track and signaling equipment, construction of four new stations and refurbishment of five old stations. The project was particularly demanding in civil works as 3.5 km of track is on viaduct and another 3 km is in tunnel. Besides the construction of a new section, the complete section needed to be upgraded to meet the national mainline standards. The design and construction were completed in two and a half years and the schedule itself consisted of roughly 16000 design and construction activities.

The public agency project owner undertook the contract under a contractor-led design and build scheme. The main reason for choosing this delivery method was that the project owner expected a single point of responsibility to better integrate the design, construction, and operation stages of the project. An additional reason for choosing a fast track delivery approach was the political significance of the completion date (public opening). Therefore, owner-perceived advantages of a fast-track delivery method were the integration and collaboration between project contributors. The core project organization included the public agency owner and the contractor. Because the owner organization did not have substantial experience in railway construction, they appointed a project management organization to manage the project on their behalf. Concurrently, the contractor's organization mobilized an engineering department for the project with the aim of coordinating design and construction. The project also had three major external stakeholders, being representatives of the urban and the suburban rail systems as well as the operating company. The former two had the role of ensuring that the newly built section complied with the existing standards of both networks and the latter had the role to ensure that the delivered facility complied with their train operating procedures.

The design scope was organized in disciplinary *work packages* and geographic *design areas.* The disciplinary work packages comprised civil design, structures, buildings and services, mechanical and electrical systems in buildings, and design of accompanying rail systems (Fig 1). Each work package was further broken down into *design areas* defined as "geographical groups of neighboring work packages or a logical system comprising a number of subsystem work packages". Because of its fragmentation, the project developed an *Interface Management Plan* to identify and manage issues that would occur between work packages, design areas and organizations in the design supply chain. As the design evolved, the identified project interfaces were planned to be translated into requirements for each of the design contributors.

The flow of the design was planned as a two stage process: conceptual design and detailed design for the owner's construction approval. The project further fragmented the design process along those stages because the project management organization was supposed to produce the conceptual design work packages and design areas for the contractor's design team. The transfer of knowledge and assumptions made in the conceptual design stage would be transferred to the contractor's engineering organization before the detailed design production. During the detailed design production the lead designer and the contractor's engineering organization needed to ensure coordination via interdisciplinary design review meetings as the principal method of design integration.

The contractor had a web-based collaboration system in place to manage the requirements across different project levels. The high-level requirements would emerge from any of the project stakeholders, the contract, or other obligations with respect to technical standards and legislation. The contractor would then translate those high-level requirements into system-level requirements with such attributes as object type, work package, design area, and contract (see Fig 1). This structure should have ensured traceability of the requirements between the design team level and the project owner.

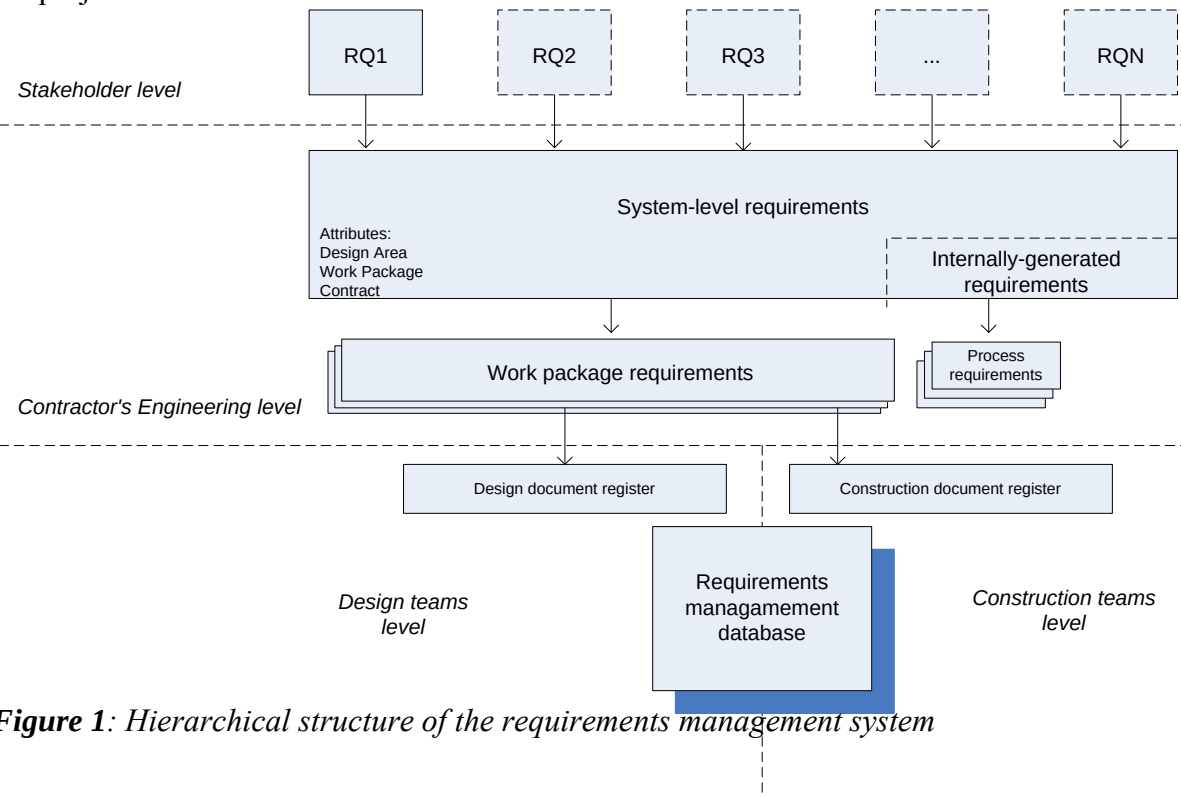


***Figure 1**: Hierarchical structure of the requirements management system*

DISCUSSION OF THE FINDINGS

In reconstructing the design management story from the perspective of the contractor's engineering organization, we immediately noticed the complexity that resulted from interdependence between the design tasks. This complexity was not included in the project management procedures that only described the hierarchical decomposition of project structure. Therefore, at the outset of the project, the design process was structured in an overly simplified way that did not predict well the implications of changes on the entire design process. We

continue with a more detailed description of how the above introduced seemingly small project requirements played out a significant role in the project. Figure 2 below depicts the traced process of a situation, in which a seemingly simple requirement amplifies and propagates through the project due to complex interdependence and sensitive dependence on initial conditions in a wicked problem-solving context.

The traced process begins with two requirements simultaneously being introduced by the client and internally within the project team. The client's requirement was that design team provides a possibility for subsequent installation of an external escalator in one of the stations. The passive provision for an external escalator, however, required that additional power be supplied to the stations and, in turn, the entire section. More power meant that thicker cables had to be arranged for its supply. Thicker cables meant a higher volt-drop and, consequently, further increased the demand for power in an interdependent loop that caused a substantial amount of the power systems to be redesigned for this sole purpose. Redesigning the power systems caused a requirement for additional space to accommodate the newly designed systems. This space, however, was not available neither in the station that had already been designed by that time (and, in other instances, also built), nor in the form of land along the tracks. Therefore, additional land had to be acquired to run the cables along the section, and the buildings had to be redesigned with the new space requirements. It caused another iteration loop in the building design that led to subsequent design integration problems due to geographically-distributed organization of the design process that was the main designer's choice.

Roughly at the same time, a second requirement emerged that needed to be implemented. It related to fire-safety as a consequence of implementing the fire-safety regulation into the design. The implementation of this requirement, in turn, caused an even greater demand for power and, consequently, more land to be acquired to run the additional cables along the tracks. When combined, the total amount of power that was now required for the section became so large that not even the local power supplier was capable of supplying it. Therefore, it wasn't until very late into the design process that the design team and the project owner decided that implementing one of the requirements is not possible and that it had to be relinquished.

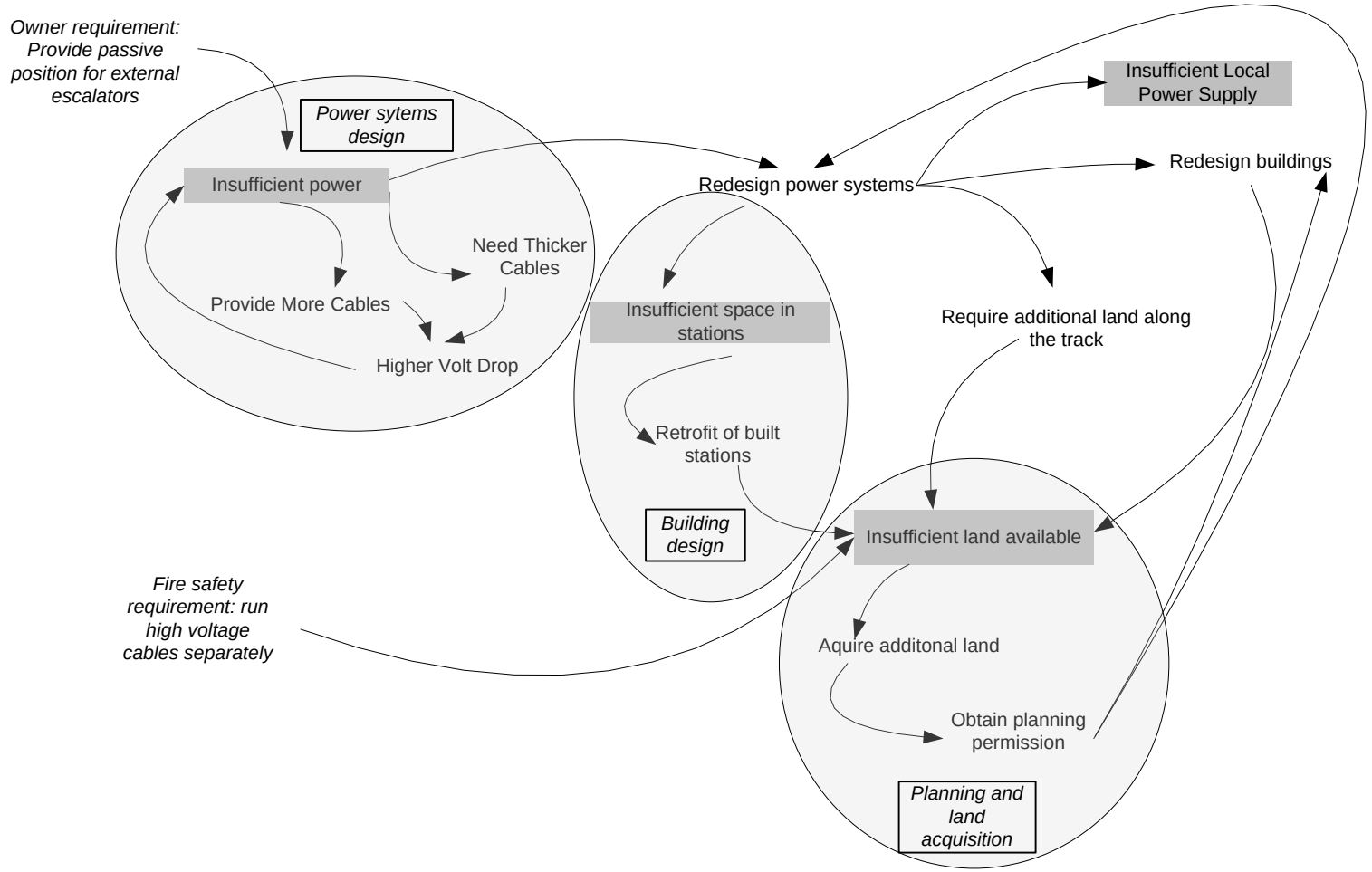


Figure 2*: The process-tracing map of sensemaking in complex interdependence of infrastructure design.*

This example demonstrates that requirements, however insignificant they may have seemed at the time when their implementation was decided upon, cause significant consequences for the project. In the case of insufficient local power supply, these difficulties were insurmountable and resulted with rejection of the requirement. The subdivision of the project linked requirements to discrete and abstract entities such as work packages, design areas, and contracts. In practice, however, parts of the system have not proven to be manageable in discrete pieces. Instead, they acted as an interconnected system of events that needs to be analyzed in the cause-effect context.

Having such a project representation would have facilitated managers' understanding of intricate interdependencies between the tasks captured within the design subsystems. The cognitive process-tracing map shows three distinct design subsystems: power systems, buildings, and planning with land acquisition. Besides the overall design iteration loop, these design subsystems performed additional iteration loops within themselves. The subdivision logic that was employed in the project did not follow these loops. Suboptimal design decomposition exacerbated fragmentation of the overall design scope with the result of unforeseen delays and costs on the project resulting from rework and problems with design integration.

PROPOSITIONS AND RECCOMENDATIONS

Based on combination of the above introduced theory and the findings from the traced process in the case study, we induce several theoretical propositions. From them, we derive the corresponding practical recommendations for managing complex engineering projects.

Proposition I: A wicked problem is characterized by reciprocal interdependence between its constituent parts.

Although it may seem tautological, this theoretical proposition argues that wicked parts of the design are also ones that are reciprocally interdependent. Their main characteristic is that a change in any one part of the system will cause changes on all the other parts of the system. As originally argued by Thompson (2003), such tasks need to be managed by the process of mutual adjustment instead of by standards and plans.

Recommendation 1.1: Differentiate the wicked from the tame parts of the design process.

Before starting to organize the design process, design managers should try to analyze the design problem and divide it into a group of tasks that result in a concept solution and a group of tasks that result in a detailed elaboration of the design concept. The former will form the wicked group and the latter, the tame group of tasks. This will be the first step towards the decomposition and management process.

Recommendation 1.2: Define success and failure criteria for the wicked group of tasks.

Since solving a wicked problem is a cognitive process of socially constructing project information, the key issue is to negotiate the goals of the project and metrics of success. Aligning the stakeholders' interests into a congruent set of project criteria will help lead the design process and reduce organizational friction between members of the project coalition.

Recommendation 1.3: Include buffer time in the project schedule.

Based on the level of complexity of the project, rework is likely to occur. Due to reciprocal interdependency in engineering design, deterministic planning is not likely to yield accurate forecasts. Including a substantial buffer time in schedules will help initially address the emergent complexity of the wicked tasks.

Recommendation 1.4: Be prepared to reiterate the entire process when new requirements arise.

Due to reciprocal interdependencies that are characteristic for design, there is high possibility of iteration to implement a requirement into the overall design. Given that any design problem is by definition wicked, taming it is only possible with limited results. Depending on how well the internal design interdependencies are assumed, managers can try to predict the impact of a requirement on the project. In certain cases, iterative loops of rework can become so frequent that project teams need significant mutual trust to avoid the failure of the project due to what Weick (1993) calls the collapse of sensemaking. In such instances, subcontracting or geographically distributing work across different offices is not advisable.

Proposition II: The better the organizational design follows the combination of tame and wicked tasks within the overall design scope, the lower the resulting fragmentation of the process.

Recommendation 2.1: Develop work breakdown structures based on the level of interdependence between the packages.

Although it is the basis of every project management system, work breakdown structures based on simple hierarchies of dependency are not sufficient to subdivide a complex design problem. Such problems should be subdivided based on interdependencies between the systems that often go beyond the classical space-discipline logic and also include relations with, for instance, external stakeholders or the overall need for communication between members of design teams.

Recommendation 2.2: Only subcontract tame tasks.

When decomposing the overall scope, it is important to create such design modules that are relatively independent of each other so that the amount of communication between the modules is reduced. The most obvious way of weakening the interdependence between the modules is overdesigning to account for possible future changes. Therefore, only tasks that are identified as tame are appropriate for subcontracting to third parties.

Recommendation 2.3: Wicked tasks should be integrated at the process level.

Although the advantages of contractually-integrated project approaches clearly exist, such approaches do not guarantee integration at the design process level. In fact, when contractors take responsibility for the entire project delivery, there is a realistic possibility of introducing an additional level of subcontracting that can be difficult to integrate into the project. Therefore, a design task that is identified as wicked should be executed by a collocated and socially-coherent

design team. Although team collocation is not the sufficient condition for efficient team performance, the authors' experience indicates that mutual adaptation, which is necessary for executing reciprocally interdependent wicked tasks, is most likely to occur in a collocated social context.

CONCLUSIONS

This study presented an early stage of inductive theorizing about the design complexity. This theorizing developed a cognitive map based on making sense of how requirements impact the overall design. This cognitive map of sensemaking indicates that reciprocal interdependency causes a requirement to amplify and propagate within the boundaries of the integrated project, thus making the problem wicked and ill-structured. The study further developed a list of theoretical propositions coupled with practical recommendations that managers should use to reduce the unforeseen uncertainty on their future projects. These recommendations advocate the need to distinguish tame from wicked parts in the design scope and accommodate the decomposition and integration strategies to the corresponding characteristics of interdependency.

The results of this study contribute to theory on several levels. The sensemaking example of design complexity, we believe, unifies two prevalent high-level approaches of construction project management: the objectivist school of systems engineering (see, for instance, Walker 2007) and the cognitive view of information processing (see, for instance, Winch 2010). More specifically, we believe that the results of this study also contribute to the toolbox of integrated project delivery (AIA 2007) and concurrent engineering (Anumba and Evbuomwan 1997) with a normative set of recommendations that can be used for organizing the integrated delivery process. Finally, we believe that the results of this study complement the standard construction design management toolbox (e.g., Austin et al. 2000; Kagioglou et al. 2000; Ahmed et al. 2003) with a view on the ill-structured problems than can complement the existing methods.

We are aware of several limitations of this study that future studies should address. Namely, generalizations drawn from a single-case study are not at the level of a particular population, but at the level of replicating causal relationships for the given sensemaking context. Gaining insight at the level of particular project characteristics would require a larger sample and a different approach. Methodologically, a continuation of this study should extend this descriptive and qualitative theorizing into further normative and predictive models. We are also aware of the need to extend the normative decision making framework based on its applicability to different procurement routes and organization structures in the construction design field. Moreover, this paper advocates neither the integrated design-build nor the traditional design-bid-build contractual arrangements. It solely attempts to offer a way of thinking in ill-structured problem solving that can occur in either of the contractual approaches. Integration, therefore, is a process-level, not contract-level concept. Finally, this paper does not attempt to give answers to aspects of the project that are beyond the decision-makers' comprehension (i.e. wicked aspects). It aims to bring about awareness of the existence of unforeseen problems and the need for their ad-hoc resolution. This is, we believe, the main practical idea from this study.

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CHARACTERIZATION OF ARCHITECTURAL AND URBAN ATMOSPHERES IN "GRANDS ENSEMBLES" (LARGE-SCALE HOUSING ESTATES), BUILT IN FRANCE OF THE 1950s AND 1973s

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ABSTRACT
This paper introduces results of three case-studies of large-scale housing estates situated in Nantes (France): Dervallières (1952/1965), Breil Malville (1955/1967) and Malakoff (1967/1971). The main objective of this "grands ensembles" study is to produce knowledge about their architectural and urban atmosphere characteristic. The atmosphere concept is defined as interaction between some physical phenomenons like: sound, light, wind with urban environment as perceived by the space occupant [Augoyard J-F, 1998]. This paper is organized globally in two parts, the first part presents brief synthesis of history and current context of these areas, second part gives idea about atmosphere's characteristic for three cases-studies. This consists in clarifying and analyzing complex relationships between urban, social and physical (sound, light, sunshine, wind, etc.) environment, taking into account user's perceptions and urban renewal.

Keywords: "grands ensembles", atmosphere, renewal, perception, characterization.

INTRODUCTION

In reference to current stake related to "the town of tomorrow", the residential zones type grands ensembles are the subject of multiple and pressing requests. These blocks constitute by their large free spaces attractive areas for dense city concepts, responding to suburban expansion and its harmful effects on the environment. The stake is also to assure harmonious social and economical development between town center and its periphery. Questions that arise about these stakes concern living conditions and atmosphere quality in these areas: is this quality taken into account in their refitting? If yes how? Are the errors made during the time of massive construction of these social housing in France avoided in their rehabilitation? These questions pin up an important aspect of urban design, which is inhabitant's practices and feelings. As you know, their requirements for comfort and wellbeing are increasingly

important, not only about functional aspects but also about environment, esthetics, and safet aspects. Therefore, renovation project can't be done without a "diagnosis" relating both material components with practices/feelings in these spaces (public and private space).

In this research, we characterize the atmosphere quality in three case-studies of large-scale housing estates situated in Nantes (France): Dervallières (1952/1965), Breil Malville (1955/1967) and Malakoff (1967/1971). Our method consists to use three separate and complementary approaches: observation approach, sensitive and physical approaches. The first two approaches are questioning true-life of the inhabitants: how do they perceive their living environment? What do they think of the social life in their district? And what are the renewal operations contributions? The last approach allows us to explain some micro-climatic phenomenon (sun, wind and temperature) by using simulation tools.

To answer previous questions, the characterization method consists initially of an "exploring" approach of urban spaces using observation (continuous and punctual) in order to discover how the inhabitants appropriate their urban spaces by identifying different types of interactions *individual-individual, individual-space and individual-microclimate*. This first approach also enables us to prepare "sensitive" approach, which consists to collect information about inhabitant's perception from surveys (questionnaire, interview). It allowed us to explain and understand some observation "scenes" noted in the first step of characterization approach with observation. Microclimatic environments described by the inhabitants are crossed thereafter with third approach called "physical" so as to determinate their emergence conditions, by using digital modeling and simulation. Finally, this multidisciplinary approach allows to establishing knowledge of architectural and urban atmosphere, which characterize large-scale housing studied, taking into account the renewal operation and the atmosphere as imagined by architect-designer.

"GRANDS ENSEMBLES" IN FRANCE FROM SUCCESS TO FAILURE

Massive construction of these housing areas in France is not only a quick and economical solution for the housing crisis after the second World-War, but also a response to the unsanitary lodgings. A census conducted in 1940 showed that only 8% of French houses had bathtubs and toilets, hot water, few windows, a minimum area ... [Comité des Grands Prix Nationaux de l'Architecture, 2007, p33]. While these estates have brought more comfort with spacious, airy and sunny apartments surrounded by green spaces, an occupant says: *"...I immediately had "love at first sight" for our new apartment. It was luminous, spacious and had the central heating; it offered fabulous view on the countryside and the greenery"* [Giovanna Francavilla testimony]. The official start construction of these housing was in 1953, when the Minister of Reconstruction and Housing Pierre Courant, carried out a series of interventions named "Courant plane" consisting in facilitating housing construction with land and financial supports, giving priority to the large-scale housing estates. In order to meet the growing demand of housing, other programs were conducted like: "ZUP, Zone à Urbaniser en Priorité" (Priority Development Zone) in 1957 replaced by "ZAC, Zone d'Aménagement Concerté" (Concerted Development Zone) in 1967. Certainly this policy had allowed massive construction of social housing but it didn't create dynamic and attractive districts. In fact, a few years after their construction, first sign of degradation appeared (in the late 1950s)

revealed by social and urban surveys. Social contexts characterized by juvenile delinquency, an enrollment rate of adults who never attended school that exceed 10%, higher unemployment, and degradation for framework built. Finally these areas were associated with segregation, nuisances and danger zones, reason why Olivier Guichard Minister of Construction, decided in 1973 to stop the housing construction exceeding 500 units.

How can be explained this degradation and this change from modern living condition to degraded and unhealthy habitat? When looking back at "grands ensembles" history one can observe that majority of these housing are assimilated to concentration camp cities, housing exiguity, proximity, noise… boredom. Overall, these areas are characterized by spatial and social relegation, with lack of transportation and leisure area, and with difficulty to create a social life and to adapt to these new conditions (to have 200 to 500 neighbors from different backgrounds and cultures). So people still feel some kind of social relegation in comparison to the people living in the city center, and this social segregation was accentuated when middle class leaves to detached houses, knowing that 80% of French people at that time desired to live in detached house. The accumulation of problems inside and outside house has made life very difficult in these housing, that's why these urban housing were a priority for urban political, in order to improve their living conditions through urban renovation and social actions. The main principle of these operations is to take into account inhabitants by creating social office council, so as to centralize the problems and inhabitants demands for giving immediate solutions.

DIVERSITY, DENSITY, COMFORT...: THE RENEWAL OF "GRANDS ENSEMBLES"

Demolish, convert or renew? Such are the questions which arise since 1980s for the future of these urban areas. Since, measures are presented in diverse actions: social (example: National Commission for the Social Development of the Districts), urban and environmental (example: Great Urban Project become Great Project of City) in order to improve the life quality in these districts. For the professional of building, the partial or total demolitions of these buildings are essential to fight against them insalubrities and enclosure, in spite some inhabitant's refusal to see their housings disappearing. First restoration operations described as "classical" (building front renovating, change of the windows, refitting of public spaces), have been carried out, with mitigate results. But the present renewal programs are deeper, diverse and more effective, consisting in complex programs, conceived on a large territorial scale with a long-term thinking on the future vocation of the district. This policy takes into account sustainable development criteria in all steps of restorations, from construction waste recycling to the improvement of the energy performances.

In a comparative study between large-open spaces of the "grands ensembles" and those of the traditional city Hatzfeld and Moutton [2006], highlights capacity of areas to adapt to urban transformations contrary to traditional centers. These open spaces have a great potential for an equal development between center city and its periphery. Successful densifications of these open spaces should allow creating social and functional diversity awaited in these districts, and reduce periphery-center displacements. If urban renewal seems to satisfy inhabitants, the important transformation must to be in apartments, because inhabitants estimate that changes

inside apartments are insufficient (handing-over in standard of electricity, change of the windows), adding the renovation defects.

Malakoff case in Nantes (1967/1971) seems a good example of this new urban policy. As part of a “Grand Projet de Ville” (Great Project of City) launched in 2004, thought was developed on Malakoff district and neighboring areas. This project was carried by social landlords, the National Agency for the Urban Restoration (ANRU) and the community of agglomeration (Nantes Metropolis) with participation of inhabitants. Budgets inequalities set up by each landlord gave interesting results to analyze. First public landlord had opted for a “classical” rehabilitation with budget of € 25 000 by apartment, the second private landlord had opted for a radical change with € 60 000 by apartment, which has enabled to improve energy performance of buildings. Indeed, energy consumption was reduced by 80kWh.ep / m² / year, saving load about 70 € / year by home [Barthel P, 2008], with double-insulation of the buildings (inside and outside) by semi-rigid 10 cm thick rockwool panels. The building architecture is also revised: apartments became more spacious, with original architecture and diversity of functions. On an urban scale, ensure house diversity and the reinforcement of the connections to city center are the priorities of this project.

STUDIES CASES SITUATED IN NANTES

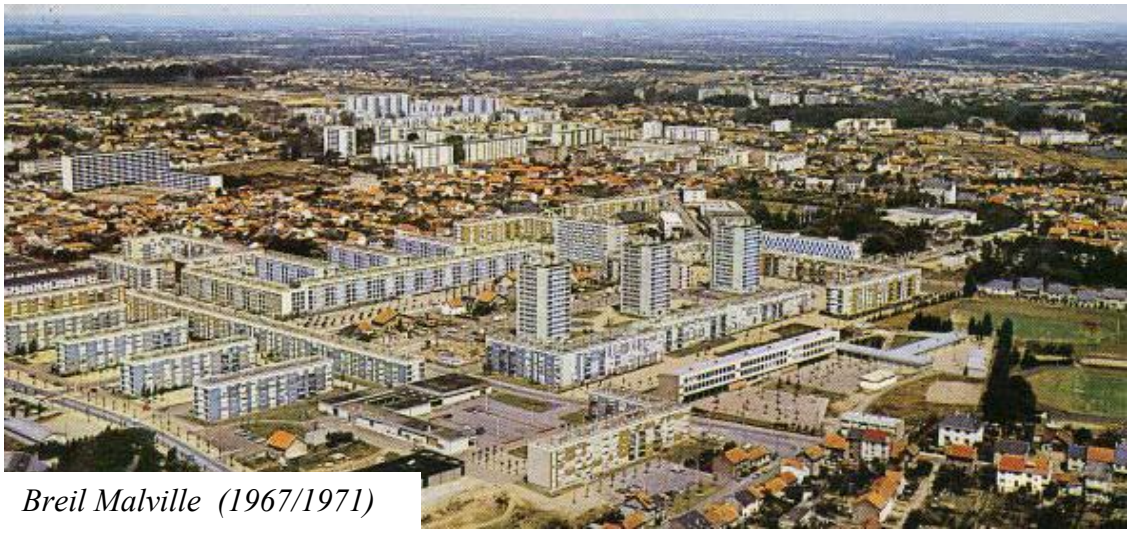
The three large scale-housing [Fig. 1] choices were built between 1953 and 1973. The first case study is “Dervallières”, first “grand ensemble” built in Nantes (1957-1965) in an old park, building implementation is done in away to preserve the natural framework, and to adapt to the climatic conditions, in order to have better quality of sunning and a protection of the dominant winds. This neighbored is situated in town periphery and contain 2600 housings. The second case is “Breil Malville” designed by the same architect than the first one. It is featured in the presence of different housing type (detached, semi-collective and collective housing) and contains 1600 housing built in 1961-1967. The last case is “Malakoff” situated close to town center, with exceptional natural framework (Loire River and “Amazonie” preserved park). Built in 1967-1971 Malakoff contains 1658 housing. The three selected districts are the subject of many restoration projects, differing in level quality, progress report and budget.



Dervallières (1967/1971)



Malakoff (1967/1971)



Breil Malville (1967/1971)

Figure 1: *the three studies cases.*

SOCIAL DIMENSION AND ITS IMPACT ON PEOPLE PERCEPTION

Interrelations between a social dimension of the district and a sensitive atmosphere are strongly present. The feature of social life in these urban areas: delinquency, poverty, unemployed and unoccupied, drug users with low education and a difficult social condition, insecurity is a major preoccupation of the inhabitants in their life environment. This report is pointed by inhabitant testimony, one of Dervallières occupant says: *"... you know, the morning when I go out from my home, I do not really pay attention to the sun, wind. I think especially to my work, my children, and to not be burgled"* [testimony taken 15/07/2009]. This mistrust feeling concerns most of "grands ensembles" inhabitants, especially the women. That's why these persons not invest in social life of district and stand apart from the others inhabitants. Hence some spaces judged dangerous and bad reputation areas are not used. For middle class family which lives in these areas a departure is a priority especially for the victims of these conditions: *"I made burgle my apartment twice, each time I go out with baggage's they steal me, fine, I can't take it anymore"* [testimony taken 15/07/2009] for the poorest class their socio-economic level not allow them to hope to leave the district, so they seek to adapt by trivialized the bad social life aspect. An inhabitant of Dervallières told us: *"Yes, these are young people, they like to have fun, and they do nothing wrong"* [testimony taken 23/07/2009].

This category of people is able to create his ideal world of sociability. What they often call for solidarity, good neighborhood, is a feeling shared by a group of people or even families who can provide some protection from outside world, seen also as a means of mutual help, mainly present between families of same origin and culture, the old neighbors and neighbors simply. This solidarity can also be found inside blocks; it concerns the cleanliness of common places as stairwells, elevator, landing of floor and also the limitation of noise at certain hours considering the bad soundproofing of apartments. On the contrary, other neighbors distinguish them by their lack of civism and the lack of respect for the community life: trash front of doors, strong music…

PRESENCE AND BEHAVIOUR IN THE PUBLIC'S AREAS FOR "GRANDS ENSEMBLES"

This paragraph presents observation results of public's areas in three cases studies, recalling that objective for this step is to identify inhabitant presence and behavior in these spaces. Observations realised during winter and summer days (day of week or weekend) in the three districts show that urban activities take place mostly in the following areas: square, playing and green areas. Other frequent activities occur in entrance hall of buildings, cellars, parking's, and stairwell. We notice that square is the most used space in these districts [Fig. 2]; the inhabitants justify it by the presence of equipments and services necessary to the everyday life. We can find in this space different activity like: purchases, meeting and discussion. By its central and strategic situation in the district, it is considered as the favorite place where young people grouping and activity, so that it experiences motorcycles and cars races, quarrels, business.

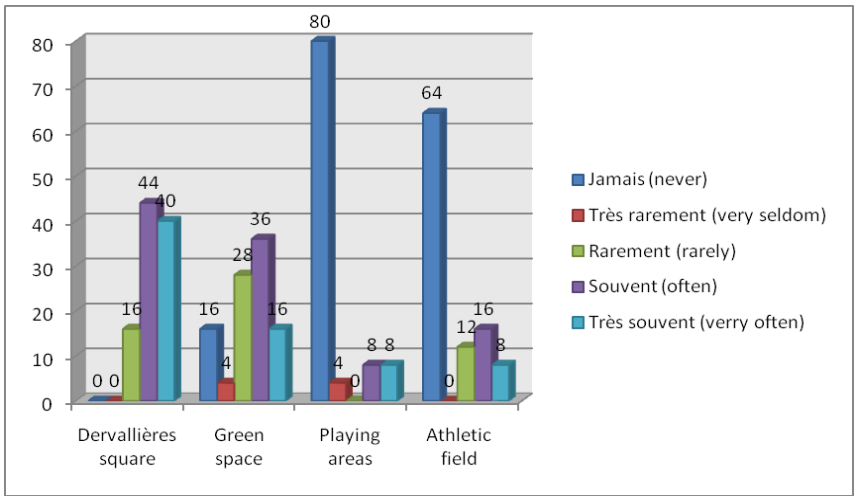


Figure 2: *use frequency of Dervallières public's space*

That is why some inhabitants prefer not to frequent this place. The city planning (street furniture, green area) and configuration of these spaces plays an important role that determinates people practices and urban dynamic. For example, Breil Malville square is not used by people because of its poorest urban arrangement, contrary to the Malakoff and Dervallieres square where inhabitants take advantage of the presence of terrace (bar and restaurant) and of the benches, to create convivial meeting moments for woman and man. In the Malakoff square, women say that they don't like to go to this place, because the glance of the person's occupation of this space is concentrated and oriented to the persons arriving at the place, which is inconvenient for them. This situation is resulting from the square configuration. If squares are the most frequented space in the three districts, the green spaces (with or without pond) are the favorite spaces of the inhabitants. In Dervallières, inhabitants display particular attachment to green space called "pond", which know another dimension after its renovation. Inhabitants appreciate this space natural landscape (vegetation, pond and ducks) that they qualify as "exceptional", "quiet", and "pleasant".

Before its renovation, space was given up by inhabitants for its dirt and for offensive odor emitted by water. Another example related to Malakoff, is the "rock" park, a green space very appreciated in spite of its bas urban arrangement. Rest areas situated in front of buildings are practically unused in three districts, while these areas are well equipped. According to the inhabitants, they prefer isolated spaces sheltered from view coming from buildings.

Atmosphere quality in large-scale housing studies

It consists to give an overview of inhabitant's perception. This was collected by surveys where thirty people by district were participating; responses were given in home or in public space, the questionnaire being completed by the investigator. Generally, the perception of architectural and social framework is rather positive, more particularly in renovated districts. According to inhabitants, this report is justified by improvement of the residences quality of many people that were living before unhealthy houses of old centers and left them to live in these "grands ensembles" (like Malakoff people). They so accessed to spacious apartment, with better sunshine and natural lighting. Of course, many inhabitants are dissatisfied about

the degradation of the built and social framework, but they remain overall satisfied of their life framework.

One of the first questions asked to the inhabitants was: do you live in your district by choice or constraint? Their answers [Fig. 3]; reveal that for 46% to 59% of the inhabitants (according to the district) it was constraint. One can distinguish in this category of inhabitant people that have become accustomed to life in these districts with time, whereas others consider that their presence is temporary, especially persons whose residency duration varied for six months to six years (young household). In the category of people having freely chosen to live in these areas, choice is generally justified by: natural and social framework of the district (like in Dervallières), proximity of worksite and town centre (the case of Malakoff), equipment and the services presence, family reunification. This people invest more in district life compared to the people forced to live there.

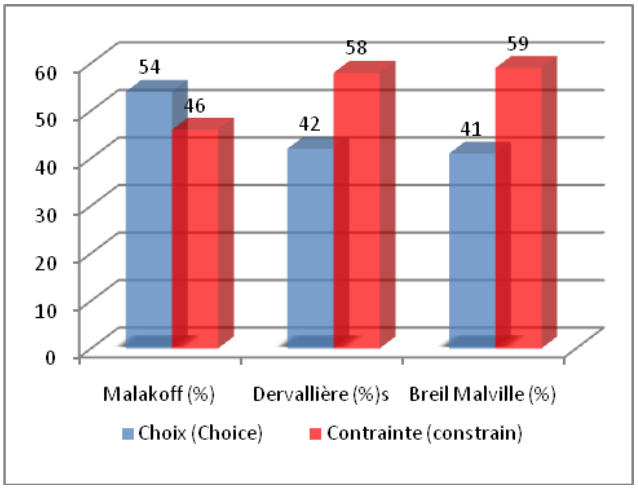


Figure 3: *live you in your district by choice or constraint?*

Evoking the natural and built framework, most of inhabitants interviewed say that architecture which characterizes blocks is banal and old [Fig. 4], consisting of standard buildings dating from the fifties years. Note that this observation is more presents in degrading and not renovating districts like Dervallières. In Breil Malville and Malakoff, renovation of some buildings is well perceived by inhabitants who found it current and original, as well as facades refitting, terrace extensions, with using of some noble materials into facades such as wood, and ceramics (thermal and aesthetic roles), very appreciated by inhabitant. For renovation called “classic” (refitting facade, change of windows), often conducted with some budget constraints, people consider them like a "mask of misery". The outside image of clean and nice building does not reflect true-life of people inside building, this judgment is justified by the bad sound and heat insulation, lack of space, defect, mediocre maintenance and degradation of commonplaces.

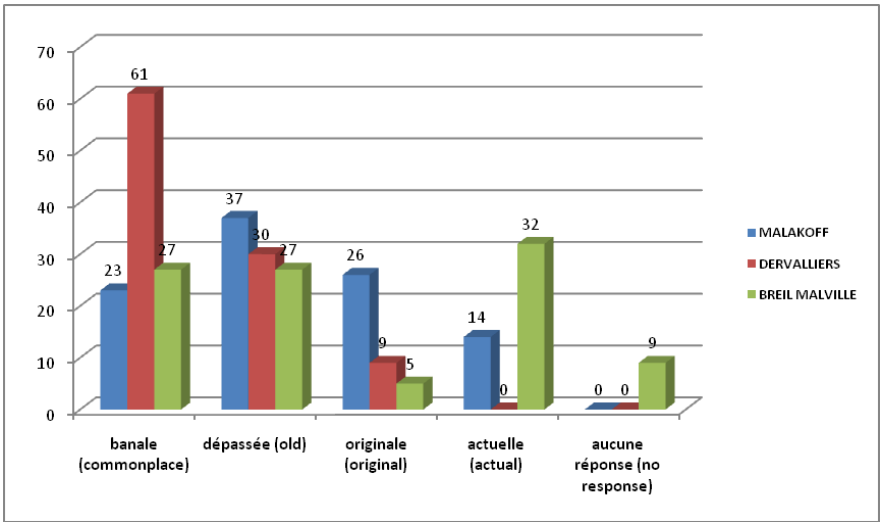


Figure 4: *How do you find the architecture of your neighborhood?*

The will of first architects to develop healthy and pleasant districts away from center town and their pollution (noise and others), has not always been respected in construction of these large-scale housing. Indeed, the choose of implantation sites depends to some land and financial constraints (a property at a lower price). For example Malakoff area built on a site near center town, bounded in the north by a railway that inhabitants see as a major source of noise in district. Contrary Dervallières is built on the site of an old park, near the town center but with more relaxed and calmer landscape. According to surveys conducted in these areas, one can observe that the urban context is not the only determining factor of the sound environment, but the social life and especially social practices are also determining for this atmosphere. In Malakoff and Dervallières, the inhabitants say that district are quite noisy (on a semantic scale of seven levels from very loud to very noiseless), noise sources are mainly associated with racing motorcycles and cars, grouping and discussions at feet of buildings (children and young people), neighborhood noise, young people conflict, renovations noise. Square is a noisiest place in these areas, before children's playing and green areas. Inside buildings, the bad soundproofing gives rise to a less intimate soundscape, as described by an inhabitant [testimony taken 27/07/2009] of Dervallières *"we hear everything in apartments, the neighbouring who walk or who speak, even when they go into WC we know it"*.

Our surveys contain questions about sunshine quality and winds sensation. In three districts, 80 % of the inhabitants say that their apartments are sunny. Indeed, the double orientation of housing allows benefiting from a maximum sunshine hours in different periods during the day. In these three districts, different built forms and orientations can be distinguished. In Dervallières, for example one can find especially low blocks (with an average of 9 floors), so the shadows caused by buildings to others are very low. On the contrary, in Malakoff, buildings are composed of low- and high- rise buildings. The last ones, with their important height (18 floors) and their respective nearness often create extended shadows with consequences on sunshine quality. In Dervallières and in Breil Maville, architect Marcel Favraud privileged an orientation on a diagonal axis (45°), what makes that buildings have a north-west south-est and south-west north-est orientation, which allows an equitable distribution of sunshine on facades. Effectively, 80 % of inhabitants questioned in

Dervallières says that their housing is well sunny, but there are particular cases where some spaces are bad sunny, because of north orientation or plants shading.

Some inhabitants have talked about overheating phenomenon in summer, localized specially in space where openings sizes are large; this finding is verified by simulation of sunshine duration [Fig.5], with the “Solène” software. The simulation affirms an overexposure of some facades. For a maximal duration equal to 12 hours (for a clear sky, and 21 June day) Mean sunshine duration by facade and for day are: 6h58 for North-West, 6h20 for South-East, 9h00 for South-West and 3h25 for North-East. Concerning Malakoff, the architects Evano, Cormier, Choisel and Leroux have opted for North-North West and South-South East facades orientations. 78 % of the inhabitants of this district say that their housing are well sunny, but others find also some spaces especially a rooms with bad orientation (North-North West). We notice that the sunshine duration of this facade is null.

Besides the sunshine quality, wind flow in these areas is also analyzed through inhabitant’s perception and simulation (Saturne software), in order to evaluate the impact of built form. In regards to this climatic factor, inhabitants mainly express discomfort situations. One can notice numerous “corner effects” in studies cases. They consist in wind accelerations at buildings angles, which can reach speed of 5m/s according to simulations made in Malakoff [Fig.6] and Dervallières with a reference wind speed equal to 3 m/s. All the identified effects have been listed in the Beaufort evaluation grid for wind speed [Gandemer G, 1976], that allows considering the impact of wind on the built space in function of categories of wind speed. As example: A speed equal to 5m/s is situated in the category 4 (hair is shaken, leaves and small branch are in permanent movement).

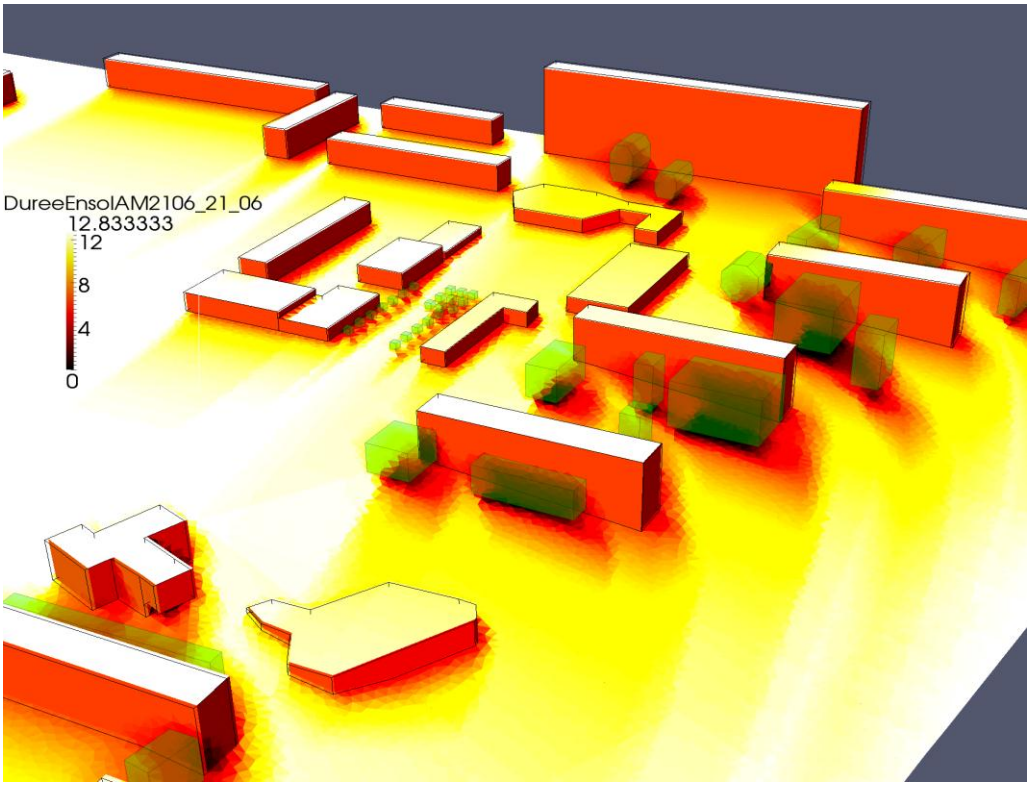


Figure 5: *sunshine duration in Dervallières simulated with Solène software, for summer day 21/06 including the simulation of vegetation*

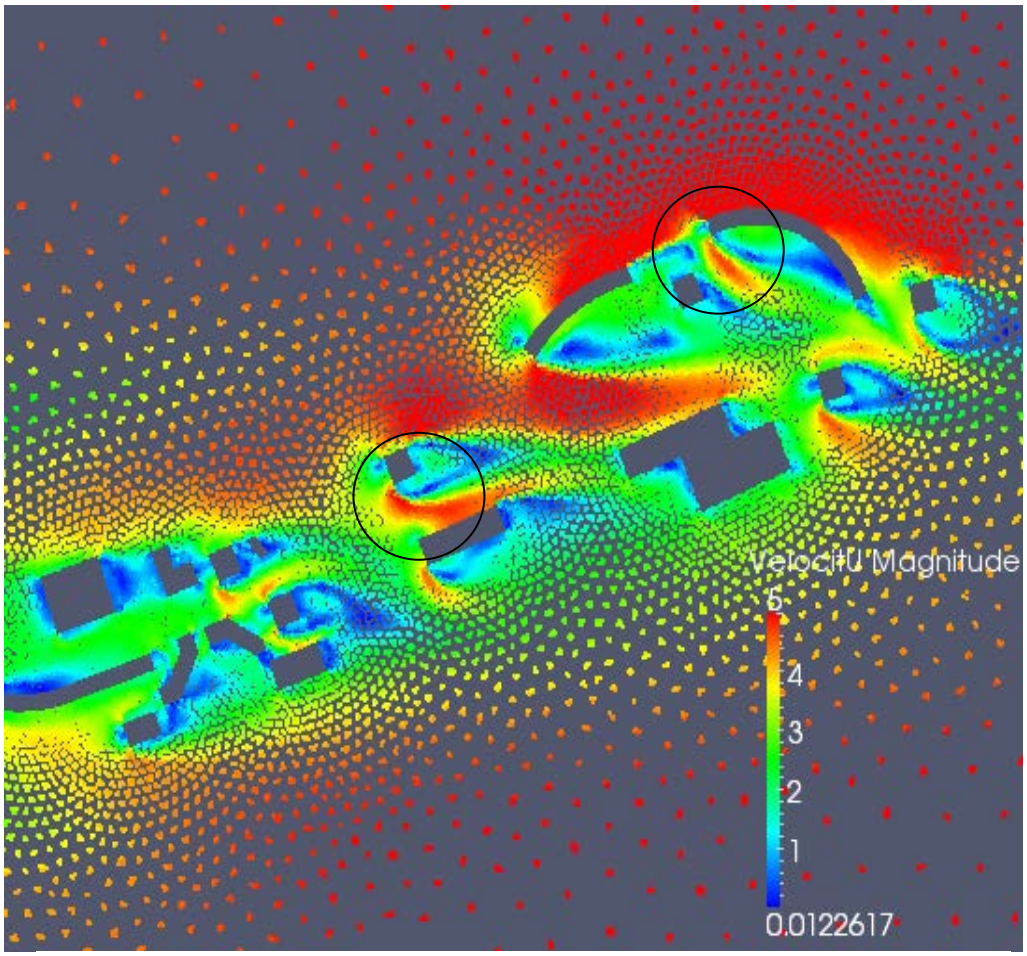


Figure 6: *flow velocity of the wind (m/s) in Malakoff, for west winds. The reference speed is 3 m/s.*

CONCLUSION

Historical and current framework of “grands ensembles” exposed briefly in the beginning of this article indicates that these blocks are French peculiarity because of their construction process and their evolution. However, they have features in common with other models of social housing developed in other countries (Holland, Germany, Spain), in terms of architecture or of their living condition often considered as rough. This study focusing on French cases allowed us to demonstrate that life quality in these districts does not only concern some difficulties that need to be surmounted, but also some qualities that should be highlighted like some inhabitants who manage to ignore negative aspects of their district and to estimate positive aspects, their life spaces become an integral part of their history and their culture. Paul Chemetov says “*ce qui est positif, c’est l’air, la lumière; ce qui est négatif c’est l’enfermement. Comment met-on en relation dans le réseau de la ville, les services, les espaces?* ” (The positive in these areas, is the air, the light; and what is negative? it is the confinement. How can we put in relation the network of the city, the services, and spaces?) [Committee of national Grand Prix, 2007, p35], this architect-planner underlined the quality potential, which still exists in these blocks, namely the natural living environment (aeration, light, sunshine, vegetation).

We notice that low use of their publics areas is justified by social life difficulties (violence, traffic, crime), creating an atmosphere of fear and mistrust among the inhabitants, without forgetting the built degradation. This situation was at the origin of several debates about demolition or conservation of this heritage, where some architects (ex: Claude Vasconi, Lacaton and Vassal) were against the idea to remove these districts knowing that the crisis of housing is still current in France, while others persons estimate that partial and/or total demolition is indispensable. If the inhabitants are globally satisfied by the restructuring of public places in these districts, the most important remains to improve inside buildings quality (insulation, exiguity) where degradation is harder to live and to bear. It is what the three architects Frederick Druot, Anne and Jean Philippe Vassal Lacaton have tried to do in a research paper "Plus" (More) on “grands ensembles”. They proposed to adapt these blocks to the current lifestyle: expansion of livable space, sun lounge with full height, garden terrace, but just one (the tower Bois-le-Prêtre in Paris) of those proposed projects in their research is under realization.

For renovation, we think that architectural and urban atmosphere can be considered as most suitable tool for urban diagnosis in these areas. Because classic sociological surveys not give precise idea of real people expectation in terms of atmosphere quality and wellbeing in their district. Solution can be consisting in organizing some “commented walk” with inhabitants; so as to enable them to describe their perception of district spaces (house and public space). These sensitive experiences can be afterward crossed with physical data (microclimatic, sound and other), what allows designers to clarify some discomfort situations raised by the inhabitants and thus to bring an improvement, or simply to ameliorate atmosphere.

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MARGINAL ABATEMENT COST CURVE FOR CO_2 EMISSIONS IN THE MULTY-FAMILY HOUSING SECTOR WITHOUT OR WITH ENERGY EFFICIENY BARRIERS

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Abstract:

First aim of this article is to estimate the CO_2 emissions cuts available in a given building stock. According to our methodology based on a sharp segmentation of the park and a close estimate of refurbishment actions' price and impact on the energy consumption we were able to assess the Marginal Abatement Cost Curve of CO_2 emissions reduction for multi-family building stock in the local area of Grenoble. CO_2 emissions from this stock can be reduced by 72% with casual refurbishment actions. The potential decrease in annual CO_2 emissions reaches300 000 tons. Surprisingly, 92% of the potential decrease is hold by actions that are profitable for a purely rational inhabitant.

Based on those results the second aim of this article is therefore to understand the barriers that prevent housing from implementing refurbishment actions. A case study based on 40 multi-family housings points out liquidity constraints, poor share of homeowners, decision-making in co-ownership and inconvenience as the four main barriers. To integrate those barriers to our model we reduced inhabitants' time horizon and add a fix cost to each refurbishment action. If a reduction in inhabitants' time horizon is not sufficient to explain the poor rate of refurbishment actions observed in the area adding a fix cost of € 15 000 per building is enough to explain them.

Keywords: thermal rehabilitation, local climate plan, barriers to energy efficiency, Marginal Abatement Cost Curve

ACKNOWLEDGEMENTS

This work was done in the frame of the ITEAC project (.i.e. "Integrated Territorial Economic Appraoch for Climate") which aims at gathering methods, data and thinking in order to build a local climate plan. The purpose is to assess, in a bottom-up perspective, the potential and the cost for the reduction of CO_2 emissions for three sectors: transport, building and energy production and supply. A large part of our work relates the first results for the building sector, made in collaboration with ENERDATA. So, we would like to thank Brieuc Bougnoux (Enerdata) and all the researchers linked up with the ITEAC project: LEPII-EDDEN, IDDRI, ENERDATA, VEOLIA, PACTE.

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INTRODUCTION

Since the implementation of the first measures for energy saving and climate preservation, the building's energy efficiency is becoming a core issue in the climate and energy policy

orientations, at the worldwide, European, national or local level. Indeed, this sector represents a large potential for energy savings and CO_2 emissions in the perspective of the implementation of cost effective measures (Price *et al*, 1998, OECD, 2003, De la Rue du Can and Price, 2007, Levine *et al.,* 2007, Ürge-Vorsatz and Novikova, 2008, IEA 2008).

The European Union set up three major directives during the last twenty years aiming at encouraging the Member States to apply minimal requirements on energy performance for the new and existing buildings. The Member States transposed these directives in national law by setting up action plans in order to achieve reducing targets in energy consumptions and GHG emissions.

In France, within the framework of environmental regulation (called the "Grenelle for environment"), a "Grenelle Building Plan" was created with the goal to cut down by 38% the energy consumption to 2020 in existing buildings and by 50% the GHG emission to 2050. It aims in particular at Renovating 400,000 housings each year from 2013 to 2020.

In this context, the forecasting models at national level provide key elements for reaching goals such as the "Grenelle Building Plan" ones (Traisnel *et al*., 2010) as they allow analyzing/testing the public incentives (Giraudet *et al*., 2011). However, the mobilization of local authorities on the energy savings issue in housing is getting stronger (Bailey 2007, Wheeler, 2008). The built up area, which get involved in the Territorial Climate Plan implementation, also enclosed the Grenelle targets regarding this sector in their area. To reach this targets, they use their competences (Housing, town planning etc) to move their territory toward energy efficiency and also provide incentives (financial and non-financial) (IAE-OCDE, 2005, Mckinsey 2008, Criqui *et al*. 2010). Indeed, the mobilization of local authorities on this issue is fundamental because the localization and the context in which buildings were built play a role on there energy efficiency.

That is why our work aims at assessing, at a territory scale, with a bottom-up approach, the environmental and economic impact of technical solutions for rehabilitation and at evaluating the cost of reduction of CO_2 volume. We focus on CO_2 because in the household building sector, this gas represents almost the whole of direct emission of GHG. We produce a marginal abatement cost curve that shows a lot of cost-effective thermal refurbishment measures.

We deal also with the issue of barriers to energy efficiency, in going by an empirical study of multi-family buildings in Grenoble area. We modify our initials assumptions to take into account the two mains barriers identified in this study and produce a new abatement cost curve.

In a first section (§ 0, p.3), we present the main criteria to carry out a relevant segmentation in order to study, from a technical point of view, the building refurbishment, i.e. the type of housing (multifamily apartments), the year of building's construction and the energy source used for the heating system. The criteria selected to carry out a segmentation of the park determine the business as usual scenario of the energy consumption and CO_2 emissions of the existing housing.

In a second section (§ 0, p.5), we come back on the principal technical solutions currently available to reduce building energy consumptions. We observe, for a standard case, the impact of these various solutions on energy consumption and CO_2 emissions.

In a third section (§ 0, p.7), we show the economic impact of these various solutions by analyzing their profitability, through indicators such as payback period, net present value and cost of an avoided CO_2ton. These estimates allow treating on a hierarchical basis the solutions according to their technico-economic effectiveness.

In the fourth and last section (§ 0, p.10), we deal with the issue of the barriers to energy efficiency, by identifying them, starting from an empirical study. We observe then the impact of the modification of the assumptions concerning present preference of the households (by reducing the payback time) on the profitability and on the cost of the CO_2 avoided of the technical solutions.

THE SEGMENTATION OF THE HOUSING PARK

We deal only with multifamily apartments and we hold two main criteria: the year of construction of the buildings and the energy source used for the heating system. We also take into account climatic data, characteristic of the studied zone.

The building's age

The date of construction makes possible to provide key information on materials used for the construction and the thermal characteristics of the building (Table). The delimitation of each period can be done according to:

- Great historical periods marking the urban history such as the Revolution, wars, the Thirty Glorious Years (i.e. the French economic welfare between 1945 and 1975), the oil crisis, etc.
- Modifications of urban policy such as the policy of the post-war period, the stop of the construction of towers blocks etc
- Changes of constructions regulation and standards which followed since 1975.

Period of construction	Context	Building materials	Energy performances
Before 1945	Period "Haussmannienne", no thermal regulation (RT)	Depend on the areas (local materials) Mainly stone and brick	Weak
1945-1974	Post-war period, lot of construction. no RT	Thin walls, in concrete without insulation, no double glazing	Very weak
1975-1981	Oil crisis which induces the 1st RT (1974)	Emergence of prefabricated systems, beginning of walls insulation, ventilation system etc.	Weak_average
1982-1999	2nd RT (1982)	Smaller buildings, generalization of double glazing and wall insulation, beginning of materials certification, beginning of old building's refurbishment	Average
After 2000	3rd and 4th RT (2000 and 2005), (RT 2012 forthcoming).	Reinforcement of wall insulation, reduction of heating needs, increase of the equipments' energy performances ; creation of new labels for buildings' certification	strong

Table 1: *Thermal characteristics of the buildings per period of construction*

The information provided by the last census of the French national institute of statistic and economics studies (INSEE), makes possible to carry out a segmentation of the housing stock on the Grenoble area according to the period of buildings construction. It appears that among the 166,311 housing in this area (including 82% of multifamily apartments), 101,744 housings (61%) were built before 1975 and 76,553 (46%) between 1945 and 1975 (information collected by Enerdata, in the framework of ITEAC project).

The large part of old housings, built with materials and techniques used between 1945 and 1974, shows an important potential for energy savings on this territory.

Heating system

The energy source (gas, fuel, heating network, electricity) and the mode used for heating (central or individual) have an impact on energy consumption. The gap between energy consumption generated by gas and the one generated by electricity is explained mainly by the fact they are expressed in primary energy (ep) which includes the energy lost between the energy production and the supply of energy in the buildings (energy actually used by consumption). The conversion factor from final energy to primary energy is 1 for all fuels (here, fuel and natural gas) and 2.58 for electricity, in order to take into account the output of electricity production and transmission. This factor of 2.58 corresponds to an international convention. It aims to compare energy consumptions according to the various sources used. In France, a controversy exists about this factor because electricity is produced mainly with nuclear power plants (between 70% and 90%) and with hydroelectricity and this factor is thus suspected not to reflect reality by exaggerating the losses related to the production and transport. However when demand peak occurs, the production is done starting from fossil energy (either in France by historical producer EDF, or in another country like Germany which exports it in France). By convention, we preserve this factor of 2.58 and tackle the question of the energy consumption of the residences in primary energy by preoccupations with coherence with the thermal regulation.

Expressed in final energy, the residences heated with electricity are less energy consuming than those heated with other energetic sources. We chose to express consumption in primary energy because the electricity production and transmission are directly related to the demand. On the other hand, expressed in CO_2 emitted, emissions are more “favorable” to electricity, at least in France, because of the large share of the nuclear power in the electrical production.

Assessment of consumption by segment: example of the Grenoble area

In crossing energy consumption by segments resulting from theoretical simulation, with the number of multifamily apartments per segment in the Grenoble area we can (i) estimate energy consumptions and the total CO_2 emissions of the multifamily housing park and (ii) identify the segments which represent the main potential of reductions.

On the figure above, it clearly appears that the buildings from 1945 to 1974 produce the most significant share of energy consumptions and CO_2 emissions.

This is explained on the one hand because this segment represents the largest number of housing in this area but also because, as we explained in section 1, building from this period have bad thermal characteristics and thus large energy loss.

But, the high share of building built in this period (46 % of the total park of multifamily apartments) can’t by itself explain the 63% of CO_2 emissions. Indeed the gap between CO_2 emissions (63%) and energy consumption (56%) is explained by the energetic mix in each period. For instance, the buildings build before 1945 are more heated with electricity (approximately 43%) than those of 1945-1974 (approximately 14%) which are mainly heated with gas (57%).

The segmentation per construction and heating energy mode enables us to draw a representation of multifamily park and to identify the segments on which it is necessary to first operate for

thermal refurbishment. It appears that buildings built between 1945 and 1974 are those on which it is most relevant to act because they have a large potential of reduction.
The determination of the energy consumptions and CO_2 emissions and the identification of the segments which have an important potential for reduction are only the starting point of our study. The final objective of this part is to evaluate the economic impact and environmental various technical solutions.

TECHNICAL SOLUTIONS FOR THERMAL RENOVATION

A broad panel of current technologies exists to carry out energy savings allowing smaller energy consumption than standard practice (Novikova, 2010). These technologies relate to various solutions such as insulation (of walls, roofs, floors etc), improvement of heating system performance, ventilation system. Technical solutions identified here only deal with the reduction of heating consumption. Moreover, we chose "ambitious" measures because of the long lifespan of the equipment in the building, and when heavy work is undertaken (like external wall insulation or boiler replacement), it is unlikely that they are reiterated quickly. This works are called "no regret measures" because it is more efficient to implement them in one time and if retrofit measures are coupled with general refurbishment, it represents a win-win opportunity (Petersdorff *et al*., 2004)

Insulation
The energy losses due to bad walls and windows insulation affect the thermal characteristics of building. If the shares vary according to the date of construction, the main loosing area is often the same: walls, windows and joineries.

- External walls Insulation: it is still poorly developed in France (Orselli, 2008). However, the restoration of the external wall is the good opportunity to add insulation (the repair of the sealing must be carried out every 20 years. This operation can be the occasion to complete work with thermal insulation). Unlike interior insulation, it makes possible to treat a greater number of thermal bridges, without provoking a lost of living space and without decreasing the building inertia. It involves also less nuisances for the occupant during the works and protects the walls against climatic risks. Several techniques of insulation exist, the main one being the installation of an insulating material covered with a coating. The insulators can be alveolar plastics or mineral wool. The effectiveness of the insulation depends on thermal resistance (R) of material used.
- Roofs insulation: they are subjected to the climatic variations (such as thermal freezing, rain, shocks etc.) which deteriorate the roofing and the tightness. The roof thermal losses account for 9 to 11%. The roofs insulation has an important potential for energy saving and its implementation is less heavy than wall insulation. It allows to reduce energy consumption and to improve comfort for the inhabitants in the top floor.
- Low floors insulation: floor lead to losses from 5 to 7% for the independent buildings and up to 9% for the joint buildings. For the apartments located at the ground floor, the floor insulation is a source of energy savings and comfort improvement. It is possible to insulate over or under the concrete flagstone. The choice of one or the other technique will depend on the accessibility of the lower part of the flagstone.

- Windows: thermal losses coming from windows can represent up to 50% of the total thermal losses of a building. In housing, window has several functionalities: it allows improving air quality by natural ventilation and it offers a natural lighting and source of heat by the recovery of thermal contributions of the sun. To reduce the losses, it is

possible either to improve existing windows, or to entirely change them. First solution is possible if original joineries are still in good condition. The second solution is recommended when original windows are in bad conditions. The replacement can be done either by preserving the door frame, or by replacing the complete door frame. Joineries can be out of wood, PVC or metal. PVC framing is most widespread because it resists the bad weather and does not require maintenance unlike joineries in wood. Metal fixed frame (aluminum) is generally reserved for large surfaces windows.

The heating system

According to the French thermal regulation for existing building (RT ex 2005), the electric radiators installed or replaced must be controlled by a powerful integrated electronic device, with at least four operating process (comfort, reduced, no-freezing, stop) and must have timer if they have other functions (blower, towels warmer etc). The standard convectors present very high electricity consumptions. Electrics radiators (with radiant source of energy) offer more homogeneous with low consumption. When the change of radiator is done at the same time or after the insulation of the building, the power necessary will be lower.

Regulation and programming allow regulated heating temperature according to external conditions and free energy contributions. A powerful electric radiator, equipped with a thermostat, can reduce from 5 to 15% the energy consumption compared to an old convector without thermostat.

For the boilers (individual or collective system), considerable progresses were made during the last years. They offer a better output and thus allow reducing energy consumptions. The two principal innovations for boiler are:

- Low temperature boilers: they have an output from 80 to 90%. They allow carrying out 12 to 15% of profits compared to traditional ones,
- Condensing boilers: they reach an output higher than the low temperature boilers thanks to the recovery of the after-heat contained in the steam of the gases combustion which are evacuated by the chimney. They make it possible to carry out from 15 to 20% of profits compared to a traditional boiler. By condensing the steam of combustion gases, they recover energy, allowing a reduction in the fuels needs. Because of their low level of CO_2 and nitrogen oxides, these boilers are also less emitting in GHG.

Ventilation system

The improvement of the ventilation system must be taken into account as soon as people want to optimize the energy performances of the ventilation system (it is a measurement of full-fledged energy saving, because air renewal generates a reducing in energy losses of around 30%), but also as soon as the thermal insulation of housing is improved (in complement of the insulation). Thus, the mechanical ventilation (MV) becomes essential to control air flows necessary to the sanitary arrangements for households.

A system of MV makes it possible to removal the inside air of the buildings while controlling the necessary flow. The air is introduced in frontage, circulates in the buildings then is included in the wet parts (kitchen, bathroom) before being rejected.

With heat recovery ventilation, the extraction and the air intake are mechanized and controlled. With heat exchanger, 90% of the evacuated hot air calories can be potentially recovered. But this technique is less cost effective than MV, because it requires more maintenance and has an electric consumption 2.5 times superior.

The Table 2 sums up the technical solutions that we integrate in our model for assessing reduction potential.

Solutions	Effectiveness	Example of technique
Wall insulation	R = 5	Polystyrene plates (15 cm, λ = 0.03)
Roof insulation	R = 5	Polyurethane plates (14 cm, λ = 0.028)
Floor insulation	R = 2,6	Glass wool (10 cm, λ = 0.039)
Windows	Uw = 1.2	Double glazing, high quality joint, PVC framings
Electric radiator	High efficiency	News radiators with integrated thermostat
boiler	High efficiency	Condensing boilers
Ventilation system	Controlling flow	Mechanical ventilation

Table 2: *Technical solutions used in the model*

We choose these main options for our assessment, but several others solutions exist (technological and non-technological), that will be integrate in our research.

ASSESSMENT OF THE TECHNICAL-ECONOMIC REDUCTION POTENTIAL

Methodology and assumptions

The aim of this section is to assess the marginal abatement cost of CO_2 emissions in the multi-family building stock in a given area (the Grenoble area) according to the cost of the CO_2 ton. The main target is to identify the refurbishment actions considering the price of the CO_2ton which make the investment profitable for society.

For every type of technical solution described in the previous section we calculate the Net Present Value (NPV) with a discount rate of 4%. This rate is used by governmental organizations to assess the efficiency of public investments since 2005 (revision of the actualization rate of public investments, chaired by Daniel Lebègue, Commissariat Général au Plan, January, the 21st 2005). We assume an increase of energy prices of 3% a year (this increase rate corresponds to the projection of IAE in 2008 and is usually used in forecasting models).

The assumption about the technical solutions' life time is based professional building field. We assumed that equipments –heating and ventilation systems- have to be changed after twenty years and the other refurbishment works have a life period of forty years.

Price of refurbishment works are based on a professional database used in building sector (the *Batiprix* database), enlightened with our expertise. We decided to assess the price of refurbishment works on marginal costs instead of total cost for wall and roof insulation. This means that we only took into account the cost of insulator equipment and not the cost of front refurbishment or roof waterproofing. For the other kind of work the cost of the full operation is taken.

To assess the impact of refurbishment actions on the energy bill we used thermal simulation software ("BAO Promodul tertiaire et collectif"), requiring an exhaustive description of the building. This software provides two different ways to evaluate the energy consumption. The first one is the calculus process used in the French regulation (called "TH-c-ex") and the second one, called below the behavioral calculus process, is closer to the German PHPP calculus process. To get more consistent results and to have elements of comparison between those two processes we made the estimation with both of them. After assessment, we chose to use the behavioral calculus process, because the results are closer to the real consumptions according to the developer of the thermal program and empirical verification. Results using THC-ex are not presented in this paper but were done to validate the results presented below.

To describe the buildings we chose between an isolated and an adjacent configuration. We decided to consider every building to be all adjacent both because buildings in the area studied are predominantly adjacent and because it tends to offset the overestimation of refurbishment actions stemming from the additive assumption described in point 0 (p.8).

Besides we assess the CO_2 emission cuts stemming from the refurbishment work over the life period. Based on the spare amount of CO_2 we then evaluate the price of the CO_2 ton that nullify the NPV. This price indicates the cost of CO_2 ton that would make the investment cost effective. For example a cost of CO_2 ton of €48 indicates that a household will not implement the refurbishment measures unless he is forced to pay a fictive tax of at least €48 for every ton of CO_2 they produce.
At this point we have, for every type of refurbishment work in every segment of building, the volume and the cost of CO_2 ton avoided that make the refurbishment work profitable.
In crossing this assessment with INSEE data presented in point 0 (p.4), we can calculate the marginal abatement cost for each segment and classify the different refurbishment work and their global impact according to the price of ton of CO_2 in order to build Marginal Abatement Cost Curve (MACC).
In order to take into account different refurbishment packages, i.e. the combination of various refurbishment actions on the same building, we tested two different hypotheses, one additive and the other cumulative:

- The additive hypothesis assumes that the effects of refurbishment actions are identical in all refurbishment packages. For example, if wall insulation reduces energy consumption by 20% and roof insulation reduces energy consumption by 10% the package would reduce energy consumption by 20% + 10% = 30%.
- The cumulative hypothesis assumes that the relative impact of a refurbishment action remains constant. For example, if wall insulation reduces energy consumption by 20% and roof insulation reduces energy consumption by 10% the cumulative effect would reduce the consumption by 1 – (1-20%)*(1-10%) = 28%.

We tested both assumptions on a couple of cases and finally opted for the additive assumption as it was closer to the software results for the whole package, although the impact was slightly overestimated. The additive assumption is closer than the cumulative one as some refurbishment actions have a synergetic effect. For example, the implementation of a sophisticated controlled mechanical ventilation system is useless if there are high air leakages by the windows. Mechanical ventilation and window change are therefore working in synergy. And if the complete insulation of the building is made the power of the heating system can be lowered.

Results
According to our model, the overall CO_2 emissions of multi-family housings' heating system in an urban area reach the level of 40,414 tons each year. To control our assessment, we compare the initial overall CO_2 emissions stemming from our model to a previous estimate made by the center which made the emission inventory in this area (In Grenoble urban area an inventory of energy consumption and CO_2 emission is conduct by ASCOPARG. This kind of inventory is conducted in almost all urban areas in France). With an estimated level of emissions of 370,000 tons each year for collective housings' heating system emission our results are closed to this estimation.
This level of emissions corresponds to a level of energy consumption of 2,469 GWh of primary energy, about 229 kWh per net floor area square meter.

Figure 1 presents the marginal abatement cost curve taking into account energy gains over the entire life of refurbishment actions.

As we also took into account energy consumption for domestic hot water in collective housings with individual gas boiler, the overall CO_2 emissions are a bit higher than in the previous part. Indeed, annual CO_2 emissions level including domestic hot water in collective housings with individual gas boiler reaches 447,254 tons.
The implementation of all refurbishment actions taken into account can reduce annual CO_2 emissions in the multi-family building sector by 300,000 tons. If we focus on heating system emissions, the potential cutbacks reach 290,000 tons, representing 72% of CO_2. The curve can be broken into three distinct parts:

- The first 20% of CO_2 potential cutbacks have a carbon price below €-200s
- The 72% followed lies in the €[-200; 0] range
- The last 8% have a positive price.

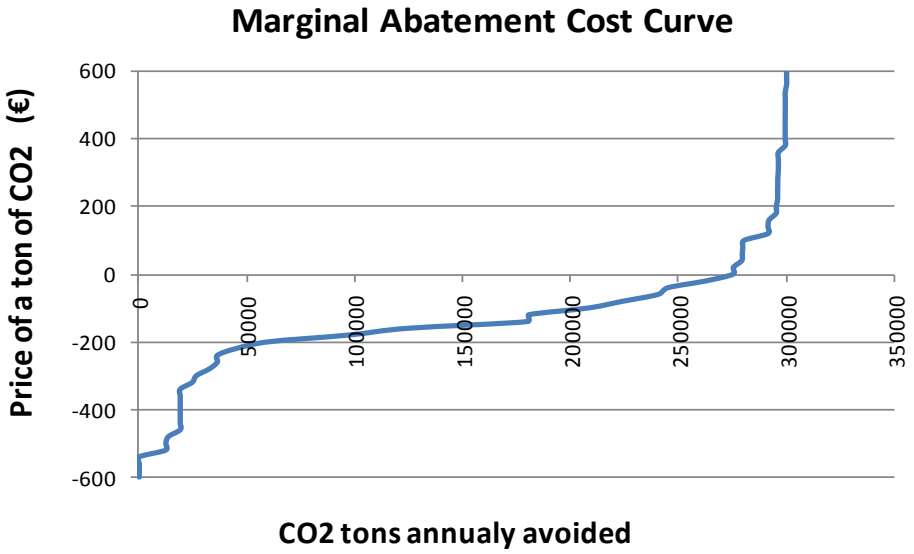


Figure 1: *Marginal abatement cost curve with life cycle analysis*

The reduction potential is different according to the period of construction and the technical solutions:

- Potential CO_2 cutbacks vary greatly with the period of construction: 1945-1975 buildings account for 59%; ante – 1945 buildings account for 27% and post 1975 buildings only account for 11%. As shown on the **Error! Reference source not found.**, the MACC is highly sensitive to the cost of the CO_2ton when its price varies between €-200 and €-20. 48 of the 115 actions are profitable on this price range. Besides, those actions stand for 68% of the potential CO_2 emissions cutback. Multi-family apartments built between 1945 and 1974 account for 44% of total collective housings in the urban area but stand for 60% of the potential of CO_2 reductions. Ante-1975 multi-family housings represent 68% of the overall housings but account for almost 87% of the potential CO_2 cutbacks. Those buildings should clearly be the heart of a low carbon refurbishment plan.
- Refurbishment actions taken into account also have different potentialities. Equipments renewal or installations stand for almost half of the potential, with change of boiler accounting for 26% of the CO_2 decrease and the ventilation system accounting for 20%. Insulation accounts for the other half of the potential, divided between wall insulation -24%-, window replacement -14%, roof insulation -9% and floor insulation -7%. Roof insulation does not account for a large share of potential reduction because of French regulations forced to isolate the roof since 1974. The impact of equipments might be overestimated as some collective buildings might have already replaced their boilers and

as the impact of ventilation system is very difficult to assess. Impact of floor insulation might as well be overestimated as we assume this action to be possible in every situation.

Finally we find four main categories of buildings after our assessment of cost effective measures: untouched (14%), poorly refurbished (i.e. with one or two actions (23%)), well refurbished (i.e. between three and five actions (47%)) and totally refurbished (16%).

The cost of those actions is M€1,793. This gives an average price of CO_2 ton avoided of €3,900.

Implication for energy policy
In France, the 2009 "Grenelle" legislation as the Grenoble Climate Plan, stands that CO_2 emissions in existing buildings have to be cut by 50% until 2050. According to the results presented in Figure 1, this goal should be achieved with a negative carbon cost of -€156 per ton.
Looking closer at refurbishment actions with the national target provides a different perspective concerning their distribution and impact.
At this cost of the CO_2 ton for ante – 1975 buildings stands for 93% of the CO_2 cutbacks, divided almost equally between the ante – 1945 and the 1945 – 1975 periods. Ante 1945 buildings now account for 48% of the potential while they only account for 27% of the overall CO_2 potential decrease, while the impact of buildings built in the 1945-1975 period is lowered.
The price of reaching the policy target is about €375,000,000. This gives a global price of the CO_2 ton avoided of about €2,150 euro. In integrating the reduction of energy bill, the weighted price of the CO_2 ton is -€227.
The main result of this graph is that 92% of CO_2 cutbacks are due to refurbishment measures with negative CO_2 cost, which means that those actions are actually profitable for society and should be naturally implemented. Therefore there are huge lacks in our model, especially in the description of the inhabitant behavior, we can wonder why those refurbishment actions have not in fact been implemented for the overwhelming majority. Understanding those lacks will be the aim of the last part of our article.

ENERGY EFFICIENCY BARRIERS

In spite of many opportunities to reduce energy consumption and CO_2 emissions at low cost, energy efficiency actions are realized at a slower rate than expected (Novikova, 2010). This is due to various barriers such as technological, informational, market-based and behavioral (as bounded rationality) characteristics (Jaffe and Stavins, 1994, Golove and Eto, 1996, de T'Seclaes, 2007, Gillingham *et al.,* 2008).

A case study: a Policy for thermal rehabilitation of 40 multifamily building in Grenoble
A thermal rehabilitation plan in a district of Grenoble was launched by the city. Among the whole technical solutions suggested, all were profitable maximum in 20 years. Moreover, in addition to the national aids (tax credit, loan without discount rate), the city brought a help in order to reduce the payback period. However, among the 43 buildings which had to make a renovation (for aesthetic reasons), which could receive financial aids and which received an energy survey financed by the city, only 22 decided to do energy efficiency works and only 2 did ambitious works (replace the boiler, walls insulation, installation of ventilation system). The others undertook between 1 and 3 operations.
This shows that even if some barriers are reduced, some of household do not invest in energy efficiency.

We carried out interviews with the agents charged to contact the households and to incite them to carry out refurbishment works, the syndics who represent 150 households and some households. From these talks, we identified the following barriers:

- Liquidity constraints: the households do not have the possibility of releasing the funds necessary for work or, when they have savings, they prefer to preserve them for other uses. This shows that the households associate works to an opportunity. Among the owners, the greatest part of them is represented either by old people or by young first-time buyers. According to the syndics, liquidity constraint is the main barrier to invest.
- The weak share of homeowners: for the buildings we studied, less than 50% of the household are owners of their housing. This element strongly reduces the will for an owner to complete work because it is not him which will recover energy saving.
- The decision-making in co-ownership: the decision to complete works, in the case of the condominiums needs a vote in general assembly. This step requires time, implication and negotiations of the whole owners which can cause discouragement. Besides some actions, e.g. roof or floor insulation, have different impacts depending on the location of the flat inside the building. Splitting the cost can be very difficult in some assemblies.
- The inconvenience of the works: this barrier depends on the kind of works, but a part of respondents pointed it out.

The difficulty is to estimate the cost of these barriers in order to determine their impact on the potential and to see how the public authority can face them.

News assumptions and perspectives

The results we presented in the previous section are obtained by assuming no other cost than refurbishment actions and with long term anticipation. This is the reason why the main part of refurbishment actions is implemented with a negative CO_2 price.

To take into account barriers like lack of information, short term view or liquidity constraints, we tested two new assumptions.

First, we reduce the decision maker's time horizon. Reducing the time horizon is a way to account for inhabitant's short term vision but it can also be the consequence of other transaction costs. This modification is equal to an increasing of discount rate. Indeed, we increase the consumer discount rate to reduce the payback period. From a social perspective a low discount rate must be used to identify the economic potential, but from a household perspective, this rate can represent the more or less "short-sightedness" (Frederick *et al*. 2002).

We find a new marginal abatement cost curve with a five year horizon in the inhabitant estimation of the NPV (Figure 2).

Even with a five year time horizon, 43% of the CO_2 potential cutbacks should be implemented with negative cost, but potential decreases with highly CO_2 price sensitive between –100 and 0. 15% of the potential cutbacks have a price below -€100 and only 6% have a price below -€140.

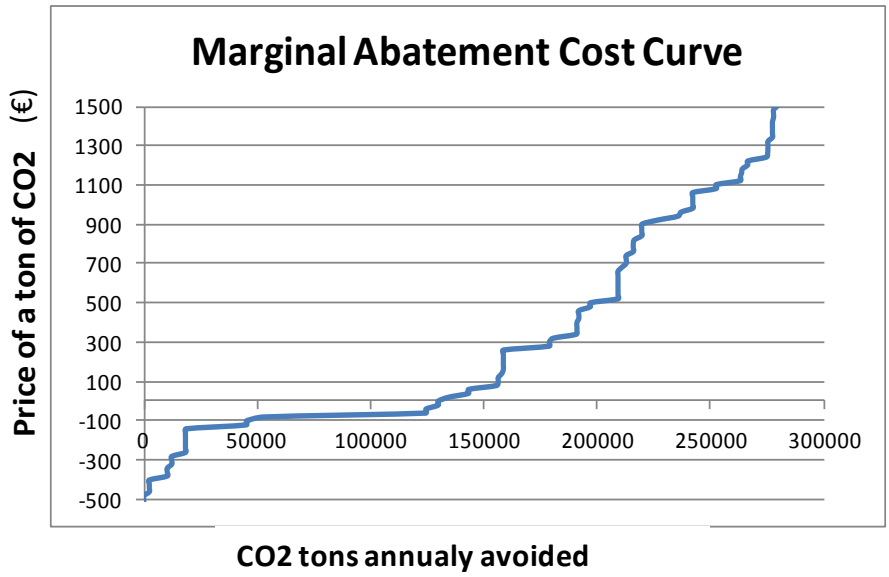


Figure 2: *Marginal abatement cost curve with a five year horizon*

Second, to take into account the inconvenience of such refurbishment actions we added a fix cost to all actions. In our model the fix cost for the building is the same for every type of action, although inconveniences stemming from refurbishment works can vary greatly. In fact, the aim of this part is to assess the sensitivity of the MACC to the fix cost rather than trying to properly estimate those costs.

With a fix cost for the building of €15 000 per action – being €1 071 for ante 1945 buildings and €536 for the rest of them- only 3% of CO_2 cuts are profitable for the inhabitants with a five years' time horizon. The MACC is therefore highly sensitive to the existence of a fix cost. On the contrary, with a fix cost of €20 000 per action for a whole building 75% of CO_2 cuts remains profitable.

A public action targeting the lengthening of inhabitants' time horizon should therefore be very efficient for the barriers that could be model by a fix cost. With the five year horizon and with a fix cost of €15 000 per action, any actions nullifying this cost would lead to an annual decrease in CO_2 emissions of 130 000 tons.

CONCLUSION AND OPPORTUNITIES FOR FURTHER RESEARCH

The methodology developed to estimate initial CO_2 emissions and potential decrease can be implemented for other building stock and should be used by any authority involved in a Territorial Climate Plan.

The first part confirms that the building sector holds a vast potential of CO_2 emissions cuts and that a large part of this potential should be reachable with no expenses from public authorities.

The originality and the main contribution of this article are to bring elements to develop a methodology to understand why those refurbishment actions are not implemented in the real world. The shortening of inhabitants' horizon or the introduction of a fix cost reflecting the inconveniences stemming from refurbishment actions are the two options explored in this paper but other barriers could be questioned in a later work. In particular, liquidity constraint and fix cost dependent from the type or the number of actions are possible assumptions to test. Besides, another development of this work could be the calibration of those barriers based on case study results.

Finally, the households support their decision to invest in energy efficiency measures on a discriminating criteria (improvement of comfort, reduction of noisy, improvement of the inside air quality etc) which decreased the only weight of economic criterion. In such a context, the use of cost effective analysis is relevant to include/understand the policy guidelines and particularly the choice of incentive tools, but it can be interesting to couple it with a multicriteria analysis in order to better comprehend the gap between the theoretical results and the choices of households.

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INFORMATION SYSTEM FOR COST ESTIMATION OF COMMUNAL INFRASTRUCTURE

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Abstract
As in many industrialized countries, the population of Germany is constantly getting older and smaller nowadays. These demographic changes cause adaptations of technical and social infrastructure in both quality and quantity, to ensure their aspects of economy and usability at long term. Therefore, urban development planning and municipal infrastructure planning have to work closely together. Decisions like expansion, renovation, re-dimensioning or even closing of municipal infrastructure should be based on long term strategies of urban development, in order to meet the budget of future remaining costs. For this reason, development strategies and important new projects have to be evaluated within their infrastructural running and life cycle costs.
A current research project in cooperation with a German Municipality will enable the involved planning teams to systematically integrate the consequences of demographic changes in their infrastructural projects in terms of supply quality and cost efficiency. As part of the project, this first study prepares the database of cost indicators and their drivers for municipal infrastructural project cost estimation in early project phases.

Keywords: Urban Infrastructure, Costs Planning, Demography

INTRODUCTION

As in many industrialized countries, the population of Germany is constantly getting older and smaller nowadays. These demographic changes cause adaptations of technical and social infrastructure in both quality and quantity, to ensure their aspects of economy and usability at long term. Therefore, settlement development planning and municipal infrastructure planning have to work closely together. Decisions like expansion, renovation, re-dimensioning or even closing of municipal infrastructure should be based on long term strategies of settlement development, in order to meet the budget of future remaining costs. As well as development strategies and large new projects have to be evaluated within their infrastructural running costs.
In 2009, two Institutes within the University of Stuttgart started a research project together with the City Administration of Stuttgart (Department for Urbanism and Urban Redevelopment) that will enable municipal planning teams to systematically integrate the consequences of demographic changes in their infrastructural projects in terms of supply quality and cost efficiency.

If for example urban planners have the opportunity to (re-)develop two different industrial wastelands (brownfields A and B) as well as one greenfield (C) within the city limits by installing residential wards, the tool to be developed at the end of this project will help to understand the specific financial input in the case of developing each area. These investment and occupancy costs include all necessary social and technical infrastructure by taking into account possible capacities of existing surrounding infrastructure, as long as these assets are integrated into a Geographic Information System (GIS) database. On the other hand, planners will get information on financial output from these new developments, based on e.g. real estate sales and future tax incomes.
These estimations demonstrate financial input and output of possible infrastructure investments over a timeframe up to 20 years and thus represent an adequate planning tool for variations within a single project as well as being a helpful tool for decision making when comparing two or more alternative developments. It might even allow them to fit the financial characteristics of a certain project into the complex municipal budget by finding the right schedule for project start.

The first idea of the proposed tool is based in on a series of precedent research projects in Germany [Preuß et al. 2009], [BMVBS 2011], [Planersocietät 2011]. And the aim of this study is to contribute to this special kind of research while developing a specific and localised tool ready to use together with and for our public partner.

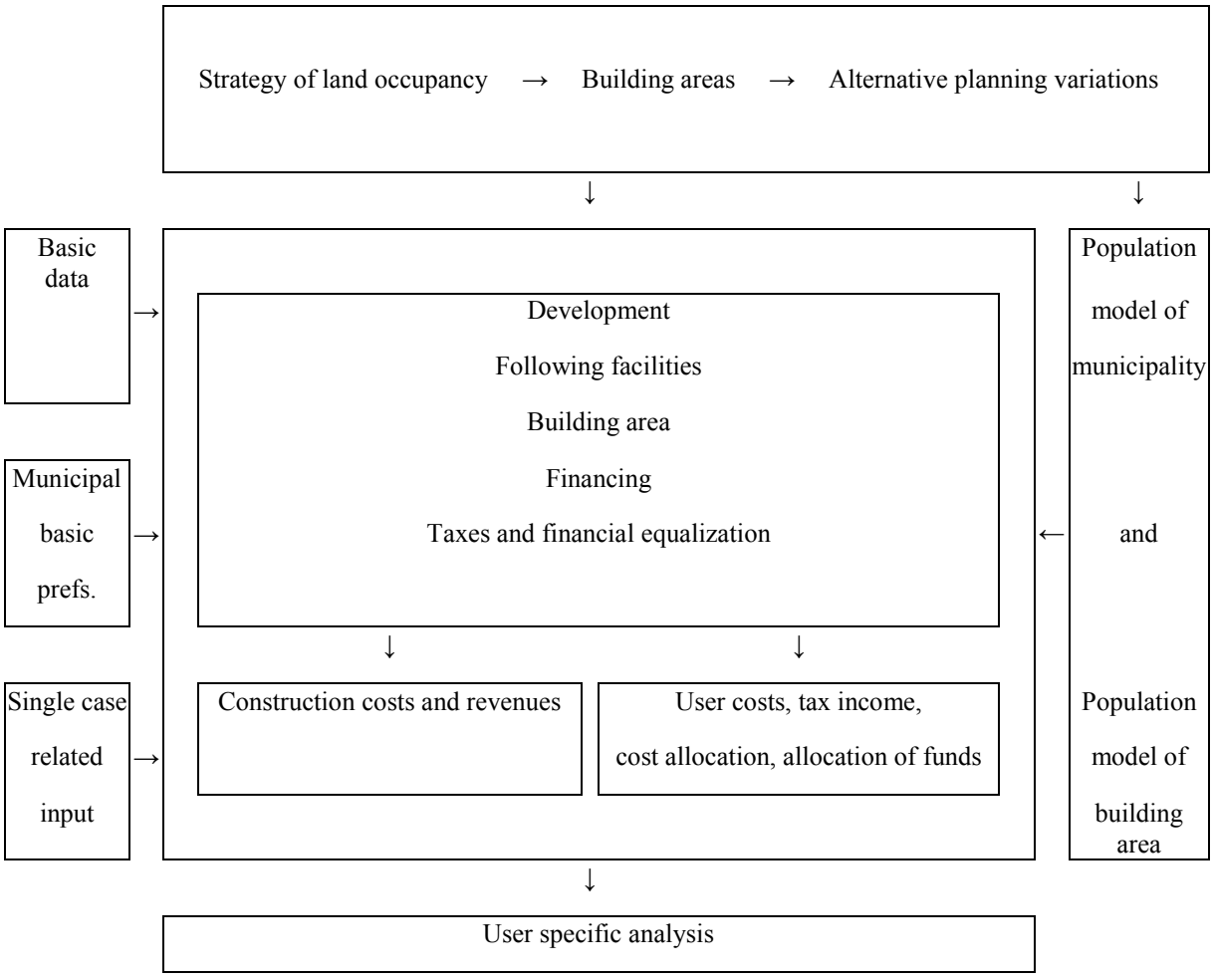


Figure 1 : *System concept and modules; example based on LEANkom [Planersocietät 2011]*

As part of the larger project (compare figure 1), this first study prepares the database of construction cost indicators as well as user cost indicators and their drivers for municipal infrastructural project cost estimation in early project phases.

PROBLEM STATEMENT

Municipal infrastructure in Germany consists mainly of two main types called social infrastructure and technical infrastructure, subdivided in their subtypes as shown in table 1.

	Type	Subtype	Example
Infrastructure	Social Infrastructure	Institution for Education	Kindergarten, School, University, etc.
		Institution for Health Care	Hospital, Rescue Institution, etc.
		Institution for Culture	Museum, Library, etc.
		Institution for Public Administration	Governmental /Municipal Administration, etc.
		Institution for Public Security	Police, Fire Department, etc.
	Technical Infrastructure	Transportation	Public Transport, Facilities for Private Transport
		Communication	Telephone, Internet, Broadcast, etc.
		Supply and Disposal	Water / Sewage, Energy, Waste, etc.

Table 1: *Types of infrastructure*

In order to enable our model to calculate construction and user cost estimations of social and technical infrastructure elements in the area to be developed, we need the necessary quantities and related cost indicators based on the same unit:

Equation 1: $Ce = q_y \times ci_y$

Ce = Cost estimation (construction costs, user costs at a single point in time)
q_y = quantity (based on unit y)
ci_y = cost indicator (based on unit y)

We will learn in a later part of the project how quantities will be defined and managed by the model, so at this stage the correct value of a quantity is taken as given. But it is important to pay attention to the unit of this quantity, as the cost indicator to be chosen has to be based on the same unit. This might be obvious in theory, but in many cases it happens to be rather difficult in real life.
As far as buildings are concerned, measurement of quantities and the related units are defined in detail in the German standard "DIN 277: Areas and volumes of buildings" [DIN 2005]. The corresponding standard "DIN 276-1: Building costs – building construction" [DIN 2008-12] defines the related cost groups for each quantity based on corresponding units for construction costs. And the standard "DIN 18960: User costs of buildings" [DIN 2008-02] defines cost groups for user costs. In addition, cost indicators for building construction costs are largely known and published, e.g. by Building Cost Information Center of German Architectural Associations [BKI 2011], and BKI just published its first user cost indicators for schools and kindergartens [Stoy et al. 2010]. All of this published data by BKI is based on above mentioned DIN standards. This means that most part of the database of cost indicators

for social infrastructure types (buildings) are well defined by specific standards, already collected or published and ready to use for early phase cost estimation.

But it is obviously different in the case of technical infrastructure. Only since two years now, there exists a German standard named "DIN 276-4: Building costs – Part 4: Civil constructions" [DIN 2009], and its corresponding standard of measurements still is missing totally. And nearly every technical infrastructure project in Germany seems to be calculated in a more or less execution oriented way. In that case, some types of technical infrastructure like roads and bridges may be based on a publication called "Catalogue of Typical Specifications for Road and Bridge Construction (Standardleistungskatalog für den Straßen- und Brückenbau)" [BMVBS 2009], but its execution oriented structure makes it quite difficult to use it for early phase cost estimation. In addition, there is no known published German data yet that might be used as cost indicator, neither for construction nor for user costs of technical infrastructure types. Construction companies seem to keep the data as their secret.
Even the German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen, DGNB) – the institution of the German label for sustainability in building construction – would need a reliable database of technical infrastructure cost indicators when it comes to their new label for sustainable neighbourhood development, especially in terms of life-cycle-cost analysis. But their experts who are just about to finish the development of this special type of DGNB label, can only confirm the lack of this kind of published cost data and structure in Germany.
This means that in order to enable the model to estimate construction and user costs of technical infrastructure projects, we have to provide reliable and publicly available cost indicators as well as define the unit definitions both indicators and quantities are based on.

When looking abroad for existing similar and maybe inspiring equivalents, the Swiss CRB (Center for rationalisation in building construction) seems to have one of the most promising systems. By publishing its eBKP-T (SN 506 512) [CRB 2010a] together with eBKP-T Bezugsgrössen (unit definitions) [CRB 2010b], CRB is offering a system to structure infrastructure cost groups and have their relevant measurements clearly defined. Another quality is its accurate and detailed definition on the level of elements, often with the possibility to sum detailed elements up to a higher level of hierarchy, which can be very useful for early phase cost estimation. However, this Swiss system is quite new and cost indicator based on its new structure are still to be developed.
Concerning our project in Germany, the idea of Swiss definition quality and structure has to be transferred and integrated into the existing German landscape of standards, of course.

PREPARATION OF DATA COLLECTION

In the case of the database for estimating social infrastructure, the large quantity of cost indicators published by BKI had been chosen in addition to the corresponding values based on city administration´s own experiences. So far, both datasets had shown to be quite correlative in first tests. The only remaining tasks concerning the non BKI data are to verify the correct measurements of quantities according to DIN 277, the correct cost grouping according to DIN 276 and DIN 18960, as well as the correct application of the construction price index to projects finished in the past years.

The units for cost indicators of social infrastructure might be described in different ways:

Equation 2: ci (Institution for Education) = EUR / m² GFA (BGF)

ci = cost indicator (unit: EUR per m² of gross floor area GFA (Brutto-Grundfläche BGF))
EUR = capital (VAT excluded)
m² GFA = unit of gross floor area GFA (Brutto-Grundfläche BGF) as defined in DIN 277-1

Nearly the whole BKI cost indicator database supplies at least GFA based construction cost indicators of published projects. But in addition to this equation 2 it would also be possible in some cases it to use another approach, depending on the availability of adequate data:

Equation 3: ci (Institution for Education) = EUR / c

ci = cost indicator (unit: EUR per capita of children visiting this type of institution for education, e.g. kindergarten, school, etc.)
EUR = capital (VAT excluded)
c = unit of the number of children visiting this type of institution in the planned area (possible capacities or existing need of education institutions in the surrounding area have to be taken into account)

Concerning the cost indicator database for estimating all types of technical infrastructure, clearly more research is needed. Because of the lack of published data in Germany, together with municipal representatives we decided to take the existing raw data from the specific city administration departments and transform them into compatible cost indicators for our model. First step: measurement of quantities. Due to governmental regulations, all types of technical infrastructure networks had been integrated into a GIS database only recently. But these real length network measurements sometimes are quite filigree and quite complex structures so that their cost indicators need another unit than "EUR / linear m" in order to be applicable in early project phase cost estimations. This is the case for the subtypes "Communication" as well as "Supply and Disposal". The question remains how to handle a road within an area of a new development that is used by a high percentage of people not living or working in this area, e.g. a thoroughfare. Therefore, as far as "Transportation" is concerned, we decided to execute a test drive with "linear m" as unit to be independent of this kind of interfering effects:

Equation 4: ci (Public Road, Type Z) = EUR / linear m

ci (Public Road, Type Z) = cost indicator valid for construction costs of a certain type of public road (types are still to be defined by section measurements, material qualities and other details)
EUR = capital (VAT excluded)
linear m = unit of the quantity, to be measured as middle axis of road section [CRB 2010]

This means of course that the subtype of "Transportation" has to be planned up to a certain level before we are able to get quantities and apply adequate cost indicators. But maybe we will achieve a good range of per capita cost indicators over time.
When it comes to a special kind of infrastructure as for example "Water Supply" and "Sewage", the idea of "Total Population (TP)" is integrated into the equation in order to understand the real requirements concerning this infrastructure network. Total Population represents the sum of inhabitants and the so called "population equivalents" (Einwohnerwert [DIN 2007]) that might be e.g. industrial companies within the examined area that are

consuming water and / or producing sewage equivalent to a population of x members. This value of total population is used to obtain a base for demand planning of the network layout and its dimensions.

As a result, the equation for water supply cost indicators is the following:

Equation 5: ci (Water Supply) = EUR / c

ci (Water Supply) = cost indicator (unit: EUR per capita)
EUR = capital (VAT excluded)
c = unit of the total population [DIN 2007]

It still has to be defined how to handle special punctual facilities within a certain type of network, for example in the case of sewage. What if a new area will accommodate 400 new households and the clarification plant attached to this network is able to integrate this additional load without extra construction costs. And what if, on the other hand, these 400 new households will cause the decision to build a new clarification plant that has capacities for far more than just the 400 x 4 = 1600 total population units (if the architecture of this area is meant to accommodate families). One possible way would be to divide theoretically the construction costs as well as the user costs of these punctual facilities by all possible users, even if the facilities are not always working to their full capacities.

In summary, table 2 provides an overview of the different proposed units allocated to the different subtypes of infrastructure.

Type	**Subtype**	**Example**	**Unit**
Social Infrastructure	Institution for Education	Kindergarten, School, University, etc.	m² GFA (BGF) [DIN 2005]
	Institution for Health Care	Hospital, Rescue Institution, etc.	m² GFA (BGF) [DIN 2005]
	Institution for Culture	Museum, Library, etc.	m² GFA (BGF) [DIN 2005]
	Institution for Public Administration	Governmental /Municipal Administration, etc.	m² GFA (BGF) [DIN 2005]
	Institution for Public Security	Police, Fire Department, etc.	m² GFA (BGF) [DIN 2005]
Technical Infrastructure	Transportation	Public Transport, Facilities for Private Transport	linear m (meter) [CRB 2010]
	Communication	Telephone, Internet, Broadcast, etc.	per capita
	Supply and Disposal	Water / Sewage, Energy, Waste, etc.	per capita of total population [DIN 2007]

Table 2: *Proposed units for early phase cost estimation*

Second step: creating the cost indicators. Fortunately, nearly all elements of the technical infrastructure GIS database in the Stuttgart Department of Civil Engineering have construction costs allocated to them. So we are able to calculate cost indicators for construction costs as soon as we have the measurements in combination with the specific cost totals of the measured areas.

As far as the user cost indicator is concerned, the Department of Civil Engineering did not yet start to integrate these cost types into their GIS database. It is said to be done only within the next two years. So, in order to be able to run the model soon as a test drive, we decided to take a few but typical examples from the recent years and try to calculate these cost indicators manually.

Finally it should be possible in some of the above mentioned cases and under certain circumstances to change the unit of a cost indicator by applying an adequate coefficient. If for example a new development needs a kindergarten for 80 children, but our cost indicator´s unit is "EUR/m² GFA". In that case, the tool should be able to convert either the 80 children into the adequate value of GFA (200 m² GFA at a ratio of 2.5 m² GFA / child), or to convert the value and unit of the cost indicator to get the same result in the end.

CONCLUSION AND NEXT STEPS

The presented research project in cooperation with the City of Stuttgart will enable the planning teams to systematically integrate the consequences of demographic changes in their infrastructural projects in terms of supply quality and cost efficiency. As part of the larger project, this first study prepares the database of cost indicators for municipal infrastructural project cost estimation in early project phases.
Based on specific German standards for cost estimating of building construction and user costs, as well as the large published database available for construction cost indicators and the coming up data for user cost indicators, the integration of estimation construction and user costs of social infrastructure within the model seems to be unproblematic. Concerning the different types of technical infrastructure, the lack of standards comparable to building construction in terms of measurement, unit definition and cost allocation makes it necessary to develop adequate own definitions. The proposed system will soon be applied in order to produce cost indicators for use in early phases cost estimation. As soon as possible, the results should then be tested in one of the next projects to get real life feedback.
A test drive demonstration of the whole model is planned to start April 2011. And we will be glad to present first results and experiences to CIB in June 2011.

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SUSTAINABLE VISIONS FOR THE CAMPUS OF THE FUTURE

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Abstract
Since 2008 new long-term agreements on energy-efficiency have become effective in the Netherlands. Participating organisations of thirty-six sectors have agreed with the Dutch government to make efforts to realise energy-efficiency of 30 percent in the period 2005-2020 and 50 percent - as a guideline - before 2030. Higher education is represented among these sectors. To achieve the energy-efficiency objectives many sectors and associations of organisations have developed sustainable visions and road maps to implement these visions.
This paper will elaborate on the sustainable vision for the sector 'higher education', summarizing the results of a research project, which included an analysis of the higher education sector, scenario studies and strategic choices for the sustainable campus. In the process of developing sustainable campuses energy efficiency is not the only goal, setting a good example for visitors, employees and a new generation of students is another.
The research project consisted of three parts: (part I) the future of the campus, describing the higher education sector, (part II) collecting tools and measures for sustainable development and (part III) combining the components of part I and part II in future models for the sustainable campus. This paper describes the process of developing sustainable visions for the university and campus of the future.

Keywords: energy-efficiency, higher education, university, campus, sustainable development

INTRODUCTION

Background of this research
Research about the sustainable campus starts with more fundamental questions about the future of higher education and the current state of the university campus. The answers are the basis of models for a sustainable campus. Nonetheless, this research project was funded to answer a more practical question, supporting the long-term agreements on energy-efficiency: what measures can be and have already been implemented to achieve sustainability goals? The challenge for the research team was to combine these approaches.

During 2008 new long-term agreements on energy-efficiency have become effective in the Netherlands. These so-called MJA3 agreements replace earlier versions of MJA (an abbreviation for the Dutch "MeerJarenAfspraak"). The current MJA agreement is more

comprehensive than the previous versions and is connected to the Dutch governmental programme on sustainable development ("Schoon en Zuinig" in Dutch, which can be translated in "clean and efficient"). Agentschap NL – an agency of the Dutch Ministry of Economic Affairs and formerly known as SenterNovem – guides all sectors in the process of creating visions and implementing sustainable strategies. MJA agreements have been signed by thirty-six sectors. Higher education represents two of these sectors: universities (academic research institutions) and institutions for higher professional education ("hogescholen" in Dutch).

The participating sectors have agreed to make efforts to realise energy efficiency progress of an average of 30% in the period 2005-2020 and 50% before 2030. For higher education all fourteen (academic research) universities and a group of institutions of higher profession education have signed the agreement. In this paper the term „university" will be used for all higher education institutions (HEIs) in this sector.

Objectives for higher education

The research team believes energy efficiency only makes sense when it is related to a sustainable development in general (as defined by the WCED – Our Common Future 1987). The term "sustainable campus" not only refers to the physical campus, but also to the overall strategy of a university and the individual users of the campus. Higher education is a sector with relatively many people involved: students, employees and visitors. A sustainable campus is dependent on the collaboration of these campus users: are they willing to change their behaviour to achieve energy efficiency goals? At the same time, sustainable solutions on campus can influence the behaviour of these users outside the campus, now and in the future. In time students will be decision-makers themselves, or policy makers on sustainable development. At least, users will take their experiences with sustainable solutions on campus and references of innovative technology to other – working, learning and living – environments. More importantly, many university employees are professors who conduct activities of exemplary nature, like lectures to students, professionals and academic colleagues and articles or interviews for different media. On top of that, visitors expect innovative solutions of universities with world-class reputations on subjects that are related to sustainability. This is all the more reason to aim at „changing the mindset" of the campus users in the process of creating a more sustainable campus.

Changing the mindset of all user groups – students, employees, visitors – by implementing sustainable solutions or by setting a good (visible) example with innovative technology is an extra objective for the sector higher education, apart from the energy efficiency targets. Consequently, this research aimed at two targets: (1) supporting strategies for energy reduction and CO_2 reduction in line with the energy-efficiency goals for 2030 and (2) a mindset change for the users of the campus, both students and employees.

Research methodology in three parts

This research project was conducted in three parts: (part I) the future of the campus, describing the higher education sector, (part II) collecting tools and measures for sustainable development and (part III) combining the components of part I and II in future models for the sustainable campus. For each part a range of sources was used. Part I and II started with literature review and document analysis, exploring the future of higher education and (strategies for) the Dutch campus for part I and the existing sustainability tools and measures for part II. Furthermore, many workshops among campus managers, students and other experts on and user groups of the campus supplied additional ideas or validated the results.

Examples are workshops with campus managers and energy coordinators, online questionnaires among students and employees in higher education and workshops among students. The results of these workshops can be found throughout this paper. Figure 1 shows how all three parts of this research are connected in the research structure.

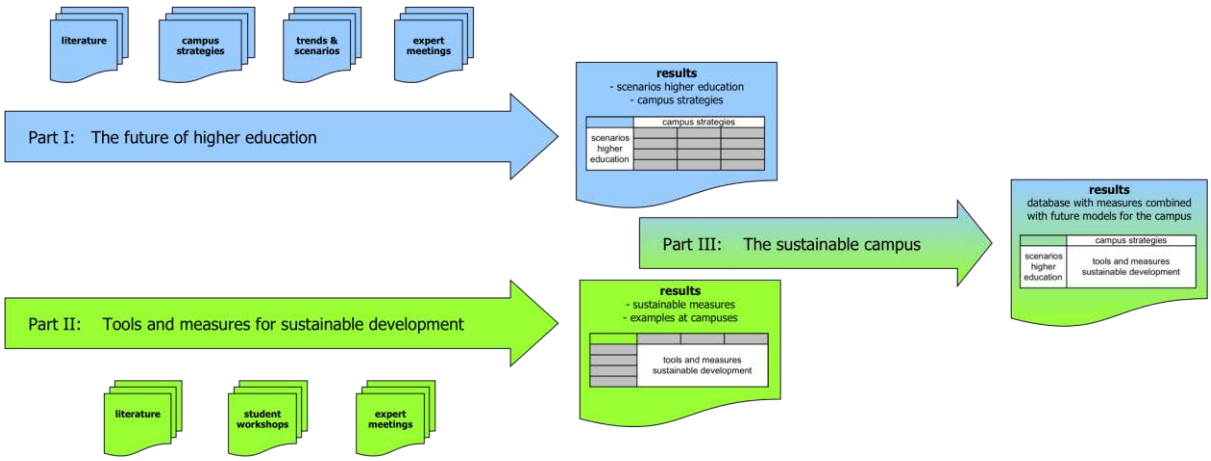


Figure 1: *The research structure in three parts*

The next sections will subsequently elaborate on (part I) the future of higher education, (part II) tools and measures for sustainable development and (part III) the sustainable campus.

PART I - FUTURE OF HIGHER EDUCATION

The future of the higher education sector can be composed by exploring the global developments that (can) influence the university and (can) shape the campus and strategic choices and policies of the universities. Both are described in part I of the research project. Yet, different generations on campus influence decision-making about future models and the support of sustainable solutions. These generations are described below.

Generations on campus

Most students in the higher education are young people in the age group of 18 to 24 years old. The employees, e.g. the scientific staff, the management staff and support services may be of other generations. It is good to realise that there is a visible generation gap between different generations. Generally the following generations are distinguished (e.g. Boschma & Groen 2006; SCUP 2009):

- The Baby Boom Generation follows World War II (1945 – 1955 up to app. 1964). The features are: a demographic bulge, a rejection or redefinition of traditional values, born in large families that they have outgrown, they are raised rigid and authoritarian; they hardly divorce and computers became familiar when they were older: they use them for finding information and surfing the Internet. They do not use chat services or social media.
- Generation X is the generation generally defined as those born after the baby boom ended (1960 - 1985). Children were part of small families - the first divorces also introduced broken families - and they were not raised very strict. As young adults they started to use computers for surfing and information and nowadays you will find them more often on chat services and social media.

- Generation Einstein (also Y or the Millennials) is brought up in the digital information society (1988 – 2000). Children of this generation want their own family, live in different structures and divorces are very common; „love baby" is a keyword in family planning and upbringing is a matter of compromising. Children are raised with computers, which they use as a social machine, chat, self-publishing and sharing, you find them continuously on chat services. This is the current generation of students.
- The next generation Z or I (Internet generation) is characterised as digital natives. These are the students of the future.

Differences between these generations indicate that they will react differently on sustainable measures, also in terms of acceptance. Younger generations will be more inclined to share facilities with other user groups; older generations are used to "unlimited resources", private territory and exclusive use of facilities and will – for instance – not easily accept sharing a workplace with colleagues. The youngest generations have been taught about "the inconvenient truth" of the climate crisis and are more aware of the urge to reduce the footprint, also by sharing floor area and less frequently used facilities with other user groups. Differences between generations might require culture changes to implement some sustainable solutions on campus. For decision-makers it is important to acknowledge that. Nevertheless, the mix of generations at HEIs also offers a challenge to use each other's creativity and ideas and to learn from each other.

Decision-makers on the sustainable campus

While many generation types are present among the users of the campus, it is also important to acknowledge the age profile of decision makers. However relevant sustainability issues are in education and research, it is usually policy makers from the supporting staff that make the decisions on the campus. Facility managers decide on the ecological concepts in the catering and products in the restaurants, energy coordinators are discussing new technologies with their colleagues. Facility manager and campus managers do consult their superiors or colleagues, but they do rarely consult the academic staff about scientific knowledge about state-of-the-art, innovative or even experimental sustainable solutions. For the higher education sector this would be highly recommended, not just to improve the common knowledge about sustainable development, but also to improve the acceptance of sustainable solutions. Academics and students on sustainability could be proud ambassadors of "practicing what they preach" on campus. The age profile of the supporting staff differs from the age profile of the academic staff. Academic staff is relatively young, also because of the PhD students and young researchers. This could lead to a situation in which the traditional policies of a relatively older supporting workforce do not match with the ideas of the younger academic workforce and the students.

These are arguments for the proposition that sustainable campus strategies are most likely to be effective when prepared with members of each user group: students, academic staff and supporting staff. They are not only more likely to be innovative, but also more likely to be accepted on campus.

Scenarios for the future

In 2009 Agentschap NL published a document describing four different scenarios for the future in 2030. With "Agentschap NL" promoting sustainable development and innovation, these scenarios not only describe the future in terms of demography, economy, technology, culture, political choices and sociological developments, but also in terms of sustainability issues or – at least – influences on how sustainable the world will be in each of these futures.

Each of the four scenarios is characterised with many images and with descriptions of economic growth, consumer profiles, state of the world, societal values, population growth in the world (and in the Netherlands), the power of public authorities, the role of the European Union, (environmental) legislation, entrepreneurship, technological developments and innovation, available resources and available human resources.

The main scenario variables that distinguish the four scenarios are (I) globalisation versus regionalisation and (II) individualisation versus social integration. Combining these two variables results in the four scenarios (see Figure 2):

(1) Global market – combining globalisation with individualisation: the world as the playing field for competitive organisations and individuals;
(2) Global solidarity – combining globalisation with social integration: the world as the collective playing field to collaborate for mutual growth;
(3) Transatlantic region – combining regionalisation with individualisation: the region or own country as a habitat to compete with other;
(4) Regional community – combining regionalisation with social integration: the region as a community to collaborate for mutual growth.



Figure 2: *Agentschap NL scenarios (photo sources: Flick.com; Jason Kuffer, Amirjina, Paolo Màrgari and Stephen Poff)*

For higher education, the research team translated these scenarios in five main variables:
(a) The number of Higher Education Institutes, the size and their profile, compared to 2010;
(b) The funding of higher education, both private and public;
(c) The use of ICT, for education, research and valorisation of knowledge;
(d) The type of students;
(e) The type of scientists – professors and researchers.

1. Global market: knowledge for sale	2. Global solidarity: knowledge to share
(a) More universities and schools compete with each other; (b) More private funding, high student fees; (c) Greater use of ICT for distance learning and research; (d) Calculating students: investing in degrees and shopping for qualifications; (e) Competition between schools for the most talented student and professor, teacher and scientist.	(a) Fewer universities, better networks between universities and better cooperation to diversify the profiles; (b) Mix of public and private resources, but emphasis on (effective use of) public resources; (c) More ICT use to maintain the network and for open source knowledge sharing; (d) Travelling students with a home base; (e) Professors are academic gypsies loyal to their home base.
3. Transatlantic region: knowledge for yourself	4. Regional community: knowledge applied locally
(a) Institutions for specific target group, selection on culture, religion, world-view; education in local language; (b) Less public and more private funding from local business community that depend on local employees and regional economic growth; (c) ICT: closed network to use for individual growth; (d) Students: traditional and uniform, enrol at university close to home, majority still lives at home; (e) Academic staff: traditional, hierarchical – lifelong contracts.	(a) Universities focusing on regional economics / demands; (b) Education in local language, in close collaboration with professional and local economic partners; (c) Strong community with a lot of personal contact, mainly using ICT for file sharing; (d) Students: environmentally conscious, socially active, not necessarily born and raised in same community – feeling responsible for community wherever they study; (e) Academic staff: idealistic, maintaining good balance between work and home, feeling responsible for community.

Figure 3: *Table with scenarios for the higher education with different characteristics*

Additional aspects for each of the scenarios are the partners for collaboration, the changing in student population and community, the changing space demand, function mix and quality requirements, the increased demand for related university functions: residential, related businesses, retail & leisure and infrastructure, the feasibility of environmental goals and sustainable ambitions. Detailed information about all scenarios on all aspects can be found in the research reports (TU Delft 2010).

Opportunities and threats for higher education

All the mentioned developments require rethinking opportunities and threats to sustainable development on the campus of the future. Universities and colleges manage a total of approximately 7 million m^2 gross floor area and have considerable (re)investment programs, seizing opportunities for sustainable development or acting against a number of trends in sustainability under the influence of policy choices. The table (figure 4) below shows these opportunities and threats more explicitly.

Opportunities for sustainable development in higher education and on campus	Threats to sustainable development in higher education and on campus
- Smaller budgets (through public funding) provide more support for sharing facilities and services among managers and end users. - Emphasis on cooperation in education and research encourages shared use of facilities and reduces demand for private space by individuals, sections, departments and even colleges and universities (sharing laboratories that require a lot of energy and money). - Increasing student numbers provide opportunities to intensify usage of existing spaces. - ICT developments can partially replace space requirements with digital tools (instead of labs) or collegerama. - Cooperation with the city (council) in providing campus functions: intensification in usage of urban functions, more opportunities for reuse.	- National and international competition among institutions may lead to: → the same laboratories at every university - or even faculty → wanting to "hang on to" talented scientists and students with facilities, requiring (more) energy and money. - Increasing numbers of students may lead to building more m^2, as more intensive space usage may demand a large culture change for the organization or may not be consistent with policy. - ICT developments may reduce campus size, but increase demand for off-campus space and energy supply (more m^2 and higher energy usage working form home and other locations *). * Energy consumption by 300 college students watching online lectures on 300 different workstations compared to the energy consumption of the construction and maintenance of classrooms.

***Figure 4**: Opportunities and threats for higher education.*

Campus strategies

The three campus strategies are based on literature on the future of the campus (Chapman 2006) translated into similar issues - purpose, meters, users and funds - and used as a framework within real estate research strategies of the Dutch universities (Den Heijer 2007). In the table (figure 5) the characteristics of these strategies are illustrated in comparison.

Strategy A “Back to the Future” (traditional campus) is most similar to the present situation or to the past traditional, closed university model. A university wants to keep a relatively large portfolio of university buildings, most of which are exclusively used by the institution itself. The so-called “exclusive campus” can add to the image or identity of the university, but is also quite expensive and has a relatively large footprint per user. However, in this strategy, the campus is exclusively for the university.

Strategy B “Intellectual Agora” (network campus) represents an open market place for the creation and exchange of knowledge, with the campus as an integral component of the city, where many spaces are shared with other users. This strategy can be characterised as a network campus: the campus is shared with partners of the university.

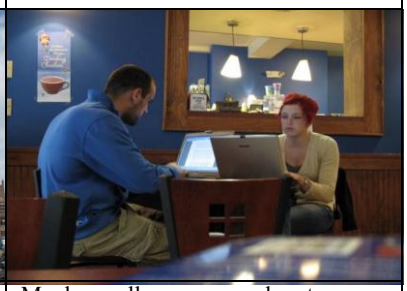
	Back to the Future (A) traditional campus	*Intellectual Agora (B) network campus*	*Clicks & Mortar (C) virtual campus*
			
Purpose	The campus does not change much in comparison with today"s campus The physical campus is gradually adapted to new quality requirements	The campus operates as an open market place for the creation and exchange of knowledge The physical campus increasingly becomes part of the urban fabric, other users are welcome	Much smaller campus due to more working/ learning from home: „dicks" replace some of the square meters (bricks) The physical campus is above all a meeting place: „creative, stimulating and with a focus on intellectual and social exchange"
m^2	Same number of m^2	Same number of m^2 Higher occupancy & usage	Less m^2 Campus is partly virtual
Users	Largely exclusive use of buildings by their own users, also at faculty level	Knowledge institutions make use of each other"s facilities and are no longer the exclusive users of their buildings	Students and lecturers spend less time at the campus, come to the campus to meet others
Euros	Same amount of resources available	More resources due to shared usage – external users pay	Same amount of resources available
Impact on quality	Same money for the same m^2 → Only enough money for "healthy and safe"	More money for the same m^2 → more quality differentiation possible → From "healthy and safe" to „inspiring"	More money for fewer m^2 → higher quality per m^2 → up to "inspiring"

Figure 5*: Strategies for the higher education*

Strategy C "Clicks & Mortar" (virtual campus) assumes there will be a much smaller campus with a great deal of inspiring space for social and intellectual encounters, an important trend in campus design. However, in this last strategy, students and employees will spend most of their time off-campus, while the campus does not supply a fulltime workplace for these user groups. The workplace can be anywhere, but consequently, the workforce is also spread around the world or region. This strategy is also referred at as a virtual campus: part of the university is virtual.

Strategic choices to make are: (1) what do we want to share with others and what do we want to exclusively use ourselves and (2) what part of the floor area can or do we want to we replace with virtual workspace? In essence, these choices have to be made in relation to the strategic vision of the university: what are the university values and how can the campus add to these? Combining these three strategies with the four scenarios creates twelve future models for HEIs, which are illustrated in next table (figure 6).

SCENARIOS STRATEGIES	Global market - Individualisation - Globalisation	Global solidarity - Social integration - Globalisation	Transatlantic region - Individualisation - Regionalisation	Regional community - Social integration - Regionalisation
	Knowledge for sale	Knowledge to share	Knowledge for yourself	Knowledge applied locally
A – "Back to the future" *exclusive campus* - exclusiveness, less sharing of facilities - many m^2 / student and employee - bigger selection, therefore smaller institution(s) - only affordable if higher tuition fees are common	Members Only	New network university	My gated community	Our village
B – "Intellectual agora" *network campus* - more cooperation with others - more frequent sharing facilities - more money / m^2 by renting out - campus = meeting place + workspace	Business & Science Park	Home base for academic gypsies	Campus to share in closed network	Our region
C - "clicks & mortar" *virtual campus* - less m^2 / student and employee - higher quality and more money / existing m^2 - campus only as meeting place - specific demands for workspace at home	Academic internet store	Open source campus	My closed virtual network	Our open virtual community

Figure 6: *Table with future models for HEIs: green indicates a logical scenario-strategy combination, orange is less realistic*

PART II - TOOLS AND MEASURES FOR SUSTAINABLE DEVELOPMENT

Many tools and measures are available to make implement sustainable strategies and to achieve sustainable objectives. In part II of this research project – parallel to part I – data was collected about these tools and measures.

Overview of tools

In the past years several tools have been developed in order (to try) to achieve sustainable ambitions. There are tools that focus on the development of an organisation, on the products or on the physical environment and tools that concentrate on testing the results. In this research the following classification used was: ambition tools, process tools, control tools, design tools, performance tools, prestige tools, user tools, support tools and testing tools. These tools can also be distinguished on the scale size they focus on, the time period during the building process they aim at, the achieved impact on the final results in practise and the effort they demand from the users in order to use the tools. The number of tools is enormous.

Depending on the specific situation, tools are more or less fit for the purpose. The overview of scenarios and strategies shows that the specific situation can differ significantly from campus to campus. This means that for the higher education sector there isn"t just one advise on the usage of tools plausible. The right choice for tools depends on the ambitions, campus culture, the willingness of the users to adapt to measures, the goals and for instance the

current themes. Three general categories of tools exist and can be divided into twelve sub categories (see figure 7): development tools (focussing on organisation and process); development tools (focussing on hardware: the built environment) and testing tools.

In figure 7 the various tools are divided into five categories, also based on prior sustainability research (TU Delft 2010):

1. Achieving a ***sustainable working place / sustainable way of working*** (for both students and staff).
2. ***Make buildings sustainable*** as objects.
3. ***Make the campus sustainable*** as setting or organisation as a whole (including the relationship with external settings).
4. ***Sustainable business process***.
5. Working on a sustainable ***mindset*** (both student and employee) (also visible outside the setting of college or university).

	Development tools 1	Development tools 2	Testing tools
Sustainable workspace	Future studies Vision development System analysis	Ambition tools User tools	
Sustainable buildings		Ambition tools Process tools Design tools Support tools	Performance tools Prestige tools
Sustainable campus	Future studies Vision development System analysis	Ambition tools Process tolls Assessment methods Control tools	
Sustainable (operational) management	Future studies Vision development System analysis	Ambition tools Assessment methods Control tools	
Sustainable mindset	Future studies Vision development		

Figure 7*: Tools for the higher education*

Overview of measures collected by student workshops

To create an overview of possible measures groups of users were asked to give their opinion. Workshops with (international) students were organised to collect information. The students were asked to use the mind mapping method to create an extensive list of measures.

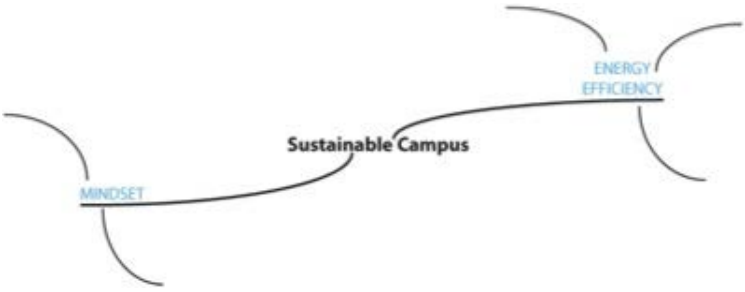


Figure 8: *Mind mapping, a technique used by students during the workshops*



***Figure 9**: Example of mind mapping result of student workshops*



***Figure 10**: Impression of a student workshop*

Notes on the results
The workshops encouraged students to think creatively. The results had some remarkable outcomes. As overall results the students‟ conclusions can be described as:

- Thinking in extreme situations in order to collect a range of measures;
- Ranking the scenarios Global Market or Regional community as their preferences;
- Having a positive approach;
- Thinking in goals and scenarios;
- Finding out that energy efficiency is possible in every scenario;
- Creating a change in mindset depends on the scenario.

The ideas of the students are summarised in a large collection of measurements. The most acceptable ones, that are the ones by the students marked as positive, are used in expert workshop to be ranked by the experts in part III of this research project.

PART III - THE SUSTAINABLE CAMPUS

In order to make future models for the sustainable campus the results of the first two parts of the research has to be combine; to validate the results these were presented for comment by

various groups of expert. These results were very useful to find a way to create a roadmap towards a sustainable campus.

Expert validation

Special expert workshops were organised. The participants were staff members of universities concerned with campus management. Measure lists created during the student workshops were used as input for the expert workshops. The experts were asked to indicate which measures are already being adopted at their organisation, which measures they missed on the list and which measures they did not find fit for their HEI. Through the Internet the questions asked during the workshop were presented in a questionnaire to staff members of other higher education organisations as well. Also members of the DHO platform were questioned: 78 questionnaires were filled out.

All experts during the workshop indicated in the matrix which scenario is the most likely for their specific higher educational organisation. They also indicated the most and least desirable scenario. The figure (11) shows the results of an expert workshop with campus managers and energy coordinators: most respondents expect globalisation; prefer social integration and fear individualization on both global and regional scale.



***Figure 11**: Results of an expert workshop with campus managers and energy coordinators*

The questionnaires contained a long list of measures meant to indicate whether one would like to apply one of these measures or rather not. Also was inventoried which measures are already applied. Most wanted measures were: creating a cold-heat storage (heat pump); possibility to turn all devices off by default (1 button per building), a public display of energy consumption to increase awareness of energy use, more green on the campus, good public transport connections, the use of renewable energy sources, a visible application of sustainability, efficient use of space (more facility sharing), more awareness and applying insulation. Unpopular measures were: the use of greenhouses on buildings for heating, a car-free day, the production of food on the campus, sharing cars, incineration on the campus, a day without printing, the use of recycled toilet paper, fitness as a source of energy and less automatic arrangements.

The measures HEIs already apply are many solutions concerning the organisation and educational courses like competitions, pilot projects, education and symposia to improve awareness of sustainable development among students, staff and guests. Also efficient use of space; insulation; good public transport; separation of waste and turning off the lights (and

computers) at night are commonly use. More ambitious measures are applied, but are not yet common. Nobody applied a day without printing or fitness as a source for sustainable energy.

Conference

On April 27, 2010 sixty to seventy campus users (energy coordinators, campus managers, academics and students) attended a conference about the sustainable campus. However the first two were the largest groups in the audience, influencing the discussion about the propositions. The propositions were supporting by an electronic enquiry system to be able to discuss the collective opinion of the audience immediately and to enable to (anonymously) relate certain answers to the user group, the age or other characteristics of the respondent. Using this technique some of the research results were validated or tested. Some of the conclusions are summarized below.

Conclusions

The audience confirmed that the most probable scenarios are either "Global Market" or "Global solidarity", with the latter being the preferred scenario. The majority of the educational institutions already adopted the measures belonging to the scenarios Global Solidarity (mostly universities) and Regional Community (mostly institutions for higher professional educationally). If they did not adopt those measures yet, those were the most desirable measures. The measures belonging to Transatlantic Region are being judged as least desirable or even negative.

A clear difference is visible between the different goals. The mindset measures are mostly desired, while there is a big difference in the judgement of energy efficient measures.

The majority of the educational institutions will probably focus on the scenario Global Market or Global Solidarity, showing that globalisation is clearly visible in the higher education sector. The experts prefer to focus on social integration. Combining those will lead to Global Solidarity. Most educational institutions fear the Transatlantic Region scenario.

Most respondents are choosing "the network campus" (strategy B "Intellectual Agora") as a preferred strategy and "home base for academic gypsies" as a preferred future model – combining strategy B with scenario "Global Solidarity". However, the audience with mainly supporting staff did acknowledge that the opinions of academic staff could differ a lot.

With various generations in the audience – 67 percent older than 45 years and 33 percent younger – it became obvious that the decision-makers are indeed of a different generation than all students and a large group of academics. Discussions about a question like "Are you willing to share your workplace for a sustainable campus?" illustrated the culture change that such a measure to reduce the footprint would require.

Nonetheless, all respondents confirm that implementing the sustainable campus of the future is a collective task, which requires involving representatives of different target groups.

RESULTS - STARTING POINT FOR THE FUTURE ROADMAP

The research results are merged in a web based tool, which can be used by higher educational institutions in order to create their own future roadmap for 2030.

The vision on the future, based on the choice of strategy and scenario, determines the sustainability factor.

The possible measures are connected on this vision and the educational institution is free to choose a combination of measures to sustain their campus.

The twelve shown visions of the future – combinations of strategies and scenarios – are being arranged in terms of sustainability. Figure 12 shows which visions are most and least sustainable. Three considerations are at the basis:

1. The virtual campus of strategy B is more sustainable than the network campus of strategy B or the exclusive campus of strategy A.
2. Scenarios or strategies (scenario 2 and 4 and strategy B) using collective use of amenities and buildings are more sustainable than the exclusive models such as strategy A and scenario 1 or 3.
3. Due to the transportation aspects the global scenarios 1 en 2 are less sustainable than the regional scenarios 2 and 4. Scenario 2, with its global cooperation, might result in "academic gypsies", and might even result in more travelling in combination with strategy A or B than scenario 1.

A comment on strategy C virtual campus is that the space reduction on the campus will result in space use on other locations, for instance at the private homes of students, teaching staff, due to the fact that a larger workspace might be needed, which has to be heated or cooled down and demands printing facilities (space and energy demand).
Combined with scenario 2 and 4 the virtual campus might need a physical location to meet each other to meet the needs of the social interaction. Should those interactions take place on campus grounds or within the existing structure of the city? Figure 12 shows a sustainability ranking of all future campus models. Again, it should be noted that this is a ranking for the campus. Models C1, C2, C3 and C4 are relatively sustainable campus models, but might cause a larger footprint at the homes of all students and employees at the same time.

	1. Global Market	2. Global Solidarity	3. Transatlantic Region	4. Regional Community
	Knowledge for sale	Knowledge to share	Knowledge for yourself	Knowledge applied locally
A. Back to the future	Members Only	New network university	My gated community	Our village
B. Intellectual agora	Business & Science Park	Home base for academic gypsies	Campus to share in closed network	Our region
C. Clicks & mortar	Academic internet store	Open source campus	My closed virtual network	Our open virtual community

Figure 12: *Sustainable ranking of future models (green to red - from most to least sustainable)*

Web based tool

One of the research results is a web-based tool that combines these models with a database of sustainable measures. This tool is available on the Internet (www.duurzamecampus.nl - currently only in Dutch). With this tool HEIs can share knowledge and experience to work together towards a sustainable campus in 2030. With four scenarios and three campus models as a starting point, the tool leads to twelve possible future models. Based on these, an

impression is given which sustainable measures fit the specific situation of a HEI. While exploring various future models the users of this tool will gradually generate a customised, sustainable vision for their own campuses.

CONCLUSION - COLLECTIVELY CREATING THE SUSTAINABLE CAMPUS

Sustainable campus strategies are most likely to be effective when prepared with members of each user group: students, academic staff and supporting staff. They are more likely to be innovative because of the diversity of user groups on campus – representing different generations. But more importantly, they are also more likely to be accepted on campus, because users have been part of the process and academic staff members can be ambassadors of the practice that they preach. The scenarios, strategies and sustainable measures – also merged in the web-based tool – are a basis for this collective process to create the sustainable campus of the future.

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BUILDING INFORMATION MODELLING AND THE CULTURE OF CONSTRUCTION PROJECT TEAMS: A CASE STUDY

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Abstract
The collaborative use of Information and Communication Technology (ICT) and Building Information Modelling (BIM) across a temporary project organisation (TPO) may represent the future of construction project delivery through greater design coordination, reduced conflict, efficiency savings, and a valuable information stream for use throughout the operational life of a building. However the success of BIM in a TPO is dependent upon participant firms that share compatible technologies, business processes and cultures, led by people who hold attitudes and display behaviours conducive to collaboration. Their collective interaction thereafter defines the culture of the TPO, more often than not resulting in differentiation, or fragmentation: true integration is the exception. This paper presents preliminary findings from a case study of a TPO, identifying differentiated cultures within the project, and explains their causes. It suggests that careful selection of trading partners and focused attention to the establishment of a TPO may mitigate many of these negative outcomes.

Keywords: ICT, BIM, TPO, culture

INTRODUCTION
Building Information Models capture the characteristics and relationships between the parts and assemblies of a building in database form, enabling them to be visualised and their behaviour tracked over time under different operating conditions. Weisberg (2000) highlights the potential this technology has to trigger significant changes in the development, design and building process, yet it has still to gain widespread acceptance in the architectural, engineering and construction (AEC) sector, lagging behind other major industries producing 3D products.

ICT provides a range of technological solutions which have the potential to standardise and streamline business processes throughout the design, construction and operational phases of a building. BIM functionality combined with improved business process alignment between trading partners should lead to increased uptake and integration across the AEC sector, providing adopters with increased profitability and value generation that ICT is said to present. However recent research indicates that psychological phenomena observed in individuals (Brewer, Gajendran & Beard, 2009) and across project teams (Gajendran & Brewer, 2009) can be just as important in determining the business outcomes of ICT/BIM adoption. Moreover, whereas literature suggests that ICT/BIM is generally a force for

integration of the TPO previous research (Brewer & Gajendran, 2010) indicates that this isn't necessarily the case, often leading to differentiation within the team, and even fragmentation. This study reports a meta-analysis of case study data of a TPO assembled to complete an iconic civic building in Australasia, focussing on the involvement of a specialist subcontractor to design and construct the engineered façade. This project was deemed suitable for this study as it utilised BIM, web-based information sharing, and a raft of other ICT. The case study data were initially collected as part of a research project funded by the Co-operative Research Centre for Construction Innovation (CRC-CI), and reanalysed using protocols developed subsequently, resulting in it being subjected to multiple forms of qualitative analysis.

LITERATURE REVIEW

It has sometimes been suggested that the low level of innovation is a consequence of a lack of conviction on the part of decision makers in the industry of the benefits - economic return - arising from its use. Classical economic theory indicates that this is a logical consequence of a rational cost benefit analysis undertaken by potential innovators, resulting in widespread rejection of its efficacy, and indeed on one level this appears irrefutable. However, such business decisions are made by humans, often on the basis of incomplete knowledge of the "facts", influenced by prior experience and also frequently emotion, in a boundedly rational way (Simon, 1991). Business decisions made on the basis of bounded rationality are rarely optimal, instead resulting in "satisficing" solutions, outcomes that can be described as being "good enough".

A better understanding of the influences that shape the attitudes of potential innovators and adopters of innovation, and particularly the attitudinal traits (Venkatesh, Morris, Davis, & Davis, 2003) of strategic decision makers who sanction and dictate their deployment within construction firms and construction project organisations would help innovation levels in the construction industry. However, the human dimension has been largely overlooked by construction industry researchers and policy-makers. At present, no research has been undertaken to comprehensively map the attitudinal profile of innovators in the construction industry.

Describing the attitudinal traits or attitudinal profile of a particular population is a technique that is familiar to both market and academic researchers, across multiple fields and disciplines. However in each case the starting point has to be a pre-existing framework of reference such as Ajzen's (1991) model, or multidimensional attitude profiling (Gann & Salter, 2000). This approach underpins the mapping of the attitudinal domain within which ICT/BIM decision-makers for TPOs operate (Brewer, 2009; Brewer & Beard, 2009). Implicit in this is the understanding that a collection of decision-makers within a single TPO will necessarily develop a group culture, be that positive or negative.

Organisational culture has been variously described as a "strong prescription for success" (Martin, Frost & O'Neill, 2004) and "an interpretation for better understanding" (Willmot, 2000). However in both cases the concept of "cultural analysis" has been mooted as an appropriate mechanism to allow its investigation.

Culture is an emergent feature of a group, which springs from the underlying assumptions and beliefs of its members about what they share in common, how the world operates and

consequently, how they should relate to it. This shapes their attitudes and often their consequent behaviour.

Schein (2004) defines culture as:
...a pattern of shared basic assumptions [beliefs] that was learned by a group as it solved its problems of external adoption and internal integration, that has worked well enough to be considered valid and, therefore, to be thought to new members as the correct way to perceive, think, and feel in relating to those problems. (p 17)

Group culture can manifest itself overtly through rituals and other behaviours, although often the most enduring cultural traits are embedded in the underlying beliefs held by its members (Schein, 2004; Rousseau, 1990). These beliefs can take one of two forms: espoused, and actual.

Espoused or claimed (beliefs) are usually those attributes that people want to be seen to possess, or believe they should demonstrate. By contrast actual beliefs are those made manifest through their unconscious behaviour. Literature (Schein, 2004) suggests that that attempting to understand culture through surface level manifestations alone (e.g. overt behaviour) is unreliable. Schein (2004) recommends surfacing deeper psychological manifestations such as underlying assumptions or beliefs as a more reliable approach. Thereafter it is possible to observe "inconsistencies" or "conflicts" between overt behaviours indicative of claimed beliefs, and underlying beliefs.

The learning or transmission of cultural assumptions or beliefs from one person to another within a group is the way in which group cultures form, whether they form spontaneously (e.g. when a group is thrown together unexpectedly) or by design (e.g. through recruitment of like-minded staff). Various metaphors have been developed to explain the cultural development of groups, likening it to engineered control mechanisms (Archer, 2004), infection (Geertz, 1966), or evolution (Sperber, 1996): where the spread or promotion of cultural traits is not actively initiated or managed there has to be an alternative, naturalistic facilitation process, as in the latter two instances. In the context of this paper the development of project team culture and the cultural influence of the industry beyond the focal project are of central importance.

Many authorities regard the integration of ICT/BIM into construction industry supply chain activities as both desirable and imperative (e.g. Department of Trade and Industry, 2001). This runs counter to its cultural norms and project-centric structure. A conceptual model of the TPO is therefore useful to analyse cultural influences on ICT use in this context (Brewer, Gajendran, & Chen, 2006). Derived from concepts originated by the Industrial Networks School of supply chain management (Ford, 1997; Hakansson & Johanson, 1992) it notes that each organisation within the project consists of a network of interacting actors, resources, and activities, all of which are necessary in order for it to function. Crucially this is extended to include the project, which itself becomes an actant. The model therefore posits that a TPO accretes around a project rather than an individual actor (e.g. the client).

There are a number of ways in which TPOs can be influenced by each other, and that these are not always contractual. Indeed they may not be formally recognised at all, rather being the product of a network of informal contacts and communications (Wasserman & Faust, 1994). It follows that whilst the adoption of ICT might facilitate the communication of ideas and information within a TPO this is only one of a number of possible communication

channels (Gajendran & Brewer, 2007). In the context of the current research it is clear that the characteristics of a TPO have the capacity to impinge upon the formation of culture in relation to the adoption and use of ICT/BIM within a project setting, both in a positive and a negative way.

Brewer (2009) develops model of innovation and attitude to explain the influences affecting the behaviour of decision-makers considering the innovative use of ICT across TPOs in the construction industry. Using Ajzen's Theory of Planned Behaviour (1991) as the point of departure it acknowledges that the ideal decision ought to be to integrate ICT throughout the primary participant organisations in a particular TPO, with its ultimate expression in the adoption of web based communication plus online access to BIM information. A meta-analysis of case study data (Brewer, Gajendran & Beard, 2009) confirmed the model's applicability for analysing the decision-making of key individuals operating within BIM-centric contexts.

The collective attitudes and behaviours of a group of people in large part serve to define their group culture (Schein, 2004). Culture has the ability to influence all areas and activities within organisations, and whilst these are usually thought of as being an individual firm, club or institution, cultural concepts can equally be applied to project teams. It has been observed that the culture of a construction project influences its level and quality of ICT uptake and integration.

Previous research identified the Critical Success Factors (CSFs) for integration of ICT as being: Organisational Commitment; Organisational Attitude to Communication; Rights and Duties of Organisations (in relation to ICT-mediated communications); Investment Drive, and; Risks related to ICT Usage (Brewer & Gajendran, 2006). Subsequent cultural analysis of these revealed that the cultural values espoused by the industry were analogous to the desired cultural values for an optimised project environment, which in turn ought to facilitate ICT integration. Unfortunately in practice it has been found that very few real life project cultures fully reflect these cultural ideals, resulting in a wide disparity between the levels of ICT integration experienced by participants in different projects and at different levels within the project supply chain.

It follows that a comparison of the actual culture of a project with the espoused values of the individual participants provides a basis upon which to identify the issues that lead to sub-optimal levels of ICT integration. The Cultural Analysis Framework for ICT integration proposed by Gajendran & Brewer (2007) maps the actual cultural characteristics of the environment into which ICT is deployed, comparing it to the cultural stereotypes first identified in their CSF study (Brewer & Gajendran, 2006).

RESEARCH METHOD

The underlying principle for this research is exploratory, intended to develop theory. However Brewer and Gajendran (2010) established both the theoretical adjacency of attitudes, behaviour, and culture, and the practical fusion of these concepts in the presence of concurrent principles and codes. These were found in independently conducted interview-based studies of the same people, relating to a common project. In preparation for this study comparisons were made of the coding for themes developed during the authors' doctoral work when applied to case study data developed by each other. Over 85% of the thematic codes developed during their doctoral work (Brewer,2009; Gajendran, 2010) could be

usefully applied to each other's interview data, and since this had been confirmed in a subsequent case study (Brewer and Gajendran, 2010) a rigourous re-analysis protocol was developed to enable the study of attitude, behaviour, and team culture based on a single set of case study interviews and supporting data.

Data re-analysis protocol
Interview transcripts originally developed for the CRC-CI project were subjected to multiple pass qualitative analyses. Each stage was designed to elicit deeper levels of understanding of the data whilst concurrently providing a concise and consistent description of the phenomena thus revealed.

The first pass of each transcript generated a memo, which was written as a "sense-making" exercise that captured the researchers understanding of it. No prior assumptions were made as to the ideas that were likely to be found.

The second pass at the data confined itself to interrogating the memos themselves in order to identify recurring themes. Any ideas considered of interest or relevance were coded by the researchers to generate a code list. This list was cross-referenced to those codes originally developed in Brewer and Gajendran (2010) in order to ensure wherever possible a consistency of terminology: where this was not possible new codes were added, thereby adding to the overall library of codes related to the topic.

The third pass of the data reviewed both the original transcripts and the memos associated with them in order to assign detailed "meaning" to relevant passages.

The final process was therefore one of abstraction, designed to explain the codes and their appearance in the transcripts with reference to both the attitude and behaviour matrix (after Brewer, 2009 - see Table 1), and the cultural analysis matrix (after Gajendran, 2010 – see Table 2).

Case study protocol
The case study was completed over several months during the construction phase of the project, and collected interview data, questionnaire data, participant-derived supply chain maps, and other peripheral data offered by the participants. Five representatives from primary stakeholders in the TPO (head contractor, client's in-house project manager, architect, steel fabricator, client's façade consultant) and three representatives from the façade supply chain (specialist subcontractor, steel fabricator, glass supplier) were interviewed. At the interview each was asked about both their firm's stance in relation to the five critical success factors for ICT integration (Brewer & Gajendran, 2006) and their own personal attitude towards them.

The interview was augmented by their completion of a questionnaire that had also been distributed by post as part of a national survey. The interviewees were also helped to sketch a diagram of the TPO supply chain as viewed from their perspective, indicating both the nature of the relationships with their trading partners, and the nature of the ICT mediated interactions with each of them.

CASE STUDY

The case study project came about subsequent to a design competition where the winning architect prepared sketch plans. These were approved by the client (city council), and were then used to prepare the documentation and cost plans. The key feature of the project was the front facade, known as the "Sculpture Wall", which consisted of an extensive glass curtain wall, curved in three planes. Subsequent to an audit of domestic facade engineering expertise and in accordance with the client's wish to minimise contractual risk (i.e. pass on risks/costs associated with design and construction flaws and delays), an overseas facade engineer was appointed as consultant to the client, who then recommended a suitable specialist subcontractor.

The design package was put out to tender ahead of the main contract for the building. Although slightly dearer than the lowest bid, the specialist subcontractor's bid was accepted. There followed a round table meeting to resolve any remaining difficulties at which the specialist subcontractor pointed out that the steel content of the design was 50% higher than they would have expected. They subsequently tabled an alternative design that used cast aluminium elements and over the next seven months this was collaboratively refined to produce significant improvements at lower cost, with most components being sourced in Asia.

The use of diverse ICT was evident in various parts of the TPO at different stages of the project. Various participants professed to have building product model (BPM)/BIM compatible software and the capability to use it collaboratively, though in reality this did not extend beyond the production of 3D CAD models with limited attached attributes. There was no formalised ICT-mediated communication structure for the TPO, though emailed document distribution was the norm, especially during the early stages of the project. Figure 1 illustrates the structural relationships between the various TPO participants.

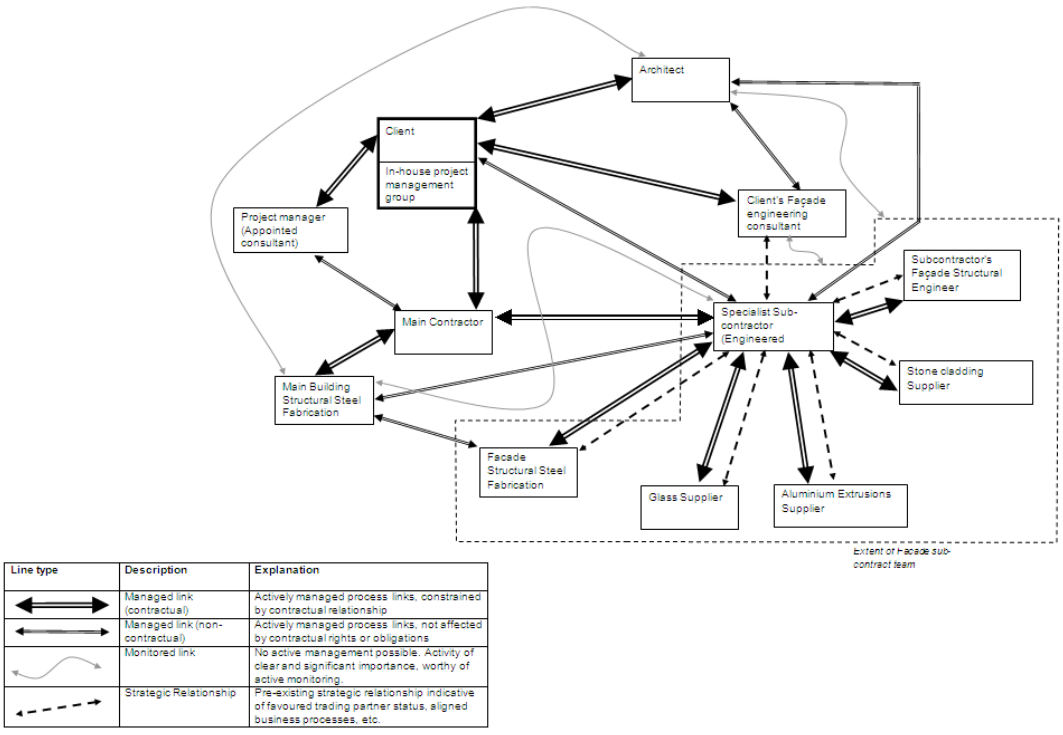


Figure 1. *Supply chain map for the case study project.*

RESULTS AND DISCUSSION

The following sections summarise the outcomes derived from the various analyses/re-analysis of multiple data obtained during the case study. In doing so they reveal the espoused values of the various participants, their true attitudes and beliefs in relation to the use of ICT in the current project, linking them to their subsequent decisions and conduct in the project environment, further linking them to the creation and subsequent development of the project team culture.

When interrogated through the application of a standard questionnaire, originally developed for use in the CRC-CI project (Gajendran, Brewer & Chen, 2005) all of the project participants' responses were found to be within one standard deviation of the sector norms. As a consequence the project participants could be thought of as being a representative sample of industry thought and practice, sharing the espoused attitudes of their colleagues in the industry. Their hopes and concerns in relation to the collaborative use of ICT within project teams therefore centred on issues associated with Organisational Commitment; Organisational Attitude to Communication; Rights and Duties of Organisations (in relation to ICT-mediated communications); Investment Drive, and; Risks related to ICT Usage (Brewer & Gajendran, 2006).

Brewer (2009) revealed that the development of attitudes and subsequent decision-making behaviour in relation to ICT-based innovation was in fact more complex, and reflected a range of boundedly rational influences. These could be summarised in the form of a map, within which the individual attitudinal profile of decision-maker could be located. The attitude and behaviour matrix developed in Brewer & Gajendran (2010) has been populated with data analysis from the study and is shown in Table 1.

Further analysis of the data reveals the aggregated impact that all of the participants' decision-making and conduct within the project team have had on the overall project team culture. The cultural analysis matrix first developed in Gajendran & Brewer (2007) has been used and populated in order to summarise these effects (see table 2). This indicates that out of a potential 17 espoused aspects of ICT integration within the project, only 3 had been integrated on the case study project, with 10 being differentiated and the remaining 4 being fragmented (see table 2, column 3). By contrast the same analysis performed on the specialist subcontractor's own supply chain revealed a very different story, with all but three of the espoused conditions for ICT integration being put into practice, these being inappropriate for a supply chain of that nature (see table 2, column 4).

In many respects this case study is a tale of two supply chains, one associated with the procurement of the building, the other entirely related to the specialist subcontractor. The contrast between the two could not be more stark, with the former being conventionally convened to deliver the bulk of the project, whilst the latter appearing to be bound together strategically in a non-exclusive set of relationships (Blankenburg Holm, Eriksson & Johanson, 1999). It is perhaps telling that the business entre between the two was facilitated by the client's facade engineering consultant, who also had a strategic relationship with the specialist facade subcontractor.

The significance of the strategic relationships in this TPO relate in the first instance to the way in which the specialist facade subcontractor had invested time and resources in establishing stable supply chain relationships with all of its suppliers, particularly in terms of its use of ICT (Blankenburg Holm et al, 1999). This extended to temporarily embedding staff

members in its suppliers firms in a training capacity, to ensure that their use of the available technologies meshed seamlessly with its own. Whilst conventional wisdom seems to indicate that "championing" of ICT innovation is principally the domain of the "informed client" (e.g. NSW Government, 2002) in this case the championing "client" was itself a supplier to the project client, who made no such demands.

Domain	Technological			Human			Business process			Personal		
Participant	Intra	Inter	Term	Intra	Inter	Term	Intra	Inter	Term	Intra	Inter	Term
Client/In-house Project Manager	Commitment to basic ICT infrastructure for common business uses	Little expectation of boundary-spanning ICT but	Long term commitment to intra-organisation integration	Commitment to ongoing staff development Built env. applications low on list of priorities			Tends to be bureaucratic				Appreciative of collaborative ICT use on current project	
Architect	ICT is a mechanism for error reduction in design.		High costs associated with model generation must be sold to client asn		Best to tone down ego when collaborating online. Trust is essential when sharing IP.		Envisages the advent of full virtual prototyping, reflecting the business practices of other industries.	ICT not regarded as a prerequisite during selection of trading partners, however flexibility is required	Essentially an evolutionary process. AEC sector something of a laggard.			
Main Contractor	Commitment to the automation of internal business processes	Disinterested /mistrusting			Tends to cynicism			ICT not regarded as a prerequisite during selection of trading partners			Doesn't believe inter-firm ICT will play a major role during his career	
Client's Façade Engineer	Central to function of business	Regards limited inter-firm interaction as inevitable during the design phase	Long-term, unable to control/limit pace of development					ICT not regarded as a prerequisite during selection of trading partners				
Main Building Fabricator	Commitment to the automation of internal business processes	Little evidence of engagement			Preference for F2F communication/paper esp. during construction phase							
Specialist Façade Subcontractor (SFS)	All staff capable of operating all systems and platforms used in-house	Preference given to trading partners who share similar platforms, but not prerequisite	Serious long term commitment to ICT. Significant portion of annual investment.		Commitment to supporting the training of trading partner staff in required technologies for ICT interaction			Commitment to supporting the training of trading partner staff in required business processed for ICT interaction	ICT compatibility essential prerequisite for doing business	Unwilling to support non-tech savvy staff.	Very aware of the potential for Catastrophe when relying on ICT – inter-personal dimension to be closely monitored	Long-term commitment
Façade Fabricator	Generally supplanting paper-based processes	Happy with interaction with SFS, less so with others in the main building contract	Long-term commitment to ICT for design and fabrication	Staff development to complement and support ICT investment	Able to meet client demand/ willing to adapt to changing client demands			Flexibility required when dealing with clients' requirement for ICT				Long-term commitment
Glass supplier	Undergoing major ICT reinvestment largely in response to client demand	Willing to align with SFS as price for doing business	Long-term commitment to ICT	Staff development to complement and support ICT investment	Willing to accept external input to assist in business process alignment with clients			Flexibility required when dealing with clients' requirement for ICT			Very adaptable, keen to exhibit best practice	Long-term commitment

Table 1. *Attitude and behaviour matrix.*

The contrasting supply chains were populated by individuals whose attitudes mirrored those who were driving the supply chains. On the one hand the client considered itself quite separate from the other participants. On the other hand the specialist facade subcontractor

insisted on high levels of involvement, even in areas of the project where it held no primary responsibility. Throughout the facade supply chain there was never any evidence of resistance to, or resentment of the imposition of specific ICT protocols from its client. All of those who were interviewed from this part of the project expressed appreciation for the streamlined way in which their supply chain relationship operated, leading to improved business outcomes for their respective firms. What cannot be determined from this study is the extent to which the collaborative nature of their relationship with the specialist facade subcontractor was mirrored in their dealings with their customers from other TPOs.

ICT Integration Trait *Successful ICT implementation requires the:*	Organisational trait *For a firm to successful integrate ICT within a TPO:*	Observed culture (TPO) *In this case it was found to be:*	Observed culture (SSC) *In this case it was found to be:*
The commitment of a firm's senior management.	Senior management should embrace ICT and commit to implement ICT in their organisation/when there is potential for ICT to support operations.	Differentiated	Integrated
The commitment of an organisation's employees	Employees need to commit to engage with ICT tools those support/enhance their personal work environment	Differentiated	Integrated
Transparency and trust among project team participants	Members of the team should develop trust and transparency within the project environment	Integrated	Integrated
The identification and sensitive handling of the ownership of the intellectual property generated during a project	Contractual arrangements should encompass safeguard on intellectual property rights.	Differentiated	Integrated
The project team members to acknowledge the sensitivity and confidentiality of other participants' information	Members are guided by explicit codes of practice and informally held ethics and moral values. The source of these value codes may come from the organisation's procedures, personal upbringing or by education.	Integrated	Integrated
A powerful ICT "champion" to support the technologically weaker organisations in project teams	Powerful member should support the weaker members through leadership, collaboration or as a result of their positional power.	Fragmented	Integrated
An organisation's continuous and conspicuous investment in staff development and training	Should continuously invest in their staff ICT development programs and training	Differentiated	Integrated
A "powerful organisation" within the team to impose ICT adoption	Could impose 'power positions' within the project to encourage appropriate level of ICT use in a project environment	Differentiated	Integrated
A "champion" to support all new technology that is to be used across a project team within a firm/Project.	Leadership structure should engage in giving proactive direction in the use of new ICT tools and techniques	Fragmented	Integrated
Standard conditions of contracts that specifically accommodate the issues raised by the use of ICT	Need to maintain contractual clarity in ICT employment through stipulating conditions of contract and adherence to the conditions. This also could be viewed as an industry regulators role.	Fragmented	Differentiated
An organisation to be prepared to engage in long-term collaborative relationships	Preparedness to engage long-term relationships with trading partners.	Differentiated	Integrated
Organisations to commit to ICT as a long-term strategic decision.	Commitment to engage in long term strategic relationships with trading partners to foster return on large ICT investments	Differentiated	Integrated
Organisations to commit to ICT as a project-based tactical decision.	Commitment to engage with ICT in project to project basis in short run in small ICT investments	Differentiated	N/A
The organisations to monitor competitor's ICT adoption.	Need monitor the competitors to gain potential competitive advantage	N/A	N/A
Addressing the fragmentation issues of the project team for improved performance of ICT-enabled operations.	Must engage in procurement methods that minimises fragmentation of project teams.	Fragmented	Differentiated
Organisations try to limit their use of multiple online systems promoted by different project participants.	This factor can be viewed purely as a technical (interoperability) issue, outside of cultural considerations. However, one can relate the espoused values to Item 12 above	Fragmented	Integrated
The security of information is vital in an ICT-enabled project environment.	This can also relate to the espoused values relating to the level of acceptance of ICT security	Differentiated	Integrated

Table 2. *Cultural analysis matrix.*

It is appropriate at this point to remember that the primary stated purpose of technological integration is to reduce the inherent information fragmentation commonly experienced in

industry (Nitithamyong & Skibniewski, 2004), and to look for clues as to why the presence of high-level new technology has apparently failed to achieve its objective in some parts of the industry, whilst proving very successful in others.

In most vital respects the construction project at the centre of this case study was typical of those found in the industry. Many of the key decision-makers who were active in the early stages of the project decided to stick with the tried and tested approaches to project procurement and consequent project team selection. None of these players had sufficient experience with high-level ICT to fully understand its potential or to drive its adoption/integration into the life of the project (NSW Government, 2002). It was therefore purely fortuitous that a project participant chosen because of the technological excellence of its product was in fact the one who eventually championed high-level ICT use across parts of the TPO.

In reality the penetration of high-level ICT/BIM from the specialist subcontractors supply chain into the TPO was quite limited. However the cultural impact of its champion was more profound. Several TPO participants spoke of a change in the culture of the project once the subcontractor became involved. They often cited its willingness to share commercially sensitive information and engage in additional, unrewarded work, thus facilitating speedy problem-solving and improved project performance. This openness and willingness was reported as being infectious, leading others including the head contractor and main building fabricator to reciprocate. No one suggested that this was an act of charity or altruism, but rather a welcome change to the normal expectation that problems in a project necessarily equated to delays, conflict and eventual increased costs. The role of ICT/BIM in facilitating this agreeable flow of information was widely regarded as being incidental, and indeed much of it occurred at a time when all parties had largely moved to an on-site presence, predominantly using paper-based drawings.

A fundamentally different story emerged from the subcontractor's own supply chain where, after a period of experimentation prior to this project a set of fairly stable supply chain relationships had developed. These necessarily spanned international boundaries, were information intensive, and required all parties to invest heavily in them. Their longevity was based in equal measure upon two characteristics: firstly, the ability to deliver quality products, to the right price, at the right time (Blankenburg Holm et al, 1999), and; secondly to engage with the specialist subcontractor using high-level ICT, including BIM-compatible information exchange, in a manner which suited their purposes (Nitithamyong & Skibniewski, 2004). Informal contact with the specialist subcontractor a couple of years later has confirmed the centrality of these principles to their ongoing relationships with supply chain partners:
You know, there are 6 billion people in the world, and it's surprising how difficult it is to find one of them who will reliably supply you with what you need on a regular basis….. When you find someone you can do business with, you cling onto them. They are pure gold. They become family. (CEO, Specialist subcontractor).

The questions remain as to whether the specialist subcontractor's influence on cultural development of the TPO was real or coincidental, and whether the experience for others in the TPO produced a lasting change in their attitude to collaboration or whether it was a purely transient phenomenon. It is unlikely that such complex questions can be satisfactorily answered, and certainly not without a prohibitive amount of forward planning in the design of a longitudinal study that follows the case study participants into further projects. Nevertheless

it is reasonable to speculate that negative attitudes to a variety of issues pertaining to TPO relationships (and the behaviours they trigger) commonly encountered in the industry are in fact cultural artefacts, developed and/or learnt from others over a considerable period of time (Schein, 2004). Such traits are not easy to overcome and yet, as the specialist subcontractor and its trading partners demonstrate, the rewards for doing so can be both enduring and rewarding. It can therefore be further speculated that if the negative cultural traits endemic in the industry have endured because they produce profitable results then positive cultural traits have to produce demonstrably more profitable outcomes in order to supplant them.

Given the foregoing it is perverse that it cannot be assumed that successful ICT/BIM outcomes can, or should be equally attainable by all. In the past ICT/BIM enthusiasts have espoused the notion of ICT integration as a panacea for the industry's ills. In this they have been amply supported, or perhaps even inspired by successive industry reviews (e.g. Egan, 2002), which have promoted industry adoption of the technological and supply chain innovations commonly found in manufacturing. Such playing field-levelling, pain-share/gain-share perspective is inherently egalitarian, and yet modern approaches to the issue such as the American Institute of Architects Integrated Project Delivery system (AIA, 2007) appear to eschew this, preferring a pragmatic technological sectarianism. In accepting the reality of differing levels of technological capability, they also acknowledge differing levels of integration between trading partners, the lowest of which ensures little more than the exchange of CAD data.

CONCLUSIONS

This case study has built upon earlier work by Brewer and Gajendran (2010), which established the theoretical overlap and practical links between the attitude and decision-making behaviour of key individuals within single firms and the resulting culture formed within TPOs. In doing so it has created a reliable methodological framework that can be used for future investigations of ICT/BIM integration within TPOs in the AEC sector.

This paper has presented an example of a highly integrated supply chain and a largely differentiated/fragmented TPO. Earlier studies (e.g. Brewer & Gajendran, 2010; Gajendran, 2009) have suggested that the latter is the industry norm.

These findings raise a number of important questions: Firstly, to what extent is it beneficial or even necessary to integrate the ICT/BIM used in a TPO across all its members? Secondly, what is the nature of the relationship between ICT/BIM integration in a TPO and its culture (i.e. does culture drive integration, does technology shape TPO culture, or is the relationship more complex)? Thirdly, how is ICT/BIM integration experienced and understood by diverse project participants?

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ENDOGENOUS RISK IN UNBALANCED BIDDING

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Abstract
Models of unbalanced bidding in unit price contracts (UPC) can be categorised into two types. The first category assists clients in detecting and contractors in optimising skew bidding. More theoretical oriented models of the second type focus on bidding behaviour in order to study market efficiency. These models predict corner solutions, i.e. zero prices, for unit prices of expected overestimated quantities. However, anecdotal evidence indicates a lack of zero prices in the actual contracts. A possible explanation for this discrepancy is risk-aversion of the contractor. However, none of the models of the latter category have incorporated risk as an endogenous variable. A model of such is presented in this paper.

Keywords: Unbalanced bidding, risk, modelling

INTRODUCTION

Unit price contacting (UPC) is common in the construction industry throughout the world. This contracting form has the client – often a public entity – preparing and taking juridical responsible for the design. The design consists of a bill of quantities with related descriptions of the work. Contractors then submit bids in forms of price vectors, one price for each quantity. The lowest vector product of prices and quantities, i.e. the lowest total price, is awarded the contract.

The simplicity of this contracting form is appealing, which can be one explanation for its frequent use. There are however problems with this contracting form. UPC has been accused of causing the low productivity in the sector. The logic behind this is that the contractor has low incentives to come up with innovations since the clients to a large extent provide rigid contracts on how the work is to be conducted (see e.g. Mandell and Nilsson, 2010).

Another argument against the use of UPC is that it opens up for unbalanced bidding, i.e., that bidders skew their bids in response to having superior information relative to the procurer. Research regarding this issue includes models for client detection and contractor optimisation of skewed bidding. Such models can provide practical guidance to practitioners but they cannot determine the extent of the problem from an efficiency perspective. Other models focus on predicting bidding behaviour in order to study market efficiency. Intuitively, the contractor's perception of risk may be an important part in unbalancing since the concept is based on uncertainty. However, to the best of our knowledge no model has incorporated the contractor's risk in bidding models.

The paper is further motivated by an apparent miss-match between the theoretical models in the literature and the empirical indications. In short, the existing theoretical models predict corner solutions that entail zero bids for overestimated quantities. However, very few zero bids are observed in data. There are potential explanations for this. An argument is made that the institutional setting in Sweden is such that the primary reason for not seeing zero bids in a Swedish data-set must be due to risk concerns among bidders. Thus, this paper sets out to incorporate the contractor's perception of risk as an endogenous variable in an unbalanced bidding model.

UNBALANCED BIDDING

The idea of unbalanced bidding in UPC contracts is not a new concept in research or practice. Gates (1967) and Stark (1974) made some early and influential work on this phenomenon. Unbalanced bidding is sprung out of the fact that the contactor is better informed than the client. This is based on the contractor finding errors in the ex ante bill of quantities, which can be used to his advantage. In general terms, the best informed contractor can both win the tendering and enhance his profits, despite the fact that he may not the most efficient contractor. Hence, the existence of unbalanced bidding entails an inefficient outcome on the market due to information rents.

There are basically two types of unbalanced bidding discussed in the literature; unbalanced bidding through "front loading" the bids and unbalanced bidding based on information rents regarding quantities. Hughes (1982) distinguished the former type of unbalancing as *finance cost/cash flow unbalancing* in contrast to the *error exploitation unbalancing*, described in the above example. Cash flow unbalancing involves the contractors marking up prices on quantities that are scheduled for early completion trading off quantities for late completion (Arditi and Chotibhongs, 2009; Skitmore and Cattell, 2011).

From an efficiency perspective, the problem with front loaded bids is that the client will make the payment to the client earlier than in a situation with full information about costs. Differences between contractors regarding information about the scheduling of the tasks to front load bids in different ways can however be questioned. Scheduling of a construction project has certain elements that cannot be changed. The pavement cannot be laid out before the construction of the sub base of the road is finalised.
Hence, a rather mild assumption would be that front loading does not differ between the contractors and that it is private information about quantities that will be the base for unbalanced bidding. The remaining paper will not deal further with front loading, but will focus entirely on the first type, i.e., unbalanced bidding following from superior information about quantities actually required.

The inefficiency of this type of unbalanced bidding can be illustrated by a numerical example. Consider a setting where two contractors compete for a road investment contract that requires only two inputs, e.g. paving and provision of gravel. A bill of quantities including estimations for gravel and pavement is announced by the client, 100 m^3 and 150 m^2. The contractors differ in the first being more efficient (i.e. having a lower marginal cost) but being less informed about the quantities actually required, i.e., the *ex post* quantities. Contractor 1 bids his marginal cost at prices 10. Assume that contractor 2 has a higher marginal cost than contractor 1 on both inputs but he has private information about the project and predicts that the gravel is underestimated and the pavement is overestimated by

the client. Given this expectation, contractor 2 raises his price on gravel and reduces the price pavement as seen in figure 1.

Ex ante	Bill of quantities	Contractor 1's bid (Uninformed)	Contractor 2's bid (Informed)
Provision of gravel	100 m^3	10	12
Pavement (paving)	150 m^2	10	8,5
Total bid		**2 500**	**2 475**

Figure 1: *Ex ante bill of quantities and bids*

As depicted in figure 1, contractor 2 submits the lowest total bid and wins the contract.

The project starts and contractor 2's prediction, that the quantities of gravel will be increased and pavement decreased, turns out to be correct. As seen in figure 2, contractor 2's skewing of prices based on his expectation of changing quantities made him win the contract and earn higher revenue.

Ex post	Actual quantities	Contractor 1's revenue	Contractor 2's revenue
Provision of gravel	110 m^3	10	12
Pavement (paving)	145 m^2	10	8,5
Final cost for client		**2 550**	**2 553**

Figure 2: *Ex post actual quantities and revenue*

Hence, due to unbalanced bidding the most efficient contractor did not win the contract. The client ended up paying an information rent to contractor 2 i.e. a higher cost than if the most efficient contractor 1 would have won.

EARLIER WORK ON UNBALANCED BIDDING

This section addresses earlier work targeting unbalanced bidding, which consists both of theoretical modelling and empirical studies.

Theoretical models of unbalanced bidding

There is a lack of exact definition of unbalanced bidding. Models are one way of making concepts more concrete. Two types of models have been developed regarding unbalanced bidding.

A first type focuses on assisting practitioners to detect possibilities for unbalanced bidding in the tendering stage and how to exploit these. The detection models supports clients' interests (see e.g. Arditi and Chotibhongs, 2009) and exploitations models assist contractors in optimising the skew (see e.g. Yizhe and Youjie (1992); Cattell et al (2008); Cattell et al (2010).

The second types of models are not designed to provide direct practical guidance to unbalanced bidding. Rather, they focus on predicting and measuring the extent of the phenomena in order to determine efficiency effects. The present paper belongs to this latter category.

In particular, there are two prominent papers in this category. The first is Ewerhart and Fieseler (2003), who model a UPC contract where two tasks are required in order to complete a project; 1 unit of material and *h* hours of labour. The contractors have private information about their type, i.e. being fast or slow in order to finish the task. This information is not known by the client, hence contractors are better informed than the client. The UPC auction starts by the client announcing his estimate on the number of hours required to complete the project. This estimate will be underestimated for slow types and overestimated for fast types. Based on their type, the contractors submit bids i.e. price vectors of material and labour. Final payment is based on the vector product of prices and quantities, where the latter is actual hours put into the project and 1 unit of material.

The usual prediction of unbalanced bidding applies; the slow types face an underestimated client prediction of hours and will mark up the price for labour and compensating the price for material downwards. This will result in a corner solution i.e. one sided bidding, where null bids will be submitted for labour by fast types and for material by slow types. The model predicts that the most inefficient types i.e. the slowest contractor, will win the bidding process. This is due to the fact that the slowest contractor will be able to exploit the gap between the estimated hours and the actual hours put down. The slow types profit function is increasing in hours. Ewerhart and Fieseler (2003) express this as the slow types are being subsidised. In the extended version of the model, it is shown that the subsidy to inefficient contractors will force the efficient ones to bid more aggressively, having a positive effect on client cost.

The second prominent article is Athey and Levin (2001), who model unbalanced bidding in timber auctions. These auctions differ from construction projects as the buyers of timber harvest rights are the bidders, and not the sellers as in a construction project. The model consists of two species of timber and allows the buyers to invest in private information. This is done by the buyers inspecting the tract before the auction in order to estimate the proportion of timber species. The auction starts with the Forest Service (seller) announcing their estimated proportion of timber species and total amount. In reverse order from the above model, the buyers will mark up the price on overestimated timber types and compensate through bidding a lower price on the underestimated type in order to secure a high bid *ex ante* and pay less *ex post*. Payment is made by the actual amount of timber and the ex ante prices. As in the above model, a risk neutral bidder will end up in a corner solution submitting the buyer's reservation price (in the extreme; zero).

The two models differ in respect to what there is asymmetric information about. In Ewerhart and Fieseler (2003) the contractors are better informed about their own ability while in Athey and Levin (2001) they are better informed about the project's characteristics. Even so, both papers predict corner solutions that entail zero price bidding on overestimated quantities.

Empirical studies on unbalanced bidding

The empirical work on unbalanced bidding has focused on capturing the correlation between differences in prices and quantities respectively.

Athey and Levin (2001) have data from both oral (N=697) and sealed (N=63) timber auctions. The study has data on the sellers estimated volume and proportion of timber type, ex ante bids and ex post (actual) volume and proportion of timber type. This data enables the authors to calculate actual payments. Some control variables as number of bidders are also included. The overall conclusion is that private information is used in the bidding by the buyers. However, the information rents are to some extent offset by competition. This empirical result can be related to the theoretical argument put forward in Ewerhart and Fieseler (2003) about the inefficiency of unbalanced bidding being offset by strengthen competition by the efficient contractor.

Regarding sealed bidding, which is the most common auction form used in construction, the study show that 65 percent of the winning bids are skewed in the expected direction. In other words, the direction in which the theory predicts, i.e. raising bids on overestimated type of timber. The empirical models regress the skew parameter, i.e. dollars spent on the overestimated species of wood, on the sellers' misestimate of the tract with some control variables. In accordance with theory the correlation is positive, which the authors interpret as the winning bid incorporating the superior information into the bid.

Bajari et al (2007) test three types of mark-ups in construction auctions, where one is the existence of unbalanced bidding. The data consist of 414 paving contracts from California between the years 1999 and 2000, which contains 1939 bids from 271 contractors. The actual ex post quantities and "Blue book" prices are also available. This data makes it possible to regress quantity overrun on the dependent variable percentage difference between the winning and the blue book price. In accordance to what the theory predicts the correlation is positive, indicating that on average a 10 percentage overrun on quantities will result in a mark-up of approximately 0.27 per cent.

THE LACK OF CORNER SOLUTIONS IN PRACTICE

Both Ewerhart and Fieseler (2003) and Athey and Levin (2001) provide models that theoretically predict corner solutions in the form of bids equal to zero. It is then striking that the empirical studies discussed above, even though they find evidence indicating that unbalanced bidding exist, do not observe zero pricing. The same observation is done in a database under development of UPC for road investments in Sweden.

The lack of zero pricing can be explained by different factors. The most evident ones are

1. That the client or law prohibit zero pricing
2. A reputational mechanism of losing future work
3. That contractors are risk averse

There is however a disagreement regarding the explanatory power of these factors. Bajari et al (2007) argue that that bids with zero unit prices are very likely to be rejected and therefore not very common. Athey and Levin (2001) support the risk-aversion explanation, even though it is not formally modelled in their paper.

The institutional setting in Sweden sheds further light on why there is a lack of zero bids in our Swedish data-set. A recent court order in Sweden challenges the first explanation for the lack of zero pricing. The case regarded a public UPC for road maintenance, which was rejected for being unbalanced with low prices (although separated zero) for one of the tasks (snow ploughing) in the contract. The rejection was appealed by the contractor with the court ruling in favour of the contractor (Förvaltningsrätten i Falun, 2010). There is a paragraph in the Public Procurement act saying that the client can reject a bid if it is too low. The paragraph refers to the overall total bid and not unique unit prices according to the verdict (Förvaltningsrätten i Falun, 2010). This can be interpreted as the law paragraph is not there to secure an efficient use of state funding but to guarantee delivery i.e. not risking standing without a contractor to take care of the state's responsibilities. This court order prevents Swedish clients from rejecting zero unit price bids and moreover inhibits client rejection as an explanatory variable for the lack of such bids on the Swedish market.

Regarding reputational mechanism, there is a law in Sweden (based on an EU directive i.e. this argument should apply to the EU) prohibiting the client to use repeated interaction and self-enforcing contracts (see e.g. Gibbons (2005) for relational contracts) The purpose of the Public Procurement Act is to hinder nepotism of government funded projects with the disadvantage of not being able to use repeated interaction as an incentive. As the law states that every new project should be objectively procured, the contractor cannot take credit for "a job well done" in prior projects. Regarding construction in general and road construction especially, public clients that are subject to this legislation represent a large part of the total amount of clients. The legislation can be used as an argument to downsize the effect that the reputational mechanism has as an explanatory variable for the lack of zero bidding. Even though repeated interaction effect cannot be completely ruled out, as tendering documents can be adjusted for a certain contractor, there is still a law against repeated interaction.

Hence, neither of the first two explanations above have much support in the institutional setting on the Swedish construction market. This leaves risk aversion as a prime candidate to explain the lack of zero pricing in Swedish UPCs.

None of the models above include risk as an endogenous factor in the models. The following section set out to do this.

THE MODEL: RISK AVERSION IN UNBALANCED BIDDING

Assume that two tasks, A and B, are required to produce a product, e.g., a road. As above, we restrict our attention to Unit Price Contract Procurements under which the principal, e.g., the road administrator, specifies quantities for A and B respectively. There are a number of agents bidding in the procurement. Their bids consist of per unit prices on A and B, denoted P_A and P_B. The agent with the lowest total price, $P_AA + P_BB$ wins.

Consider a stylized setting in which there are several agents bidding. These all have the same information as the principal, i.e., they have no reason to suspect that the actual ex post quantities will differ from the specified quantities A and B. We refer to these agents as

"uninformed". We introduce one agent who is better informed about the quantities actually required, A_{true} and B_{true}, than the principal and the uninformed agents. To capture this, we assume that this "informed agent" knows that the *expected* quantities actually required is $A + \alpha$ and $B + \beta$, respectively. It seems plausible that there, ex ante, is some uncertainty surrounding these quantities. Thus, let the required quantities be $A_{true} = A + \alpha + \varepsilon$ and $B_{true} = B + \beta + \eta$, where ε and η are stochastic variables. For simplicity, let $\varepsilon \sim U[\varepsilon_{low}, \varepsilon_{high}]$ *and* $\eta \sim U[\eta_{low}, \eta_{high}]$, where $\varepsilon_{low} = -\varepsilon_{high}$ and $\eta_{low} = -\eta_{high}$ such that the distributions are both symmetrical around zero.

Conducting each task is assumed to be associated with a constant marginal cost. The informed agent's total cost for task A is given by $TC_A^I = C_A^I (A + \alpha + \varepsilon)$ and for B it is $TC_B^I = C_B^I (B + \beta + \eta)$. The net payment received is given by:

$$\pi = (P_A^I - C_A^I)(A + \alpha + \varepsilon) + (P_B^I - C_B^I)(B + \beta + \eta) \quad (1)$$

Where P_A^I and P_B^I denote the informed agent's per unit bid for tasks A and B respectively. As will be shown, the informed agent may let its superior information influence the bid prices P_A and P_B. There are two restrictions limiting the degree to which the bids may be tweaked. Firstly, neither bid must be negative, i.e., $P_A^I \geq 0$ and $P_B^I \geq 0$ Secondly, the total bid, i.e., $P_A A + P_B B$, must be (weakly) lower than the competing bidders' to win. Let us denote the competing bids as P_A^U and P_B^U for task A and B respectively (U denotes that these are the uniform agents' bids). We may then write a "bid restriction" which must be fulfilled for the informed agent to win the procurement as:

$$P_B^I \leq \frac{A(P_A^U - P_A^I)}{B} + P_B^U \quad (2)$$

We will subsequently assume that (2) is binding, as a strict inequality implies leaving unnecessary surplus to the procurer. Thereby, we may use (2) to substitute for the informed agent's bid on B, thus allowing us to optimize over the bid on A only.

The agent may be risk averse. We capture this by letting the agent's expected pay-off be $E\{\pi\} - Rvar\{\pi\}$, where R is a coefficient measuring risk aversion. When $R = 0$ the agent is risk neutral and when $R > 0$ he is risk averse. Using (1) and (a binding) (2) we may express the expected net payment as:

$$E\{\pi\} = (P_A^I - C_A^I)(A + \alpha) + \left(\frac{A(P_A^U - P_A^I)}{B} + P_B^U - C_B^I\right)(B + \beta) \quad (3)$$

and its variance, $var\{\pi\}$, as:

$$var\{\pi\} = \frac{1}{2}\left(\eta_{high}^2\left(\frac{A(P_A^U - P_A^I)}{B} + P_B^U - C_B^I\right)^2 + \epsilon_{high}^2(P_A^I - C_A^I)^2\right) \quad (4)$$

The objective for the informed agent is to choose P_A^I and P_B^I so the expected pay-off is maximized. To facilitate the presentation, let us assume that all agents have the same marginal cost structure and that the competition among the uninformed agent is strong enough to drive their bids down to marginal cost. This assumption allows us to substitute P_A^U and P_B^U in (3) and (4) by C_A^I and C_B^I, respectively, which greatly simplifies the interpretation of the resulting outcome. The expected pay-off is then

$$(A+\alpha)(P_A^I - C_A^I) - \frac{A(B+\beta)(P_A^I - C_A^I)}{B} - \frac{R(C_A^I - P_A^I)^2(A^2\eta_{\text{high}}^2 + B^2\epsilon_{\text{high}}^2)}{3B^2} \quad (5)$$

From (5) we may derive the following first order condition

$$P_A^{I*} = C_A^I + \frac{3B^2\alpha - 3AB\beta}{2R(A^2\eta_{\text{high}}^2 + B^2\epsilon_{\text{high}}^2)} \quad (6)$$

The first term in (6) is the agent's marginal cost. The second is a (possibly negative) mark-up that the agent will apply to his bid on task *A* as a consequence of his superior information. From (6) we can draw a series of conclusions regarding the agent's optimal bidding strategy.

The first observation is that the mark-up increases in α. This is in line with the intuition behind strategic bidding. A positive α implies that the (expected) true quantity is larger than the procured one. Thus, the agent would like to increase the asking price per unit of that quantity and thereby gain from the expected increase in required quantity.

Second, the mark-up decreases in β. This follows from the bid restriction. If the agent increases his bid on task *A*, he must decrease the bid on some other task. As there are only two tasks in this model, this means reducing the bid on task *B*. A positive β implies that also the true task *B* quantity will, in expectation, exceed the procured one. In that case, decreasing the bid for task *B* results in an expected loss on task *B*. Thus, when β increases the bid on task *A* must decrease in optimum, ceteris paribus.

A related observation is found in that if *B*=0, i.e., only task *A* is procured, the second term in (6) is zero. That is, even if α is positive, the agent is unable to bid strategically by increasing P_A^I above marginal cost, as there is no second task with which to compensate the total bid. On the other hand, if *A*=0, which implies that the principal only procures task *B*, but the agent believes that task *A* is needed, i.e., α is positive, he may place a bid above marginal cost for task *A*. In this, somewhat unrealistic case, neither *B* nor β puts any restriction on the bid simply because P_A^I will have no impact on the total bid (as it will be calculated at *A*=0).

Third, and perhaps most interestingly, both the risk aversion coefficient, *R*, and the limits of the probability distributions appear with positive signs in the denominator of (6). The former implies that the optimal bid for P_A^I decreases in risk aversion and the latter that it decreases in the range of the stochastic variables, i.e. the risk. Both these suggest that there is a downside for the agent in bidding strategically following from that this behaviour exposes him to risk. Thus, there is a trade-off between expected net payment and risk exposure. The informed agent may use his superior information to increase the expected net payment by the means of unbalanced bidding, but in so doing the variance of the net payment will increase. The latter refrains a risk averse agent from skewing his bids too aggressively.

That this trade-off is central to the understanding of the agent's behaviour is illustrated by looking at the behaviour of a risk neutral agent. Equation (6) cannot handle risk neutral agents as it would result in a denominator equal to zero. By setting $R = 0$ already in (5) and differentiating the resulting expression with respect to P_A^I yields

$$\frac{\partial E[\pi]|_{R=0}}{\partial P_A^I} = \alpha - \frac{A\beta}{B} \quad (7)$$

Equation (7) shows the extreme incentives involved for an informed risk neutral agent. As long as $\alpha > A\beta / B$, the expected pay-off always increases in P_A^I. That is, we end up in a corner solution stating that P_A^I should be set as high as possible, i.e., a similar outcome as in Ewerhart and Fieseler (2003) and Athey and Levin (2001). The only restriction is through the bid restriction and that we do not allow for negative prices, i.e., what limits P_A^I is that P_B^I must be set to zero. When $\alpha < A\beta / B$, the opposite applies; we will end up in a corner solution only limited by that P_A^I may not be lower than zero. It is only when α exactly equals $A\beta / B$ that a corner solution is avoided. In that case the informed agent will bid his marginal costs.

CONCLUSIONS

Most papers on unbalanced bidding conclude that risk neutral contractors will submit zero unit price bids on overestimated quantities. When making risk aversion endogenous, the model presented in this paper comes up with an internal solution. This result is more in line with the available data.

Apart from risk aversion, the inconsistency between theory and data can also be explained by a reputation mechanism or a ban on zero pricing. The institutional setting of the Swedish construction market gives little or no support to the latter explanations, leaving risk aversion as a prime candidate to explain the inconsistency. This entails that the explanatory value of a model for unbalanced bidding is improved by including the contractor's perception of risk.

The model captures the intuitively appealing characteristics that the contractor's risk perception may affect the extent of unbalanced bidding. It shows that unbalanced bidding increases the expected net payment from the contract. However, it also increases the contractor's risk exposure.

This is captured in the above model through a variable about an informed contractor's level of risk aversion. In line with earlier models in the literature, the model predicts that a risk neutral bidder will maximize skew bidding by submitting zero prices on the overestimated quantities. The model shows that the incentives for such behaviour are very strong. But by allowing the contractors to be risk averse, the model predicts an internal solution without zero pricing which is more in line with the data available.

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BUILDING RENOVATION – A NEW INDUSTRY?

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Abstract
Based on construction economics, building economics and assessments of building service life, the renovation need of buildings is notably higher than the actual amount of building renovation. As energy saving renovations become more common, the volume of building renovation is forecast to grow even further. Building renovation suffers from both a lack of suppliers and tailored solutions.
This study has searched for a reason for this phenomenon. This is a theoretical study in economics, testing the rationalisation ability of three different economics theories, including the theory of construction economics, evolutionary economic theory and the theory of creating customer value.
In accordance with construction economics theory, renovation construction competes in all owner sectors with other expenditures, and since renovations can be postponed, they often are. Demand is not activated by interesting supply or by supply corresponding to the needs. Renovation projects are implemented with a production-oriented new construction concept. In addition, a user-oriented approach does not produce a good outcome if it does not include catering for the special features of renovation construction.

Keywords: renovation, building stock

INTRODUCTION

In developed countries construction has long been used to respond to a quantitative demand for new buildings. There has been a preference to demolish old properties to make way for new construction rather than renovate them. In the past, fires and wars have destroyed the building stock and thereby removed the need for renovation. As a result of new construction, the building stock has expanded greatly, and the cultural heritage it represents is valued as a part of sustainable development.

The battle against climate change has increased interested in renovation. Significant cuts in greenhouse gas emissions can be achieved by making the building stock more energy-efficient. Because the building stock consumes a great deal of energy, it promises a hefty potential benefit. In contrast with many other consumers of fossil-based energy, the energy requirements of the building stock can be satisfied with low-emission sources of energy or with renewable energy.

As a result of the expansion and ageing of the building stock and new requirements for its energy-efficiency, renovation is seen as a growth sector in developed countries. Renovation has also become a commercially interesting market for businesses, as property owners have relinquished their own maintenance organisations.

Renovation is undergoing a transition, with several development alternatives to choose from. Should the existing building stock be made more energy-efficient through renovation, or should existing buildings be replaced with new and more energy-efficient ones? To what extent will digitally produced services, logistics and new forms of working reduce the need for space?

The building stock and its properties have been widely studied. In contrast, renovation has received much less attention from researchers than has new construction. And when it comes to improving energy-efficiency, the focus has been on technological development, without giving proper consideration to how this technology is to be installed in buildings.

RESEARCH QUESTION

The object of this study is renovation as business. The primary aim of the study is to identify a workable theory to describe the development of renovation. A theoretical basis is needed to enable improvements in renovation and thereby respond to identified challenges.

RENOVATION

The term 'renovation' is used in statistics to distinguish between construction work on existing building stock and new construction; it includes both repair work and work undertaken for other reasons. Sometime the superior term for the concept discussed here is not 'renovation' but 'repair', defined as the altering of a built object towards a desired state, either technologically or functionally. Hierarchically they are an umbrella term for the following:

- 'refurbishment' and 'renewal', where a building or parts thereof are renewed,
- 'modernisation', 'rehabilitation', 'retrofit or refit', 'refresh' and 'upgrading', where the quality of the object is significantly improved, for instance by improving the energy efficiency of a building, linking it to the water and sewer networks, or installing a lift,
- 'rebuilding' and 'reconfigure', where the purpose or manner of use of a building is altered, and
- 'restoration', which aims to preserve or bring back the cultural historical value or architectural value of the object.

'Demolition' is the destruction of a building. Materials can be 'reused' or 'recycled'. If a new building is then built on the same plot, even if it is similar to the previous one, this is 'rebuilding'.

THEORIES

Construction economics, a well-developed theory applied in several studies, links construction to development of the social and economic structure (Ruddock, Lopes 2006). According to the theory (Bon curve), the purpose of construction is to build spaces, areas and connections. When they are taken into productive use, construction's proportion of gross domestic product (GDP) shrinks. The utility of the theory has been demonstrated by comparing economies at different stages of development or comparing regional development (Crosthwaite 2000). These analyses have been achieved by comparing construction investments or profits as a proportion of GDP.

The theory describes the market of quantitative demand. In addition to quantity, demand for construction is affected by changing needs (Gruneberg 2009). Even if the economic structure is stable according to quantitative metrics, changes in content require construction. Internal structures do not assume permanent form, in fact their rate of change accelerates. Old economic sectors become more productive, die out, split or generate new sectors. Growing productivity frees up resources for entirely new sectors. According to **evolutionary economics**, among other theories, this sort of development is a prerequisite for sustained growth (Saviotti, Pyka 2004).

With the development of new technologies, a number of different theories have emerged about the birth of new sectors. Observations to the effect that old sectors can split into new ones or that technology can give birth to an entirely new sector can be seen as falling under the rubric of **business economics** (Hamel 2000). Various sector emergence mechanisms have their advantages and drawbacks. When an old sector is reinvented, the resources of the old sector can be harnessed for new activity. Blue Ocean Strategy (Kim, Mauborgne 2005), for example, puts forward a number of cases to demonstrate that it has been possible to renew traditional and even challenging sectors by reconceiving the market. The strategy places value innovations in a key position.

When a sector is conceived from nothing it does not have an old sector's burdens, such as the need to "unlearn" practices or to unlock potential. This route is defended by the theory of Disruptive Technology (Christensen 1997), which says that improvements alone have never had revolutionary effects. Disruptive technology emphasises renewal by way of technological innovation.

New sector generation is studied with reference to a number of sectors. A model of sector generation has been built by drawing together research from different fields (Gustafsson et al. 2010). Generation of a new sector requires a trigger, an industry identity, an activity network and commercial viability.

EMPIRICAL MATERIAL

The explanatory ability of the theories is tested against Finland's renovation market. Three cross-sectional studies of renovation in Finland were carried out by Pajakkala & Lehtinen (1982); Vainio, Nippala & Lehtinen (1991) and Vainio, Jaakkonen, Nippala, Lehtinen & Isaksson (2002). The studies gathered information both about renovation projects and about business participation in renovation work.

Since 2000, Statistics Finland has compiled information about construction companies' renovation activity (Statistics Finland 2010). At the end of the 2000s, qualitative information about renovation was compiled for the Ministry of the Environment's implementation plan for the Strategy for Renovation 2009–2017 (Ministry of Environment 2007), and for monitoring the measures outlined therein. Pipe repairs are examined as an example from the perspective of value return to the client (Paiho et al. 2009).

DEVELOPMENT OF BUILDING RENOVATION IN FINLAND

Building renovation in the 1980'

Drivers. The primary reason for renovations was to save energy and the secondary reason was related to functionality (spatial reorganisation). Deteriorated condition was only the third reason for renovation because on average age of building stock was only 23 years. Building renovation concentrated on buildings constructed before 1960. (Pajakkala, Lehtinen 1984)

Commercial renovation. Most renovation projects were carried out by building owners or their organisations. Only a quarter of building renovation activity was commercial. That was the reason why developers, designers and the industry did not even consider building renovation a construction activity. Nor did the banks what paralleled loans for building renovation with the consumption credit. (Pajakkala, Lehtinen 1984)

Barriers. The undeveloped technology of the construction industry, the inability to produce tailored solutions and the general lack of know-how became the technical challenges for building renovation. Housing associations were unable to decide whether or not to carry out renovations. (Pajakkala, Lehtinen 1984)

In order to resolve the technical issues, a research programme that examined building renovation from 1986-1990 was started in the middle of 1980s. The research programme concluded that building renovation would develop into a secondary sector of the building industry.

Building renovation in the 1990s

Drivers. Changes in use were the reason for renovating other types of buildings. The study found that the efficient use of square meters in new construction led to an increase in the need to renovate even newer buildings. The interiors and fittings of residential buildings were customised, but the structures were not renovated until the technical life span of the building was reached. Proportionately, buildings constructed prior to 1960 were still renovated most often and most extensively. (Matilainen, Lehtinen & Vainio 1991)

Commercial renovation. Commercial building renovation has increased during the decade before the study and by 1990, it accounted for 40 percent of all renovations. (Kontuniemi, Lehtinen & Vainio 1991)

Barriers. A number of areas needed improvement. Know-how was required for surveying, determining the renovation needs, planning the renovation and for carrying out the actual work. Also issues related to cooperation between the different parties of the project needed improvement. Deficiencies were identified in the availability of services connected with building renovation, model agreements and suitable materials, prefabricated products as well as machinery and equipment. The expertise of designers and builders who worked on new constructions was not applicable to renovation projects. The study recommended expanding training to include building owners. (Matilainen, Lehtinen & Vainio 1991)

The renovation technology for prefabricated buildings, as well as the maintenance know-how of real estate owners and the tools to assist them, was added to the existing list of developmental needs. To address these issues, a research programme called Remontti (Renovation) was carried out from 1992-1996.

Building renovation in the 2000s

Drivers. The average age of the building stock is 30 years, which means that half of the building stock has reached an age at which renovation is increasingly required. The fact that the renovations of older public buildings are being postponed is backfiring – and resulting in more costly renovation projects. Still it was obvious that changes in the content of building renovation as well as higher quality requirements will increase the amount of building renovation more than factors such as escalating building stock or ageing. (Vainio et al. 2002)

Commercial renovation. Seventy percent of building renovations was done commercially and at the same time, both the share of the owner's own work and that of voluntary work in building renovation had reduced. The share of commercial renovations increased due to legal requirements to involve skilled labour in the planning and implementation of any projects that received public funding. Structural changes towards partial renovations have increased the share of specialised contractors that carry out the actual work. (Vainio et al. 2002)

Barriers. The renovation of buildings is often neglected due to problems with financing or the high level of associated costs. Financing is a particular problem when it comes to the renovation of public buildings. For residential buildings, decision-making remains the most problematic issue that slows down the renovation activities. The problems in the renovation work itself are often technical, but they may also be related with the quality or availability of resources. (Vainio et al. 2002)

During 2000-2010 many research programs and campaigns have been carried out. Many of them are focused to solve existing mold and moisture problems. Also energy efficiency has been on the research agenda. The ministry of environment has also launched the strategy for renovation 2017 (Ministry of Environment 2007). One part of it is developing renovation processes. The idea is that demand arouses supply.

According the statistics renovation and new building are today nearly equal size. Building renovation can no longer be seen as merely an activity that balances the economic cycles of new construction. From the beginning of 1980' the share of commercial renovation has grown form quarter to 70 percent (table 1).

Table 1. *The development of renovation markets (Source: Statistics Finland).*

	Building renovation % / new %	**Commercial renovation per total renovation %**
1980'	25% / 75%	25%
1990'	35% / 65%	40%
2000'	40% / 60%	70%
2010'	45% / 55%	70%

The share of renovation activities is in Finland lower than in Europe, where building renovation already receives over half of all the investments in construction (figure 1).

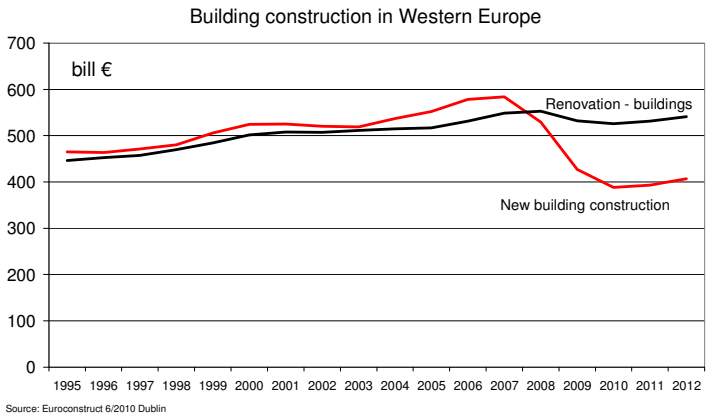


Figure 1. *Building construction in Western Europe, besides European Union member states includes also Norway and Switzersland, but excludes new EU members states*

There is no sign of specialisation in renovation work among companies with payrolls larger than 20 employees (figure 2). Rather the contrary expect HPAC contracting. Companies operating in the expanded renovation market are smaller than this (fewer than 20 employees). Real estate services companies and building materials retailers have also claimed their share of the market. The retail building materials and construction products sectors have developed a range of products for DIY renovation and also provide installation services. Increased demand has been met with technology developed in new construction.

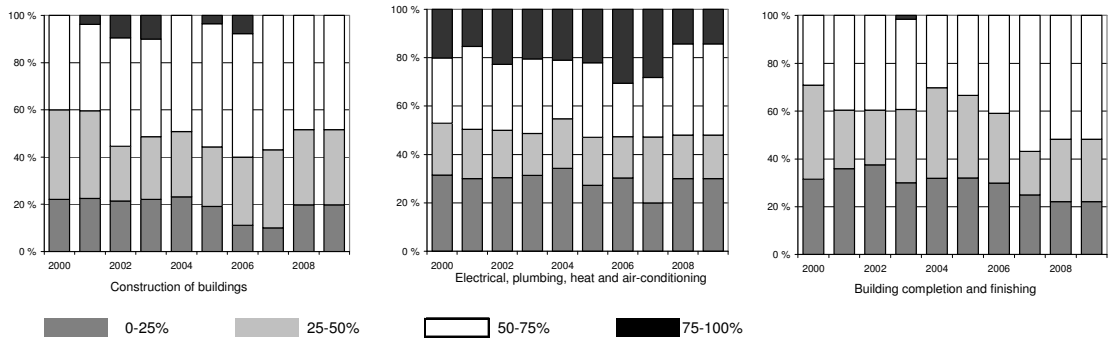


Figure 2. *The turnover from renovation building of building construction enterprises (Source: Statistics Finland).*

Generating customer value

As a result of the age structure of Finland's building stock, pipe repairs have become more common and created demand for special contractors in this field. Demand has created supply, and this is visible in the fact that for a large proportion of companies in this field, renovation is a more important business than new construction. For contracting companies, repair work is an almost identical technical procedure to installation of piping in new buildings. Of course, demolition of old structures and contracting are part of pipe repair work even in buildings that are in use.

Demand for pipe repair work has increased; demand has been met with products and services familiar from new technology. In 2008, both housing companies that had commissioned pipe repairs and the companies that had carried them out were surveyed on their experiences (Paiho et al. 2009). Both samplings were divided into projects that had gone well and gone badly. The customers were divided on the basis of their subjective answer to the question of whether they were satisfied with the purchased service. The businesses were divided according to their feeling as to how well the pipe repair work went.

The group of disappointed customers criticised the service ability of their chosen contractor. The criticism focused almost exclusively on the process. This is a feature that distinguishes renovation from new construction. New construction is an exclusively industrial activity in which, normally, customers only assess the final result. In renovation work, the object of assessment – more than the final result, even – is the process itself.

Satisfied customers valued the contractor's service ability as well as the workmanship and behaviour of the installers. They tolerated the disturbances and inconveniences caused by pipe repair work providing they were informed about them in advance. But if they came without warning, this prompted criticism. For this reason, renovation work is also seen as communications work. Companies also perceive communications to be a challenge. What makes it a challenge is that there is no need for it in the industrial process of new construction, and that non-professionals and professionals lack a common language. The recipients also vary in their ability to draw on and understand the information they are given.

DISCUSSION

Construction is a part of change

The Bon curve theory has been demonstrated by comparing economies at different stages of development. Examined this way, the development of construction has been made to look dramatic. The trend has been depicted in the form of a ∩-curve or even a Λ-curve. One gains the impression that construction is collapsing in developed countries, yet construction has not collapsed as expected, because quantitative demand has changed into qualitative demand and sustained new construction.

Theory that links the amount of construction to the structure of society has counted only new investment as construction. Including renovation does avoid the perception of collapse, but it does not constitute a major change in the theory's direction. Construction as a proportion of GDP in developed countries simply shrinks at a more gradual pace (Vainio 2010).

Disregard for maintenance and renovation has been and, unfortunately, remains the prevailing practice among decision-makers. In deciding on new investments, there is still a failure to simultaneously consider the degree to which future financial resources are committed to maintenance and renovation.

Renovate or replace?

In some cases, renovation work may be left entirely unaccounted for. Buildings may be used until technically or functionally exhausted, demolished, and then replaced with new buildings constructed in their place. This is financially justifiable if the price of the land is high in relation to the building's value, or if demolishing an old building allows a more profitable

business to be built in its place. New construction may be the more economical solution than renovation.

If the strategy is not to demolish and replace old buildings, the amount of renovation activity should grow linearly as a function of the amount of old buildings, and accelerate as a function of the buildings' age. The most surprising result of cross-sectional studies of renovation in Finland has been the high amount of renovation of buildings that are relatively new in relation to their technical operating life. Rather than being prompted on technical grounds, the renovations have been justified with reference to changes in premises requirements, among other factors.

Evolutionary economic theory about sector changes offers an explanation for this phenomenon. Changes and increasing complexity in the structure of the economy demand spaces that are different from those built for previous needs.

Renovation itself also embodies evolutionary growth theory, which says that growth requires both quantitative growth and diversification of content. The accelerating pace of change in economic sectors caused by exogenous variables requires renovation of the building stock. Endogenous growth factors are represented by a growing and ageing building stock. As each new generation of building stock comes up for renovation, the content of renovation activity becomes increasingly diverse.

Money flows matter

As is true of the construction market as a whole, the renovation market can be further divided into markets responding to demand from the private companies and housing companies owned by landlords, public sector and individuals. The two first ones have both revenues and expenses, the two last ones see only expenses.

Demanding clients, primarily construction professionals such as builders of commercial office space, are key drivers in the development and improvement of construction. New office buildings are also more technologically progressive than residential buildings. New construction technologies have first been adopted in construction of office buildings, whence they have gradually also spread to residential buildings.

There has also been a structural shift in commercial office space ownership. Companies no longer own their own premises, but instead operate out of rented premises and can easily move into new ones. Decisions to carry out renovation work on commercial premises are made on financial grounds. The buildings are renovated if it is financially sensible; otherwise they are demolished and replaced with new construction. International investment capital available in recent years has directed funds into new construction, with little effort made to renovate existing premises. Demolition will remain an attractive alternative in future, when implementation of new technologies in service production will see a reduced need for space. The virtual world is already becoming a noteworthy alternative to buildings and construction.

In public sector budgeting, too, decision-makers have been readier to approve new investments than direct funds towards maintenance of existing buildings. New construction has seen the accumulation of a large and, over time, aged building stock, as a result of which renovation needs now exceed the financial resources available to that end.

Housing companies are an interesting customer segment, because the prefabricated high-rise apartment buildings owned by them offer, in terms of their technology, a homogenous and moderately sized market even for companies operating in the local market only. As customers, housing companies are non-professional, decision-making is difficult and choices are made on the basis of price. Housing companies offer a large and interesting market, but they are of little or no help when it comes to product and production development.

Problems identified as far back as the 1980s continue to plague renovation. When problems have been identified, research programmes have been directed towards solving them. The most active actors in research programmes have been officials, property owners and representatives of the construction products industry.

The object of officials' concern has been the condition, housing health and occupational health of publicly funded buildings – especially rental properties. Officials have also been concerned about the condition of buildings in the education and health care sectors. Offices have received their own share of attention thanks to sick building syndrome (SBS). Tools have been developed to manage, assess and research the condition of buildings, to resolve air quality issues, and to plan renovations. What lacks is development of renovation site activities.

THEORY FOR RENOVATION AND FUTURE DEVELOPMENT

Evolutionary economic theory about the splitting of old sectors and the formation of entirely new ones offers an explanation for the growth in demand for both new construction and renovation. It also explains why so many space modifications are made to the building stock.

The development of the construction sector can also be understood in terms of evolutionary theory. Over time, different parts of construction have diverged into their own separate sectors. This trend will continue. New companies will eventually develop in response to emerging markets, while the most active companies will attempt to mould the sector's offering to suit themselves.

According evolutionary theory the development of a sector can push into fast motion internal changes, such as the innovation of a new technology or the discovery of a so-called "blue ocean" in an existing market. Evolutionary economic theory emphasises the impact of external disturbances. In construction, external disturbances have resulted in changes and irreversible effects throughout history. At the 2010 CIB conference, it was observed of the global financial crisis: "a good crisis should never be wasted."

For renovation, such a crisis might be the declared aim to improve the energy-efficiency of the building stock and cut greenhouse gas emissions. Something similar took place in the 1970s. At that time the effects of the energy crisis left their mark on new construction, but not on renovation. The energy-efficiency of buildings constructed in the wake of the crisis improved, and now standards have been set for renovation. Repairs alone no longer suffice; what are needed are much greater energy savings.

Sectors have been successfully renewed in a number of ways. Traditional sectors have been challenged by the emergence of new technologies that allow the same product or service to be produced more cheaply. Old sectors with a strong identity have also been able to reinvent themselves by questioning the status quo and changing their approach.

The construction sector, which has its own strong sector identity, has been able to renew itself. It has moved away from simply meeting demand for new construction to producing a range of services. Companies with an international presence have recently appeared on the market, learning from the global nature and information-intensive approach of the ICT industry. These companies have commodified their activities, concentrated on their product and invested in the expertise and technology it requires.

From the perspective of companies, renovation is divided into several markets. Renovation of commercially owned buildings largely corresponds to new construction of the same buildings. Property owners make professional decisions on renovations and associated purchases in accordance with their strategy. The strategy may emphasise economy or sustainable development. Companies can themselves decide on the conditions on which they bid for contracts.

The market for renovation of public buildings is contradictory but interesting from the perspective of companies. The projects are large but bidding is decided on price, because the renovation needs of public sector buildings outstrip available financial resources. The projects themselves can be completed under production conditions, because in the larger-scale renovations the buildings are evacuated for the duration of the work.

The renovation market in small, household-owned houses and housing companies is substantial but problematic. The project size is well suited to smaller companies, but, as has been seen, renovation completed according to this concept does not achieve great strides in development.

CONCLUSION

This study examined the period from the 1980s, when building construction was not recognised as part of the building industry in Finland. In the past 30 years, the building renovation industry has grown almost as large as the new construction industry. Initially, building renovation was expected to become a subsector for the building industry. It offered companies an alternative market that could be used to balance the effect of the economic cycles on the new construction market. Studies have shown that building renovation requires a different set of skills and technologies that new construction. Despite this, it has been considered possible for a company to alternate between renovation and new construction.

Renovation is only one means of improving the built environment. In future, it will face competition on this front from demolition. The requirements of sectors change, and existing buildings do not necessarily lend themselves to new needs. For example, activities may change in such a way that space is no longer needed for working humans, but for machines. An increasing number of existing buildings will be completely renovated for new purposes, treating the building as a raw material.

But there are still activities that cannot be replaced with virtual solutions. There are also property owners who are committed to their premises. For the owners, the systematic demolition of buildings and their replacement with new ones is a financial impossibility, an ecologically bad move, and would require more resources than are available.

The development of building renovation as part of the building industry follows the principles of evolutionary economic theory. According to evolutionary economic theory, economic growth requires the development of existing industries, rising profitability and the creation of new industries. Over time, the different branches of the industry then become specialised.

The objectives set for the energy efficiency of building stock and for reducing greenhouse gases will create both qualitative and quantitative challenges for building renovation. Small steps are not enough to overcome these challenges. Instead, a major developmental leap is needed, one that will only be possible with companies that specialise to building renovations.

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LEADING INDICATORS FOR CIVIL ENGINEERING

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Abstract
The opening and globalisation of the market presents additional information needs. In the closed market, planning information gave a clear enough picture of the civil engineering situation. The same source of information is still used when looking at the situation in the open market. Companies and central government have often viewed the economic cycle of civil engineering somewhat differently because there is different kind information available.

The goal of this research has been to distinguish from the information flood those pieces of information that best predict future development to help procurements and operative planning of companies. The market structure has become more complicated and more indicators are needed than before. The lack of quantitative data has to be compensated by expert opinions. The leading indicator candidates are the change of GDP, the outsize projects, the finance situation of clients and the expert opinion.

Keywords: leading indicators, civil engineering, market change

INTRODUCTION

Civil engineering has undergone a transition from a largely closed market to an open one resulted from EEA Agreement (1994). The migration of customer and production sectors to a market open both nationally and internationally has created discontinuities on many different levels. Customers do not need to content themselves with the local or national service providers. They have the chance to look for suppliers from an international market. Suppliers in turn can specialise in this regard and seek customers from a broader geographical area.

The rate of change in the open market is accelerating. The impact of changes in the international economy, international contracts, the marginal terms of the customer industry's economics, etc., on civil engineering are stronger and more direct (Nippala & Petäjä, 2004). It has been an objective of this project to find indicators that forecast future civil engineering market.

The remaining part of the paper is organised in the following way. Firstly, the research question is formulated. Secondly, the review of findings from European and Finnish civil engineering market are summarised. Finally, the results – leading indicators – are presented and for the last some conclusions.

RESEARCH QUESTION

In a closed market, activities are planned according to the available resources. In an open market, demand depends on the needs of customer industries and on financial considerations; as a result, the significance of reliable business information has increased. Information is needed both for short-term operational planning and for long-term strategic planning.

In the closed market, planning information gave a clear enough picture of the future. The same source of information is still used when looking at the situation in the open market. The economic cycle of civil engineering is typically said to be synonymous with the figure describing few large civil engineering investments in the government budget. If the paragraph outlines a major change due to an impending highway project, "civil engineering works are on the rise." The end of the highway project means that the "civil engineering works are in decline." This information is broadcast, being deemed reliable and easily accessible.

Companies and central government have often viewed the economic cycle of civil engineering somewhat differently. Central government sees the increase in its civil engineering funding, while companies see foundation and earth construction ending with the slump in residential construction. New indicators must now be found because the civil engineering market is more open and the old indicators fail to describe the future market. The business environment has become complicated and emphasises the meaning of reliable business information.

The research question is to identify limited amount but reliable and in common accepted leading indicators to describe civil engineering market development. The frame consist variables produced by the official statistic supplemented by tailored time series. The statistical information is historical and can be used only as starting point. The reliable foresee data is that companies and organisations need most.

In this paper the indicators are identified to describe the interaction between civil engineering construction and its operating environment. The interaction can be couched in specific terms, for example in the supply-demand situation and in the development of costs.

DEFINITIONS

Civil engineering business outruns statistical classification

The statistical classification of economic activities in the European Community, abbreviated as NACE, designates the nomenclature of economic activities in the European Union (Eurostat, 2008). It provides the definition of civil engineering. It includes general construction for civil engineering objects, including new work, repair, additions and alterations, the erection of pre-fabricated structures on the site and also construction of temporary nature.

Civil engineering consists of:

42120 Construction of railways and underground railways
42130 Construction of bridges and tunnels
42210 Construction of utility projects for fluids
42220 Construction of utility projects for electricity and telecommunications
42910 Construction of water projects
42991 Development and building of civil engineering projects
42999 Other civil engineering n.e.c.

The Statistical classification defines the industry according to its end product. Those works that are not end products are excluded. For example foundation engineering is not an end product. The definition of civil engineering does not cover the construction of underground spaces, earthwork connected with the commencement of mining activity, the foundation works of residential buildings, or the property maintenance of outdoor areas. All of these are market segments of interest to companies that operate in the civil engineering industry.

Business cycles and indicators
Fluctuation in the level of economic activity is quite common in developed countries. These movements are known as business cycles. A business cycle usually has four distinct phases: the upswing or recovery phase, the peak, the downswing phase and the trough. As most forecasters know, establishing one's current position in the business cycle is not that straightforward. Better results appear to be achieved, therefore, when combining quantitative and qualitative data in the economic forecasting models (Snyman, 2009).

Economic indicators can be classified into three categories according to their usual timing in relation to the business cycle: leading indicators, lagging indicators, and coincident indicators (Eurostat, 2010).

A leading indicator is an economic statistical indicator that changes before general economic conditions have started to change and therefore can be used to predict turning points in the business cycle. Typical examples of leading indicators are stock prices, business and consumer expectations. Within short-term statistics the number of building permits is a typical leading indicator.

A lagging indicator is an economic statistical indicator that changes after macroeconomic conditions have already changed. Typical examples of lagging indicators are unemployment figures, profits or interest rates. Within short-term statistics the number of persons employed is a typical lagging indicator.

A coincident indicator is an economic statistical indicator that changes (more or less) simultaneously with general economic conditions and therefore reflects the current status of the economy. Typical examples of coincident indicators are industrial production or turnover. A coincident index may be used to identify, after the fact, the dates of peaks and troughs in the business cycle.

REVIEW OF CIVIL ENGINEERING MARKET

European civil engineering 2000-2010

Depending on the country, civil engineering is mainly financed by local communities, other regional units or by the central government. The funding opportunities of the public sector affect the demand for civil engineering. A healthy economy increases tax revenues, which decrease when an economy is flailing. Civil engineering can be utilised as a tool to balance the national economy. Small new projects and renovations are often started when the economy is doing well (Graf, 2000).

The opposite also holds true: when the economic situation is bad, it can be a good time for civil engineers. In many countries, the effects of the international financial crisis were battled by starting or bringing forward civil engineering investments (Stemperini, 2009).

In particular, the imminence of local elections provokes acceleration in the civil engineering works carried out. After the elections, the preferences of the elected party become visible in the civil engineering projects. The Euroconstruct summary from year 2000 highlights the activity of private citizens or associations as a common reason for delays in the planned schedules of the works' completion.

It is also possible to order the commencement of civil engineering works by statute, as has been the case with clean water, waste water and air purification projects. The aim of Directive 2000/60/EC of the European Parliament and Council is to make the protection of waterways as effective as possible, to prevent the contamination of groundwater and to secure the supply of clean water (The European Parliament and The European Council, 2000). The implementation of the directive is clearly visible in the commencement of civil engineering projects. In turn, the aim of Directive 2001/81/EC is to create national emission limits for air pollutants (The European Parliament and The European Council, 2001). Meeting these requirements may necessitate the construction of new highway networks.

Investment in infrastructure is also related to the competitiveness of business and the functionality of society. The Trans-European Networks (transportation TEN T, energy TEN E and telecommunications networks eTEN) are going to link Europe by 2025. When compared to European-level networks, congested cities demand investment in mass transportation, such as underground rail network projects among others. The development of technology is closely connected to the construction of both TEN and other networks (European Commission, 2008).

The price of oil was emphasised as a factor affecting the civil engineering industry. The effects of the price of oil were two-fold: it increased investments in the energy industry, but it also increased the input costs of civil engineering. The discussion over the price of oil expanded to cover the entire energy industry. Since 2004 (Vries, 2004) the need to invest in renewable, emission-free or minimum emission energy has been mentioned energy directive (The European Parliament and The European Council, 2010).

Finnish civil engineering sector – structural change

The Finnish civil engineering market can be logically divides into three periods: time before 1990, 1991–2010 and after 2010. The first period consists of the time when state organisations and municipalities had their own planning and contracting units. Private industries, like the house building, were alone in contracting out to private contractors.

The middle period began 1991, when the first civil service department was incorporated. It was the Civil Aviation Administration, today Finavia Corporation. During the time period 1991–2010 also others changes occurred in civil engineering construction. Both the central and local government outsourced their contracting units. The last period begins 2011 when the last central civil service department - Navigation Administration - will be incorporated (VTT).

- time before 1991

Civil engineering has always been closely tied to the development of society and business life. Civil engineering is needed when suburban areas and communities are constructed. The needs of industries and societies affect the traffic, energy and communication networks. In addition to specific needs, the civil engineering industry was used as a tool in labour and regional politics up until the 1980s. The labour political dimension was discarded due to technological development and unemployment benefits, while the regional political dimension remained until the 1990s (Karjalainen & Pajakkala, 1985).

- time 1991–2010

Since the recession at the beginning of the 1990s civil engineering has also been guided by economic realities. Projects are given priority according to how they boost the economy. Part of the public infrastructure has become privately owned; in this respect, decisions are made on a purely economic basis.

In recent years, construction has been an outgrowth of the change in regional structures and by migration, which concentrates the population in attractive cities and their surrounding communities. The altered and increased traffic flows demand both mass transport solutions and highway investments. Construction in an existing urban area brings with it marginal terms: tampering with an existing built environment and taking part of the construction underground.

Since the mid 1990s many of the formerly closed markets of infra construction has been opened up for competition. This has brought an expansion in the selection of end products and increased significance for the private sector as constructor. However, the public sector still dominates, with 80 per cent of all infrastructures (Official Statistics of Finland A).

Investments in construction concentrate on the buildings, highways and networks of the existing built environment. While some investments are used for renovations, others are used to upgrade constructions to meet the requirements of society. The role of companies as implementers of investment work has grown to 70 percent and in infrastructure maintenance to 65 percent (VTT).

Currently, the end products of civil engineering can be either private or public. Often, they are classified according to their role as transfer or distribution networks, but most commonly, their classification is based on their functionality. As an example, a function can be the transfer and distribution of electricity.

The examination framework of the national economy divides the end products (use) between the public and the private sectors. This use can be either investment or consumption. Based on this division, construction can be divided into public sector construction investments and consumption, i.e. upkeep and maintenance, and to the corresponding construction investments and consumption of the private sector.

In addition to the work of their trademark industry, companies in the civil engineering industry also carry out foundation work for residential buildings and property maintenance of outdoor areas. By this definition, civil engineering work in Finland in 2009 totalled around EUR 6.1 billion. In recent years, the significant changes in the residential building industry have made a major impact on the civil engineering market (table 1).

***Table 1**. The % change of civil engineering production volume in Finland compared to previous years (VTT).*

	2009 EUR Billion	2007 %	2008 %	2009 %
Total	5,5	0	+2	-2.5
Investments	3,9	0	+3	-4
Maintenance	1,6	-1	-1	+1
Foundation work for buildings	0,6	+14	0	-27

- future

The period after 2010 starts with an insecure financial situation. The world monetary crisis in 2008 and the subsequent rapid recovery keep the oil price high and have influence on the Finnish civil engineering sector. The European economic situation is also insecure because of the Greek, Irish and Portugal economic difficulties.

The economic situation for the Finnish state is also worsening, with Finland having to pay back loans taken out for the 2008–2009 recession. For Finnish civil engineering this will mean a greater onus in future on the private sector.

The demand of metal minerals is growing because in developing countries. This has awoken mining companies' interest. In the Northern Finland there is dozens mining projects in their early stages. The mine investment itself and needed transport infrastructure demand civil engineering.

The energy efficiency targets set to building stock has already caused demolish projects. This is also business area for earth moving contractors.

POTENTIAL LEADING INDICATORS

Finland

Before 1990' the majority of civil engineering work was in the form of road building contracted by the state's own contracting unit. If extra money were available, more work (subcontracting) could be ordered during the year. Railway, street, water supply, sewerage and many other civil engineering sector constructions were also carried out by state or local municipal organisations, all with budgets and investment plans.

During 1991-2010 public sectors decreased ownership in contracting and also as infrastructure owner. Today investments in energy, district heating, water supply and airports are made by the private sector. These sectors, more or less dependent on the economic situation, decrease their investments very quickly if the economic situation gets worse. This makes GDP an important indicator (figure 1).

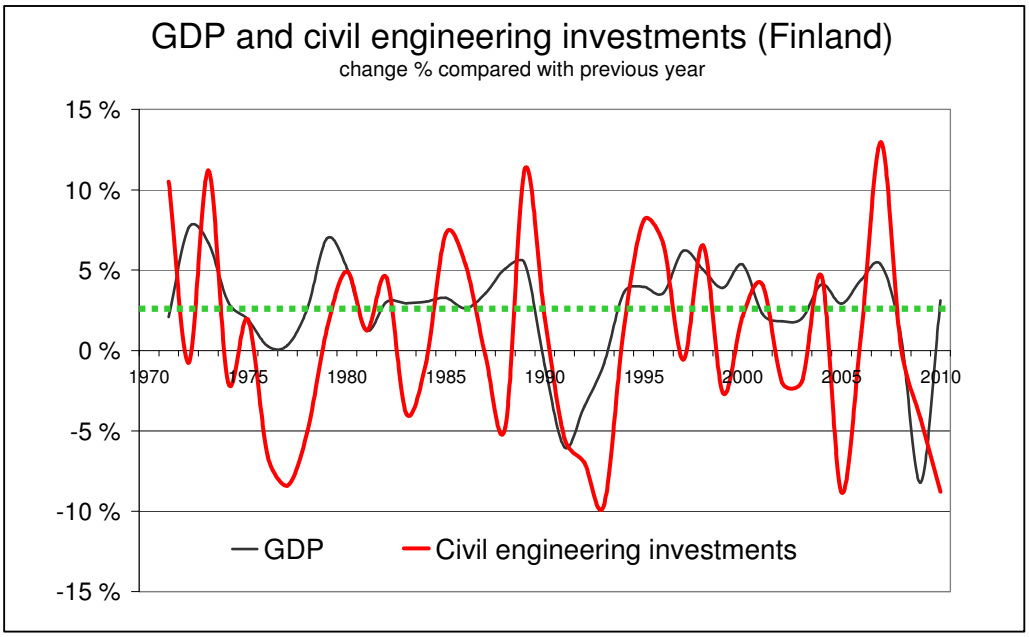


***Figure 1**. If GDP growth remains under +3 per cent, construction growth will be negative (Official Statistics of Finland B).*

The influence of outsize projects on the civil engineering market was realised as early as the 1980s. Outsize projects can have remarkable influence (figure 2). In the aviation sector, for example, one outsize project may double or triple the construction work for the whole year in that subsector (VTT). This information helps to forecast the construction volume for the following years. Even outsize projects have an important influence on the market they were properly followed up until after 2005.

Over recent years the survey of planning engineering offices has been reasonably successful in forecasting the changes in civil engineering (VTT). Contractors' surveys are another good indicator for future development, with knowledge months in advance of the forthcoming market situation based on the number of calls for bids. A further useful indicator is the number of contracts, although with forecasting only four months ahead there are some limitations to the use of this information.

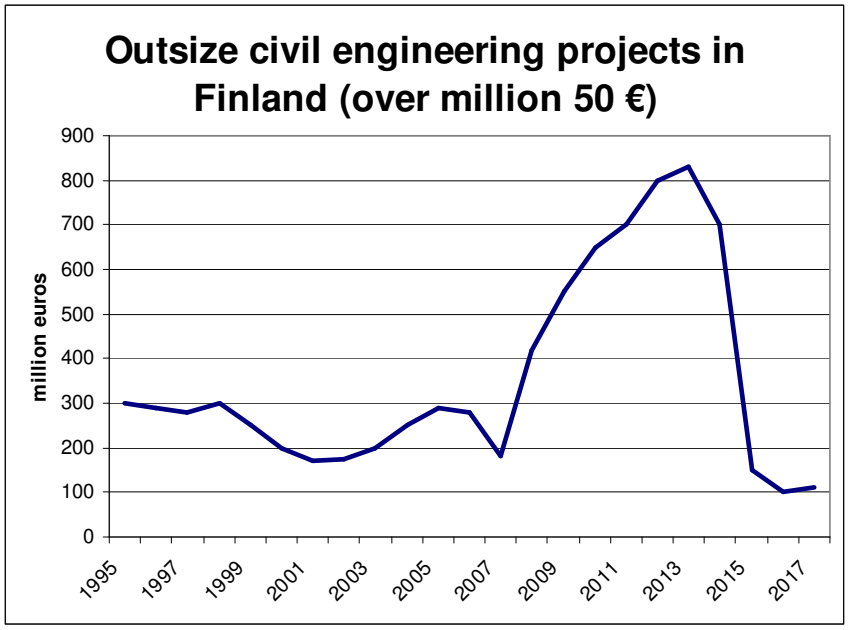


Figure 2. *Total for public and private projects (over EUR 50 million) in Finland, calculated at the end of 2009 (VTT).*

In Finland ministry of finance has established a group of experts to discuss civil engineering and the economic situation. The experts represent various sectors, such as contractors, scientists, ministries and associations. The group forecasts the civil engineering volume for the following year (Raksu, 2010).

The drivers and indicators from Finland and Europe are gathered to tables 2 and 3. In the table 2 are the drivers. At the general level nearly all European level drivers have some influence also over national level. But not vice versa, a small country doesn't have influence in the European level civil engineering markets. Short run indicators are presented in the table 3.

Table 2. *The identified European level and national level civil engineering investment drivers.*

Driver	***European level drivers***	***National level drivers, (case Finland)***
EU directive and legislation	*Directive 2000/60/EC, secure of clean water*	*National legislation (National Building Code)*
TEN Network	*Investment in infrastructure in new member countries*	*State road and railway investment budget*
Economic growth - depression	*Stimulus package*	*Stimulus package*
Budget deficit less than 3 percent and government debt less than 60% of GDP	*Restrictions in finance (Greece, Ireland, Portugal)*	*Future restrictions in Finland*
Elections	--	*Local elections accelerates civil engineering investments*

Table 3. *Identified European level and national level leading indicators for short term forecasting.*

Indicators	***European level indicator***	***National level indicator, (case Finland)***
Economic growth	*GDP growth forecast by finance sector and research institutes*	*GDP growth forecast by Bank of Finland and etc. research institutes*
Volume growth	*Volume growth forecast by Euroconstruct members*	*Volume growth forecast by Raksu-group*
Outsize projects	*At country level by Euroconstruct members*	*Follow up of outsize projects*
Direct demand	--	*Financial standing of clients*
Indirect demand	*Industry, mining, energy investment plans*	*Industry, mining, energy investment plans*

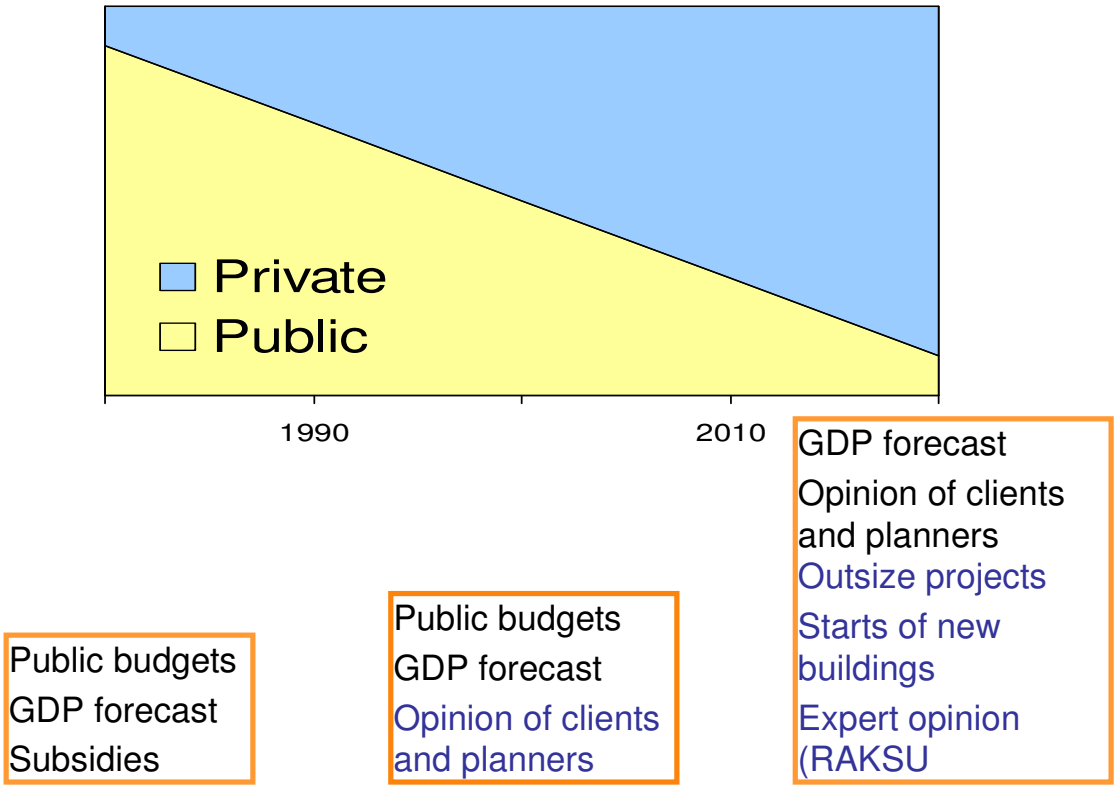


Figure 3. *The Finnish Civil Engineering can be divided to three periods: before 1990, 1990-2010 and after 2010 according to the private contractors' market share.*

DISCUSSION

When public sector contractor has significant share of market key indicators were public sector budget, state subsidies, region politics and GDP forecast. Despite the structural change the most important factor is the state main budget. The Finnish public sector has as client still approximately 55 per cent market share. The remaining 45 per cent share of other sectors is growing. That market development is followed up by opinion questionnaires of planners and infrastructure owners (clients).

In some certain part of markets outsize projects has big influence of market size. Public and private projects over EUR 50 million (outsize projects) make up about 5–10 per cent of the total construction volume in Finland. In some civil engineering sectors an outsize project may represent 50 per cent or even more of all investments. For example, the Vuosaari harbour project in the Helsinki Metropolitan Area constituted over 50 per cent of total waterway investment at that time.

The foundation of new houses forms about 15–20 per cent of the work carried out by civil engineering contractors. This is a key sector for companies operating outside growing city areas. The fluctuations in building construction have been remarkable. GDP is also a fairly accurate forecast of building construction. If we include building foundation work to civil engineering market the new building starts will be one leading indicator to civil engineering market.

All above mentioned are procyclic indicators and move in the same direction as the civil engineering market: they increase when the market is doing well; decrease when it is doing badly. In choosing the indicators also the importance and availability must be taken account.

Despites above mentioned indicators, there are many other. It is typical that indicators point the different development. This is one reason, why Ministry of Finance has called civil engineering sector professionals (“Raksu group”) to analyze markets and make together forecast. The opinion of Raksu group is also classified as a leading indicator.

CONCLUSION

The focus of this paper is on the key indicators for Finnish civil engineering construction. The only needed indicators before 1990 would have been the public sector’s investment plan (state) and regional investments (municipalities). The structural change 1991–2010 increased the private sector role as client.

From point of view anticipating the private sector as client is problematic because of the planning data is scattered. Some useful data is collected by industry organizations. The Ministry of Finance use the opinion of RAKSU expert group to describe this submarket.

The findings concerning Finnish and European civil engineering market are quite similar. The indicator system is suitable for analyzing international civil engineering construction. The most significant differences are the role of private sector and the time horizon. Even the Euroconstruct tries to foresee business cycles, the reports focus on long run drivers.

Development work on the key leading indicators continues in 2011-2012. A new research (Vainio & Nippala, 2010) will possess a more scientific touch, including testing of the theory described in this paper.

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CAD-CAM AND CNC TECHNOLOGY IMPLEMENTATION FOR A SUSTAINABLE REFURBISHMENT OF HISTORIC DISTRICTS. A CASE STUDY FOR BILBAO

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Abstract
After having researched a construction system based on CAD-CAM and CNC, we come to the conclusion that this system is appropriate for implementing it in refurbishment processes in old buildings. More precisely, refurbishment in buildings erected before industrialization with wooden structure and masonry facades in dense and historic city quarters. The main goals of the construction system are the recyclability of all elements, energy savings, bioclimatic performance, economy, accuracy and safety in the building site and simple procedures to write the project documentation.

The old quarters accessibility is often a handicap for implementing standardized components. In this case, the structural panels can be elevated to the floors with a reasonable physical effort for the worker, using the staircase, instead of an electric elevator.

Moreover, the heterogeneous personal economical resources of the neighbours in the building, is often an added problem for executing overall refurbishment of buildings. This system allows to make partial refurbishments and can work in different phases.

The new program layout planned for the buildings or apartments solved with the common refurbishment technologies and systems, requires an added slab of 20 cm for the drainage piping system. The application of the system can avoid this.

The construction system is adaptable to any geometry. In this way, there is no problem to applying the system on non-orthogonal plots. Using a CAD-CAM coordinated system the structure is easily adaptable to irregular geometries and dimensions.

During the first industrial era, in the historic city centre buildings, the insertion of plumbing system in a wooden structure building was rarely successful. The wooden structure near these plumbing facilities, is almost always rotten or damaged. The proposed construction system offers a solution for this problematic.

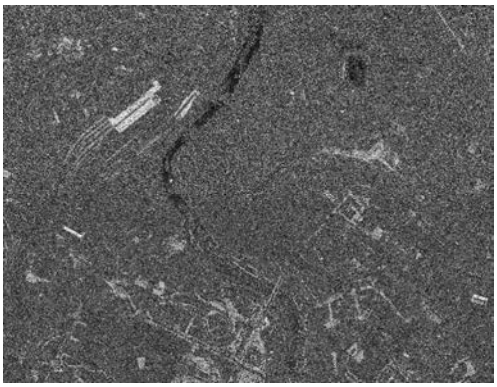
Normally such historic buildings don´t have a correct insulation. The system allows a bioclimatic performance of the whole building.

Keywords: CAD-CAM technology, historic district refurbishment

1.-INTRODUCTION: Research framework

1.1.-Urban context

This research is limited to the refurbishment of the Old Quarter of Bilbao. The urban shape of this part of the city was shaped between the 12th and 13th century. They used the so called ``Gothic Plot´´ to organize the structure of the city. Those plots are four meters wide and fifteen meters long. The front of the plot faces the street and the back of the plot to a "carcava" or gully (two meters wide medieval back street). In the beginning the buildings were two or three stories high, and they had a courtyard or a garden in the back side. But at the beginning of the 14th century, the whole plot became occupied by the building. Nowadays, the buildings have five floors, they form blocks and sometimes they share an inner courtyard. That means that the central area of each separate building has no sunlight. The current buildings were built around the year 1800, that is before the industrial era. Since then, they have been constantly modified. They are commonly divided in apartments in the first to the fifth floor and a commercial use space in the bottom floors.



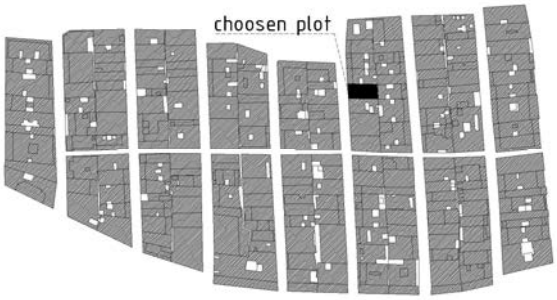


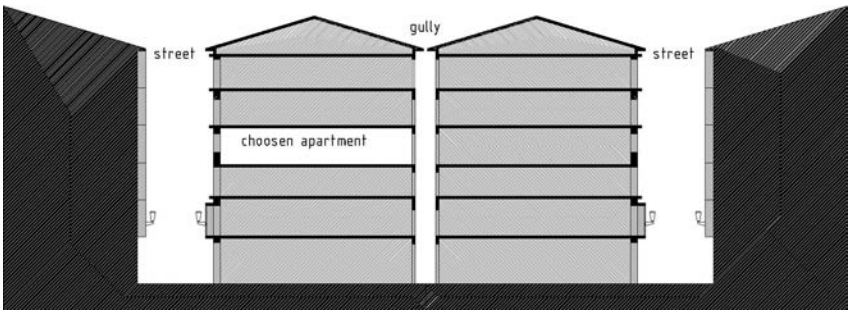
Figure 1and 2: *Orthophoto of the Old Quarter of Bilbao and location of the plot where the research has been made .*

1.2.-Built context

The buildings are built using a timber framework (beam and column structure). The floor structure is made up with rafters and boards. The last bay facing the street is filled with two feet brick masonry or stone wall. The bay facing the gully is closed with a one foot wide brick wall. The inner distribution was built with one quarter feet wide brick walls. Normally, the layout was the same in all floors. This distribution often ties the wooden framework and sometimes collaborates as a structural piece. The goals of this research are to create a tool for the refurbishment of those buildings and to repair the pathologies in the wooden structure.

1.3.-Property context

The property of those buildings is divided in two parts: The common use property and the private property. The common property is made up of the facades, roof, structure, common installation supplies and staircase (and the lift, in the few cases it exists). The private property concerns the inner area of each apartment and its installation system. The refurbishing works will be different if they are focused on the common part or the private property.





Figures 3 and 4: *Cross section and facade of the chosen building.*

1.4.-Technology

The tool created from this research, will be used in the following context:
-The architect or the designer uses three dimensional Computer Aided Drawing software.
-The fabrication or the different elements of the refurbished building is made using Computer Numerical Control machinery. This means, that the technology is available in the industrial companies nearby Bilbao.

1.5.-Materials

The Refurbishment System created from this research uses mostly plywood or laminated wood. Steel for reinforcement purposes will be used when necessary. Wood is available in the Basque Region and it covers the 30% of the territory land-surface. Timber industry is quite developed both for construction and for furniture. Steel working is also a developed industry.

2.-Why Refurbish the Bilbao's historic district.

2.1.-Environmental improvement

The buildings included in this research have needs to improve their thermal and acoustic insulation. Those building have five times less insulation than the required for new buildings by the Building Code (``Código Técnico de la Edificación´´).

Calculation of a Thermal insulation Resistance .

WALL

-Stone wall **60 cm wide.**

- Superficial Resistance of the enclosure in contact with interior and exterior air.

Rsi = 0,10 m2 K/W
Rse= 0,04 m2 K/W

Layer n°	Material	Thermal resistance e(m)	λ	R
Int.	Rsi =1/hi			0.10
02	Stone wall	0.6	3	0.2
Ext.	Rse =1/h_e			0.04
			R_T =	0.34

Energetic demand limitation

Test if U < $U_{max.}$	U1 =	1/ R_T =	2.94	<	U_{max} =	0.53	NO

Figure 5: *Calculation table: Thermal Insulation Resistance of a 60 cm stone wall .*

2.2.-Lack of land surface for building residential areas
In the last fifty years, the use of land for urban purposes has reached the 65 % of the total municipal area of the municipality of Bilbao. The Basque Region of Biscay (NUTS-3) is a Predominantly Urban Region. There is an evident lack of land.

2.3.-Empty dwellings or in disuse
The proportion of empty houses in the target neighbourhood doubles the one in the rest of the city. 616 apartments out of 3.206 are empty nowadays. That's near 20 %. Reasons are multiple but mostly, it's because these apartments don´t offer enough facilities. As it has been said before, these buildings are 200 years old. Within the empty houses, not all of them have sufficient comfort, such as heating, hot water or even a kitchen and shower. Another fact is that these buildings don´t have an elevator.

It is common for some apartments in the building to have been newly refurbished and others don't even have a shower. This is a consequence of the property system mentioned before. Refurbishment is necessary to turn all the empty space into proper and dignified dwellings. The local administration has made a subvention program for refurbishment, and it has been working with it during the last 25 years.

3.-Problems for Refurbishment in the Old Quarter of Bilbao

3.1.-Project
The council's office for Planning asks for a project whenever an apartment is going to be subject of new layout transformations. The ancient layout usually has up to four rooms, two of them usually lack windows. The kitchen and the bathroom usually are attached, both in the back side of the apartment.

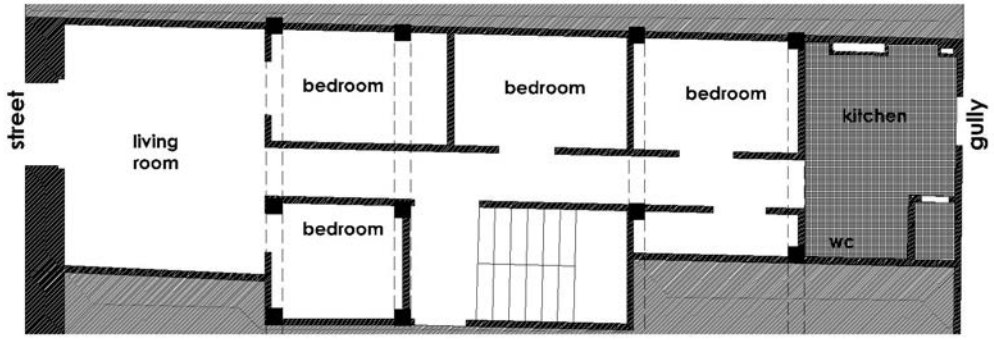
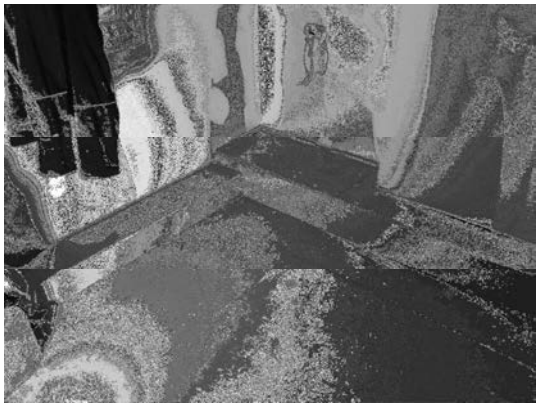


Figure 6: *Apartment´s floor-plan before refurbishment was made.*

The project must fulfil what the Local Plan -regarding technical and hygiene requirements- requires for a standard or basic home. Such apartment needs a space for living room and kitchen, a bedroom and a complete bathroom. The kitchen needs forced ventilation to the gully and not the main facade. All the spaces must have natural light and ventilation, except the bathroom, which can also work with mechanical air renewal. There are apartments within the Gothic plot which are four meters wide and fifteen meters long, with only two windows, one to the street one to the gully. The main drainage pipe of the building is usually in the back of the building.

During the industrial era, in the end of nineteenth century and in the beginning of the 20th, the plumbing system was inserted. The location of the system was always close to the gully. In order to keep the budget low, the kitchen and the bathroom were close to this plumbing system. During the project design process, in order to fulfill the local requirements for a basic home, the architect or designer ``needs´´ this area attached to the gully for placing the bedroom or living room. Otherwise, the bedroom will have no natural light or ventilation. Therefore, the bathroom is moved to the centre of the floor-plan. The displacement of the bathroom requires more room for the drainage pipe and also a longer one. The local building regulations oblige the placing of the private pipes and their connection to the main ducts within the apartment that they serve. In consequence, a step will have to be built in order to attain a correct evacuation of black waters. That is, the bathroom level is usually higher than the rest of the home. This is a common procedure to avoid installing mechanical pumps that often do not guarantee a continued use.

Figures 7 and 8: *Fecal pipe and its stair.*

3.2.-The rotten structure

As the demolishment is being carried out, the structure is unveiled. After 200 years, the wooden framework near humidity sources is usually rotten. The moisture sources are the plumbing system and the rain water in the back gully. This plumbing system, mostly built with steel pipes, has been worn out over the years. This system used to pierce or go through the flooring, so the wooden structure near the pipes is always rotten. During the refurbishment period the rotten framework must be reinforced.




Figures 9 and 10: *Rotten structure and typical steel reinforcement.*

3.3.-Neighbors
During the refurbishment process, it is almost inevitable to disturb neighbours. The property division between an apartment and the one below, is often a 2 centimetres wide wooden board and a 2 cm wide plaster board. Considering that near the gully the wooden board is almost always rotten, it's quite easy to make a hole -sometimes in consequence of rubble falling down-.

3.4.-Accessing the building site
Narrow staircases are an impediment for transporting material to the apartment. The proposed systems should deal with pieces in suitable dimensions for transportation purposes. A small scaffolding is commonly used but its has to be compulsory certified and signed by an architect -which will add on to budget-. Another limitation is that imposed by the pedestrian zone regulations. Cars are only allowed from 8.00 to 11.00 am.

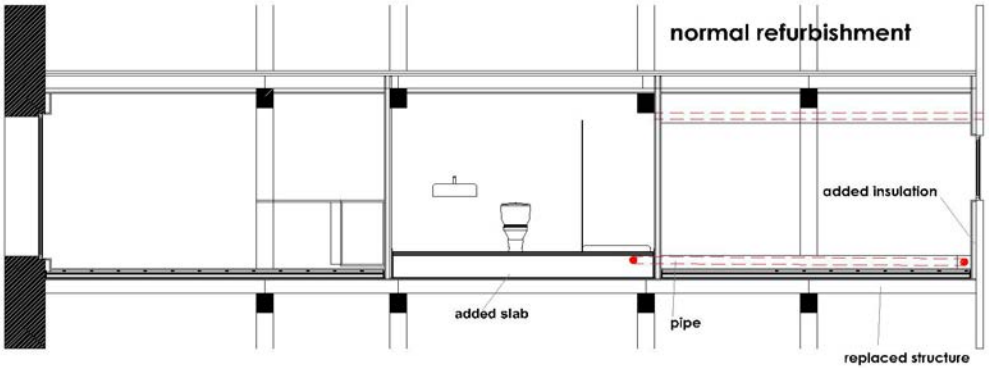


Figure 11: *Cross section of an apartment refurbished with common technology.*

4.-Research methodology

The research is made with the aim to define and prove a Construction System for Refurbishment in Old City Quarters using CAD-CAM and CNC. Currently, the research is in the design and test of building elements phase. Both design and testing are made by computer. The next phase will be creating prototypes to test them in a real situation. Defining each part of this construction system is compromised by the research itself and by the outputs obtained with the prototypes.

4.1.-Approach to the construction system
The main goals of the construction system are the recyclability of all elements, energy saving, bioclimatic performance, economy, accuracy and safety in the building site and simple procedures to write the project documentation. Adaptability to geometries, and different building situations.

4.2.-Generic design, first approach
As it is has been said before, the system will be adapted to any building in the Bilbao Old Quarter. But first, a generic design has been developed. This generic design will be focused in:

Common layout level
-the structural reinforcement and the new structural framework
-the enclosure system, and specially the thermal and acoustic insulation

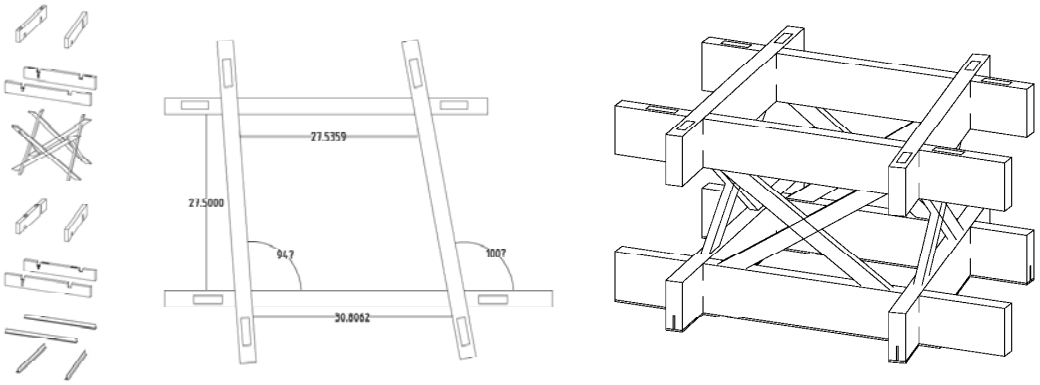
Private layout level
-the partition system, should be as adaptable as possible. The system is flexible in partition and in installations.
-providing space for the installation system

The Construction System will be modified and improved during the research process.

4.3.-Checking the generic design by computer simulation
A test with a three dimensional CAD model, will check some features of the system. The outputs of the simulation say that the structural behaviour of the system is correct.

With the 3D model, we can also check that the different pieces of the system can be produced in the CNC machine. This way, the cutting proposed for each element is based in state of the art technology, without wasting material.

4.4.-Conclusions and definition of the generic design
Once the results of the simulations are finished, the generic design can defined. The research is in this phase now



Figures 12, 13 and 14: *Pieces and Scheme of the structure made in CNC.*

4.5.-Projecting and building the prototype
Once the design is finished, the Construction System should be tested in real situation. For this purpose, a collaboration with local administration is needed. It seems quite difficult that a private owner of an apartment will expend money in a Construction System that it is not even proved. So, a public refurbishment work will be needed to apply the prototype in real case.

4.6.-Testing the prototype
The prototype will be tested structurally, thermally and acoustically. But the timing of the fabrication and building process as well as all the facts that could enlarge the budget will be also studied.

4.7.-Conclusions and final report for the application of the Construction System
After testing various prototypes, the System will be ready to apply in all the cases. A handbook or manual to use the Construction System as a designers tool can be designed. After the research, the system will be considered as a language or as a tool that both the designer and the builder will use. A computer plug-in could also be developed. This plug-in could be useful for the following:
-as data base offering frequent solutions.

-to adapt the construction solutions to the different geometry cases that will be refurbished.
-to calculate the needs of the structure and insulation.
-to generate documents for the project, such as budget report etc.
- to coordinate the designer and the manufacturer.

5.-REFURBISHING WITH CNC

5.1.-Building with CNC. The context nowadays.
CAD (Computer Aided Design), CAM (Computer Aided Manufacturing) and CNC (Computer Numerical Control) have been mostly used in industry more than in construction. Shipping industry, automotive industry are quite used to such tools. Within construction area, the furniture industry and the timber industry are the ones that have developed their own know-how.

There has been a more developed use of the CAD-CAM and CNC technology in new building constructions than in refurbishment processes. Particularly, when the designed form's complexity cannot be solved with traditional technology. It is also applicable when the budget is too high.

One of the earliest precedent in architecture for using CNC-CAM technology is professor Mark Burry's approach in 1.993 for the Sagrada Família church in Barcelona, which required a forehand research to reach Gaudi's original design. The next step was to make a 3D parametrical model using advanced CAD to define the future stereotomy. Then a polystyrene prototype was erected. And finally, the lateral and central naves, the 7 meter wide, 35 meter high Rose window screen wall for the West Transept were erected with just 10 mm tolerance.

Another examples are Frank O. Gehry's projects. The forms he designs, ``need´´ somehow to be built with CAD-CAM technology. The Guggenheim museum in Bilbao, finished in 1.997, is one example. Here, the main structure was made in steel, a material that is malleable and can be cut in CNC. The same architect, with the assistance of Thomas Bock used concrete pre-cast elements in the ``Neuer Zollhof ´´project, located in Düsseldorf (Germany). In this project, the polystyrene-formworks were produced by CNC-milling machines.

Recently, the CNC technology are being developed in timber structure buildings. These are a few of the recent and finished examples:

- Campus Restaurant with Auditorium for the Trumpf company in Ditzingen (Germany) by the Barkow Leibinger Architekten studio and finished in 2.008.

-Pompidou Media Centre in Metz (France) by the architect Shigeru Ban and finished in 2.010.

-Pavilion for the Federal Horticultural Show in Koblenz (Germany) by many authors and finished in 2.011

We can see that the technology for designing and building is already set. The mentioned examples show structures that mostly bear light weights, sush as roofs. Creating structures for bigger loads, such as floors, is the next challenge for this technology in timber structures.

5.2.-The generic design

The following paragraphs will explain the design process in a clear way. The starting point is the search for an optimal construction system.

A system which will allow for an up to date and manifold service in the same way newly built buildings do. A constructions system that can harbor a wide-range of uses during the life span of each space, from the ground floor all the way to the roof. An optimal system that can house all the needed facilities. A system that can guarantee a bioclimatic behaviour.

There is no intention in this first approach to come about new spatial solutions for architecture. It is rather a research for an constructive development. And so, the spatial solutions and partitions mentioned are of common and conventional character. Thus, we want to achieve a system that can serve a normal space.

Neither is the object of the present approach to design new facilities or service installations. On the contrary, we would like to house those systems in a proper way, in the correct place. We also intend for them to be totally accessible for repairing and follow ups.

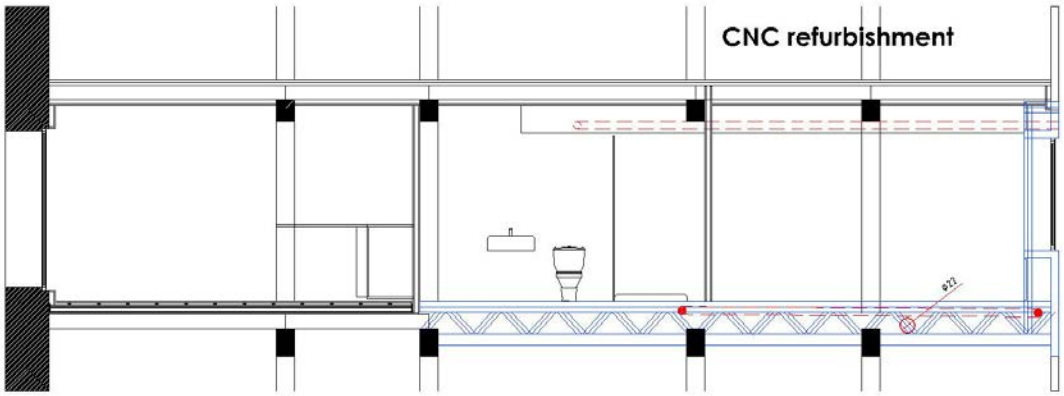


Figure 15: *Cross section of an apartment refurbished with CNC.*

Nowadays, the facilities take up more and more space and usually run along the ceiling. Air-conditioning and sanitation ducts are usually the ones with bigger dimensions. In consequence, they ask for a wide floor section. In many buildings the distance from the ceiling to the top of the finished floor can take over 60 cm. This is also observed in residential buildings. So, we will proceed to assume this distance (60 centimetres) for our building system. Moreover, the fact that the service ducts run independent of the structure or partition walls, allows for interior partitions to be flexible.

The construction system should be based in bioclimatic principles. It should keep energy in, lower the energy demand and profit from the solar energy in order to attain healthier interior environments. Therefore, and in order to achieve a higher heat isolation, a double skin facade is proposed. The two planes would be separated by 90 cm or more.

If we study the scheme, free of any structural support, we believe a double-support truss can be easily adapted by placing it in the interstitial space between the facade planes.

Ultimately, we will obtain 3 types of spaces. The primary one is the lived space and the secondary one “serves” the other one. This second level space can be optionally used for

storage and every day purposes. It will depend on the ruling use of the building, as well as on the width of the mentioned space. Finally, we must mention the third type of space which is located horizontally between two primary spaces. Its purpose is to exclusively house facilities and structure.

In order to develop this system, we should not despise the use of recyclable materials such as plywood, WPC, composite panels and the like. The choice will depend on how adequate it is for each project. At the same time, it is indispensable to create the building system using state of the art CNC cutting machinery. This allows:
- for adaptability in non –orthogonal plots; the machine is able to cut in a wide range of angles.
- we do not need to follow a certain module system; it is easy to coordinate with other dimensions. The cutting is realised with the needed accuracy depending on the context. It is a customised design.
- Project execution guarantee. What is projected, is drafted and built in site exactly.

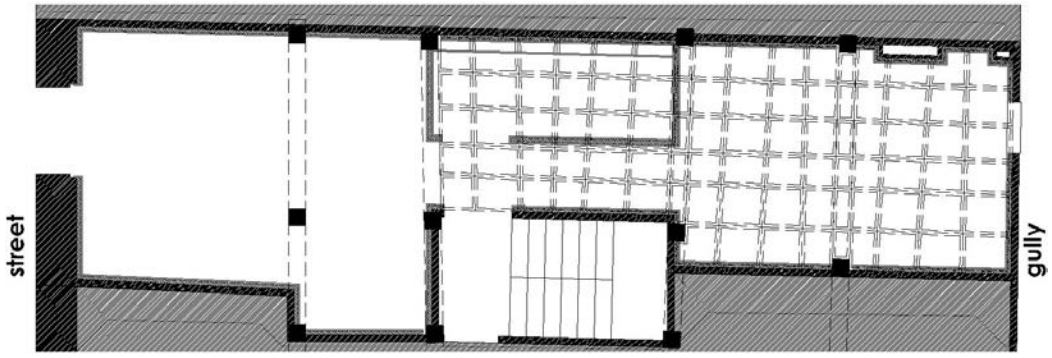


Figure 16: *Scheme of the reinforcement made by using CNC TECHNOLOGY. A none orthogonal grid is made.*

It appears that all buildings, just as other equipment, will be in the need of a continued maintenance and follow up by law. This also applies for the building services and facilities. The building, as it seems, will be required to guarantee the adequate service regarding the structure and the facilities. Our system should be adaptable to such a reality.

5.3.-Maintenance and flexibility
The system's structure, partitions and facilities are entirely flexible. The joints must be adjusted and released with a simple turn of a key. This would permit that the user, together with technical advice and the help of an architect, could move any element of the building. The facilities run through the horizontal structure. As an example, it is proved that in a 60 cm floor width, a drainage duct of 110mm diameter, can evacuate and reach the vertical duct with a 12% slope.

So, we can say that the only fixed element that should be reflected in each floor is a vertical thruway for facilities. The less 'elbows' a duct has, the larger efficiency of the service can be. This applies for most of the installations. The user in each floor is free to design an adapted layout, based on personal needs and taste. The same building can house different layouts without compromising the floors below or on top. In addition, they can also be changed through time.

5.4.-Project process and CAD-CAM coordination

The process starts with the project. Both project and building have to be coordinated. As mentioned before, a plug-in will be installed in the CAD program that the designer uses. So with this plug-in the designer can draw with accuracy the building. The designer starts the project using the data base solutions. One might think this way of working prevents the designers from being creative. Far from that, the system offers multiple choices to the designer. Making a parallelism, it can't be said that the laws and norms of concrete are a restriction for the designer, but instead offer multiple solutions.

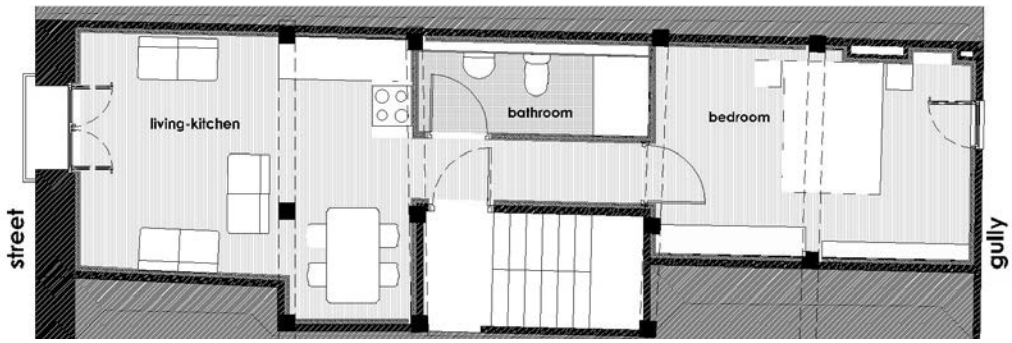


Figure 17: *Project for the apartment.*

With some general measurements as a starting point, preliminary and execution projects are developed. The project must seek the most precise dimensioning, but it is also convenient to take into account some tolerance variance. The designer has a complete control over what it is designed. Once the project is modelled in 3D, the designer could know if the solution proposed for each project fulfils the structural and insulation requirements and regulations.

5.5.-The process for building with CNC.

Once we receive the building permit, we will proceed to check the current state of the dwellings on top and below of ours. We will certify the state –existing cracks and other deficiencies- by writing a report. We should check if the partition walls on the top house and in ours concur. It is probable that they are in contact and so loads might be transmitted. In such case we will build discharge reinforcements to direct the loads towards the rafters. This must be done before starting to tear down the existing partitions walls. The reinforcement elements will be part of the new structure system. In order to install correctly these pieces, we will tear down the ceiling. By doing so, we will also manage to do a more concise diagnose of the state the top rafters and beams are in. A bigger quantity of reinforcement might be needed then.

Before starting to demolish the walls, we must locate a flexible element around the wall so it can cushion the strike of the toppling material. In this way we will prevent the floor from cracking and of rubbish falling down to the apartment below. It is recommended that a prop or post will be placed to avoid movements created by demolishment vibrations.

Once the partitions are put down, we can take apart the floor boards, and proceed to check on the rafters and beams below them. By experience, it is usually enough to do so in the floor of bathrooms and kitchen. In the rest of the bays, it is enough to look around the pillar bases. This process for demolishment can easily extend throughout two weeks. It is common to bring down the rubbish by hand through narrow stairways. This complicates and adds extra tiredness to the job.

At this stage of the process, the space is better read without the partition walls and with the structure unveiled. We can now take accurate measurements, either with measuring tape or digital tools. As for the next step, we must draft a proper and exact floor-plan, reflecting on it the possible collapses in the party walls and the planimetry of the floor as well as the ceiling.

Once we have produced the accurate 3D model, we shall redraw the project thinking on the manufacturing stage. The CNC machinery will produce accurate reproductions of the pieces on the 3D model.

A worthy advantage is obtained with this method, we can supply the building site with the needed pieces without having to store them in a warehouse. It is a direct and fast relationship between the workshop and the site.

5.6.-Maintennance of the building CNC.
All the project will be saved completely, element to element as it was built. Using the CNC technology permits that years later after the refurbishment was made, we can make the same piece as original. Even more, we can provide new pieces for new situations, and those new pieces could be attached or jointed perfectly.

The apartment that has been refurbished with this construction system will easily adapt to a new user. Apartments change from hand to hand. If we want to have this adaptability, there must be a maintenance, a parallel service has to be provided. This way, there will be a permanent link between the contractor and the user. This is not new, not even in construction world. The ideal situation would be that the building user could install or un-install the partition walls or structure elements wherever he or she is interested. The client or the space user could request this parallel service to provide change of structure from place to place. If he would need a piece, he could buy or rent from the maintenance service. Of course, a technician should allow all these changes.

The system is both flexible in structure, in partition and in installations. The joists of the structure and partition could be opened or closed with a simple wrench. So the user, with the help or guidance of a architect (or similar), could move the partition, the installation or even the structure. All this is supported by a flexible installation, partition and structure scheme. Almost everything is movable, the only element that should be kept in place or fixed on every floor, it´s an installation shunt (even this could me movable but not recommended).

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THE INTERPLAY BETWEEN PUBLIC PROCURING AUTHORITY AND PRIVATE COMPETITORS: EXPERIENCES WITH THE COMPETITIVE DIALOGUE

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Abstract
In 2004 the European Commission introduced the competitive dialogue as a procurement procedure to enable for an open public-private dialogue leading to more innovation, increased competition and more trust. Since 2004 this procedure has been increasingly applied in complex Dutch road infrastructure projects. In this paper experiences from practice are analysed to assess if the goals of the European Commission are met. Conclusions were drawn on the basis of interviews with experienced public and private actors and validated during expert meetings with contract managers.

Results indicate that the competitive dialogue can lead to more innovation when overcoming the reserved attitude and risk avoidance of public procuring authorities. Competition in Dutch procurement increased by use of the dialogue, and although the public-private contact in the procurement procedure leads to increased trust, it is hard to maintain this in an environment driven by competition. It is concluded that notwithstanding the use of de competitive dialogue, the ideal of an open public-private dialogue has not yet been realised. Recommendations are to stimulate innovation by not specifying the desired end-result in detail beforehand, reward openness and limit the dialogue to the complex issues.

Keywords: competitive dialogue, road infrastructure projects, innovation, competition, trust

INTRODUCTION

In 2004 the European Commission introduced the new procurement procedure competitive dialogue. The competitive dialogue can be applied in the case of particularly complex contracts, where contracting authorities consider that use of the open or restricted procedure will not allow the award of the contract. The new procurement procedure, an alternative to the negotiation procedure, is aimed to include a more open public-private dialogue, with more innovation and increased competition (European Commission, 2004).

Over the last years the competitive dialogue procedure has been increasingly applied in Dutch planning practice. Road infrastructure projects have become increasingly complex,

amongst others due to increased involvement of more outspoken stakeholders and scarcity of space. The competitive dialogue therefore has become a popular procurement procedure in road infrastructure projects at the national level. Illustrative for this is the fact that in 2007 16 construction projects (including road infrastructure as well as buildings) were procured by the CD procedure. In 2010 at least 15 infrastructure projects were procured by this procedure (Stichting CROW, 2011).

Although the procedure is becoming more commonly applied, it remains unknown whether the goals of the European Commission are met in Dutch practice. Evaluation of the instrument is often limited to its application in isolated cases; a thorough evaluation of the instrument relating to the goals of the European Commission is lacking. In this paper an analysis is described of experiences from the Dutch practice in order to assess whether the goals of the European Commission are met. Additionally, it aims to provide recommendations on how to improve public-private interaction in general and the competitive dialogue specifically.

EFFECTIVENESS ASSESSMENT

The question of how effective the CD procedure actually is, is an evaluative one. Without going into detail about all the methods used in policy evaluation studies, one can note some common typologies found in evaluation research. Next to plan evaluations, also process and product evaluations are defined (Swanborn, 2007). The evaluation of a policy instrument like the CD procedure is a product evaluation, also called end evaluation, effect evaluation, impact evaluation, outcome evaluation, summative evaluation or goal-fixed evaluation (Swanborn, 2007, p. 58). This type of evaluation study contains both impact and efficiency aspects, with the effectiveness assessment being one of three impact studies (see Figure 1).

Product evaluation
Impact study Sensu lato (Comparison between the objectives of the policy and its impact). o *Goal attainment assessment* (to what extent are the goals achieved?) o *Effectiveness assessment* (are the goals achieved and, if so, to what extent is this due to the policy?) Sensu stricto (Focus on the effects of the policy, without reference to the objectives) o *Impact assessment* (what are the effects of the policy (both aimed for effects and side effects, both direct and indirect)?) **Efficiency study** (The interrelatedness of the benefits/effects and the costs of the policy (cost-benefit analyses or cost-effectiveness studies))

Figure 1: *Types of product evaluation studies (Swanborn, 2007)*

Effectiveness is a criterion that reflects how the effects of a policy instrument relate to its objectives. Alongside the intended effects (the objectives) of the policy instruments, one also has to consider the unintended effects (side-effects), since these could make the policy less effective. This is why Vedung (2000, p.36) speaks of effectiveness evaluations as "side-effect evaluations". This is schematically illustrated in Figure 2 (Vedung, 2000, p. 50).

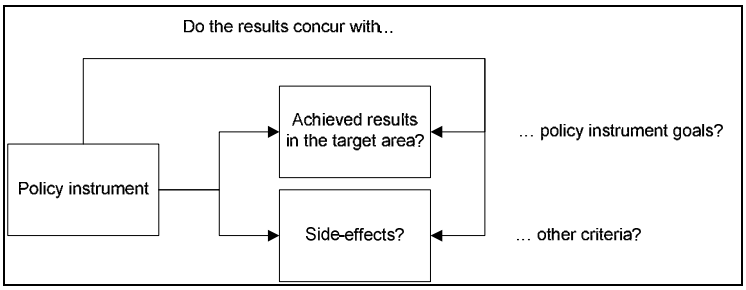


Figure 2: *Effectiveness assessment*

Thus, to assess the CD procedure's effectiveness, both its objectives and its effects need to be mapped. A description of the CD procedure its characteristics and the objectives of the European Commission (the policy rhetoric) is provided in the first part of this paper. The next part will describe both the effects and side-effects of the CD procedure, after which these are related to the initial objectives of the procedure and possible counter-effective effects, thus drawing conclusions about the overall effectiveness of the CD procedure. However, first the methodology and the validity of the research is discussed in the next paragraph.

RESEARCH DESIGN

As we have seen in the previous section, the assessment of policy instrument impact consists of overviews of both its effects and its side-effects. A description of the objectives of the European Commission with the CD procedure (the policy rhetoric) will be provided in the next Section. To compare these objectives with results in the target area and with possible side-effects, both effects and side-effects should be mapped. Interviews with several stakeholders in the process of procuring complex projects were conducted to come to this overview. On the basis of these interviews, conclusions were drawn about the experiences with the dialogue of involved public and private actors in several Dutch infrastructure projects. Subsequently, the results were validated during expert meetings with contract managers.

Interviews

The individually conducted interviews were of a semi-structured nature so that we would obtain general information concerning the EC's objectives with the CD procedure and to gain insight into these issues. The stakeholders interviewed at this stage of the study were experts from science, procuring agencies, contractors and advisors (See Figure 3). All of the 51 selected stakeholders were willing to participate in the interviews, which lasted 45 minutes and consisted of three main parts. Part A served to assess the general opinion of the experts about the CD procedure. Part B considered the positive and negative effects of the CD procedure, and Part C was included to determine chances and limitations of the CD procedure. This last part was added to the earlier parts about the direct (side)-effects to derive indirect (side)-effects of the CD procedure.

Main group		Function
A. Law / science	1	Professor in Dutch private law, contract law, construction and procurement law
	2	Professor in Construction law, Lawyer in construction and procurement law
	3	Lawyer in e.g. Construction, Development, International Arbitration, Joint Ventures, Projects, Public Procurement
	4	Attorney and lawyer in corporate law transactions, privatisations, large-scale contracting processes, PPP and project financing
	5	Lawyer in environment and planning practice, including PPP
	6	Chartered accountant and senior lecturer at the European Institute of Public Administration in PPP, public procurement and comparative public service delivery
B. Procuring agencies	1	Infrastructure project manager Dutch Department of Infrastructure and the Environment
	2	Contract manager Dutch Department of Infrastructure and the Environment
	3	Project manager Dutch Department of Infrastructure and the Environment
	4	Project director Dutch Department of Infrastructure and the Environment
	5	Advisor PPP Dutch Department of Infrastructure and the Environment
	6	Senior Financial Advisor Dutch Department of Infrastructure and the Environment
	7	Senior advisor Market relations and procurement Dutch Department of Infrastructure and the Environment
	8	Purchasing manager Dutch Department of Infrastructure and the Environment
	9	Advisor to the Infrastructure Board of the Dutch Department of Infrastructure and the Environment
	10	Contract manager Dutch Department of Infrastructure and the Environment
	11	Contract manager, Dutch Department of Infrastructure and the Environment
	12	Manager Back office, Dutch Department of Infrastructure and the Environment
	13	Purchasing manager, Dutch Department of Infrastructure and the Environment
	14	Contract manager, Dutch Department of Infrastructure and the Environment
	15	Judicial advisor, Dutch Department of Infrastructure and the Environment
	16	Planning manager, Dutch Department of Infrastructure and the Environment
	17	Judicial advisor, Dutch Department of Infrastructure and the Environment
	18	Environment manager, Dutch Department of Infrastructure and the Environment
	19	Judicial advisor, Dutch Department of Infrastructure and the Environment
	20	Contract manager, Dutch Department of Infrastructure and the Environment
	21	Project director, Dutch Department of Infrastructure and the Environment
C. Industry (contractors)	1	Project and contract manager, large construction firm
	2	Director Concessions, large construction firm
	3	Director PPP, large construction firm
	4	Project manager from a large infrastructure construction firm
	5	Project manager for discipline and work exceeding projects, large construction firm
	6	Director PPP Projects, large infrastructure firm
	7	Project manager PPP, large construction firm
	8	Project director, large construction firm
	9	Project director, small construction firm
	10	Director Integral Projects, large construction firm
	11	Director Tender Division, large construction firm

	12	Senior project advisor, large construction firm
	13	Project director, freelance, hired by large construction consortium
	14	Operations superintendent, large construction firm
	15	Director Tender Division, large construction firm
D. Advisors	1	Senior Consultant in Contract and Project Management, large engineering firm
	2	Senior Consultant, large engineering firm
	3	Senior advisor, association of Dutch construction and infrastructure firms
	4	Consultant, project management firm
	5	Consultant in Contract management and Procurement, consultancy firm
	6	Management consultant, consultancy firm
	7	Senior consultant, project management firm, Partner for infrastructural projects in the Dutch network of innovators in construction
	8	International Procurement Policy Advisor at the Office of Government Commerce
	9	Transport and Traffic advisor, large engineering firm

Figure 3: *Stakeholder participants*

The qualitative data analysis software QSR Nvivo was used in the analysis of the transcribed interviews. After transcription, codes (called 'nodes' in NVivo) were assigned to text fragments using a bottom-up approach (starting without any strong prior assumptions about coding classifications). The purpose of bottom-up coding is to classify a large number of textual data units into a smaller number of homogeneous categories. The subsequent use of software in analysing the qualitative information allowed a more objective assessment and facilitated more complex examination of the data (Weitzman and Miles, 1995; Marshall, 2002), leading to conclusions about the effectiveness of the CD procedure on the procurement of complex construction projects.

Validation

Based on the results from the NVIVO database, we are able to tell what the majority of participants sees as most important effect of the CD procedure on the procurement of complex construction projects. Although the validity of these conclusions is strived after by several means of triangulation, we decided to validate the conclusions after all. This was done by discussing the conclusions in the form of statements with a group of 15 project managers from the Dutch Highways and Waterways Agency. The discussion did not fundamentally change the conclusions, but did lead to adjustments of the conclusions: the project managers nuanced some of the bold statements, making the conclusions doing more justice to reality.

COMPETITIVE DIALOGUE PROCEDURE

The European Commission provides several procedures for the procurement of public works: the open procedure, the restricted procedure, the negotiated procedure and the competitive dialogue. In the open and the restricted procedures contract negotiations are not allowed. In the negotiated procedure this is allowed, but there are no detailed rules as to how this should take place or when this should end before contract signature. This made the European Commission question the appropriateness of the negotiated procedure in complex projects as substantive negotiations with a preferred bidder could distort competition (OGC, 2008). Therefore, the competitive dialogue (CD) has been introduced in 2004. With the introduction the European commission aimed at achieving several goals: increased *competition*, increased

innovation, stimulated *trust*, and a more open and structured *dialogue* (see Hoezen and Doree (2008) for a reconstruction).

Competition is visible in the set-up of the procedure. The contracting authority has the possibility to select a preferred bidder over several rounds. In these confidential individual rounds , the contracting authority discusses the preliminary offer with the private competitors. The confidentiality and the staged selection ensure a competitive process.

Besides the competitive character, the CD is aimed to be a flexible procedure that could stimulate *innovative* solutions (Nagelkerke et al., 2008). Innovativeness is stimulated by applying MEAT-criteria (Most Economically Advantageous Tender). In these criteria more than just the price of construction work determines the outcome of the procurement. Quality criteria, which can contain all kind of factors, have to be used if the CD-procedure is applied.

In an advise of the Committee for Legal affairs and the Internal Market to the European Parliament it was suggested that "the content and limits of the negotiated procedure should be made transparent for both procuring authorities and contenders and, in the interests of both parties, should provide the basis for collaboration based on trust" (Committee on Legal Affairs and the Internal Market of the European Parliament, 2001, p.100). From then on, the objective of the CD procedure of *stimulating trust* was reflected in the design of the CD procedure.

Another aim of the CD-procedure is to stimulate an *open and structured dialogue*. In the procedure extensive negotiations after a preferred bidder is chosen is prohibited (OGC, 2008). The CD is restricted to particularly complex contracts, where contracting authorities consider that the use of the open or restricted procedure will not allow the award of the contract (article 1.11 of 2004/18/EC, European Commission 2004). Projects are complex if contract authorities are (1) not objectively able to define the technical means or capable of satisfying their needs or objectives, and/or are (2) not objectively able to specify the judicial and/or financial make-up of a project. When these conditions are met, negotiations in a dialogue are a crucial element to come to sound proposals and project delivery.

The CD-procedure consists of several stages (see Figure 4). Before the dialogue itself starts, the project has to be announced in an official notice in the journal of the European Union(1). Subsequently, bidders can be selected on the basis of pre-qualification criteria, after which the actual dialogue can start. The dialogue can consist of several rounds of negotiations between the procuring authority and individual bidders over (parts of) preliminary bids. After this phase of dialogues, the final tenders are submitted and the bids are evaluated on the basis of the predetermined award criteria. These need to be MEAT-criteria, that besides price also take quality aspects into account. Next, the preferred bid is chosen and the contract can be closed.

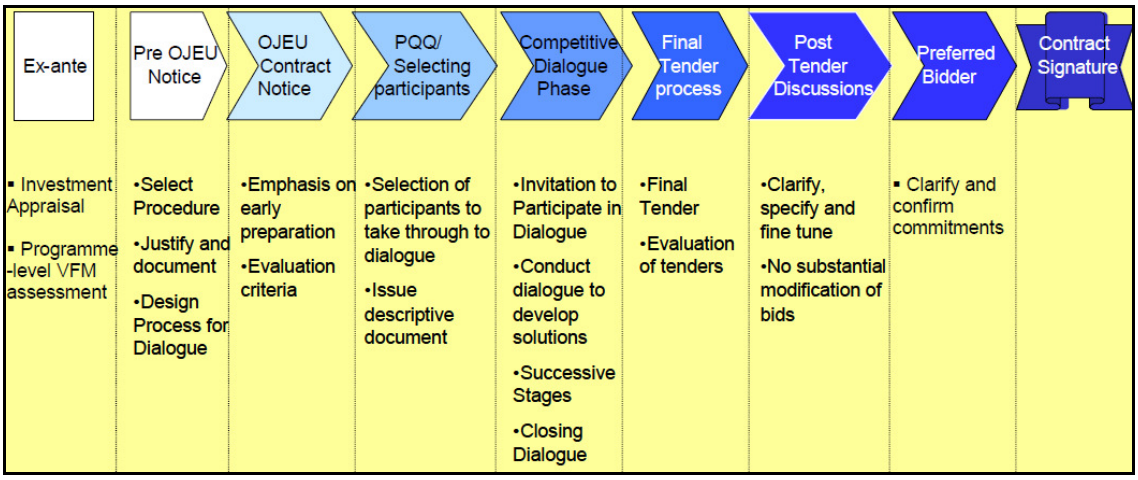


Figure 4: *Overview of CD-procedure* (Source: HM Treasury and OGC, 2008, p.11)

EFFECTS OF THE CD-PROCEDURE

This part will describe both the effects and side-effects of the CD procedure. But first an overview is given of some issues that play a role in the CD-procedure.

The CD procedure has been applied in several infrastructure projects since it was implemented into Dutch law in 2006. The size and order of the projects it concerns differ from small (about 25 million euro's) to large (about 3 billion euro's) and from constructing to reconstructing. The experts taking part in the interviews as well the contract managers involved in the validation were experienced in a wide range of projects with diverse characteristics.

General impressions

In general it can be stated that the set-up and the implementation of the procedure has improved looking back from the end of 2010 to the first experiences in 2006. To a certain extent, this can be attributed to the increased experience with applying the procedure at the side of the contracting authority. It is increasingly efficient in organising effective dialogue rounds, asking and answering questions, meanwhile keeping the level-playing field intact. Private competitors have also attributed to the improvement of the CD procedure. Designated tender organisations have been set in place in which experience with dialogues is shared and the gained experience with the 'open' initial rounds of the dialogue make the CD procedure run more smooth.

However, some operational problems still remain. It proves to be difficult to collect all relevant information for carrying out the dialogue and distribute information effectively from the contracting authority to the competitors. A reason are the different integrated contracts that are procured through the CD procedure. These contracts require that not only information concerning the construction, but also information on financing, maintenance and operation needs to be available up-front. If this information is available, the way in which it is distributed can also be improved. Currently, contracting authorities simply hand over all available information, which causes the competitors to be overloaded with information. They need to spend a considerable amount of time to assess the quality, relevance and usability of the distributed information.

Another issue that is discussed extensively is the compensation for participation in the CD procedure. In the Netherlands, it is common practice to compensate the private competitors for their efforts in the dialogue rounds. Time and money is spent to come to competitive bids that take into account the wishes of the contracting authority. However, according to the private competitors, the compensation often does not properly reflect the investments made to come to this bid. The transaction costs are higher than expected. Reasons can be found at both the public and the private side: The public authority often requests too much detail in the bids and the dialogue rounds and the private competitors work out their solutions too much to reduce uncertainties.

A last issue that deserves attention is the continuity in the personnel. The long span of infrastructure procurement processes makes that tender teams at both the public and the private side undergo changes during procurement. This causes a loss of valuable project-specific, tacit knowledge that is difficult to replace (see Lenferink et al. (2011) for an extensive discussion).

Now that the major issues in implementing the procedure have been described, the effects of the CD procedure will be discussed for the four main goals of the European Commission: innovation, competition, trust and dialogue.

Innovation

Results indicate that the competitive dialogue can lead to more innovation. However, this innovation mainly consists of *process innovation*. The private competitors prove to be more efficient in bridging the boundaries between different fields, and regarding projects in a more integral way. The project process innovation includes smart ways of combining procedures and methods to adjust activities in the several stages of a project to each other The project process innovations can positively influence the time planning a project takes and could amongst others, lead to less nuisance in construction due to smart phasing of activities.

Besides project process innovation, also the process of the CD-procedure has improved. The main driver behind this kind of process innovation is experience. The involved actors get more experienced with the procedure and with the processes involved. They have to spend less time fabricating requested products or discussing these products in dialogue rounds. For example, the functions and contents that should be in a “plan of action”, as often requested by the contracting authority in the initial stage of the CD-procedure, need not to be discussed anymore in a separate meeting. The competitors all have gained experience in writing such plans.

Product innovation on the other hand proves to be more difficult to achieve. A reason for this is the reserved attitude and related risk avoidance at the public contracting authority. Although it advocates open output specifications, on basis of which the private competitors can make their bid, the attitude in the dialogue is often reserved. It proves to be difficult for the public authority to distribute tasks and responsibilities fully to the private sector. This difficulty is reflected in strict planning and tender documents which limit the room for innovative solutions. The cautious attitude strengthens this effect; parties involved tend to prefer proven solutions to minimize risks.

Competition

The dialogue has proven to increase competition in Dutch procurement. In fact, the procedure is more dominated by competitive forces than expected beforehand by the European

Commission. Complex projects, in which the competitive dialogue is allowed, usually involve great sums of money. The involved competitors are therefore cautious to keep the perceived chances and opportunities to themselves. This is manifested in the character of the different dialogue rounds. Chances and opportunities which could be of added value to the project quality are only limitedly discussed and at a late stage in the dialogue. Because of the fear of cherry-picking, competitors keep the project-winning ideas as long as possible to themselves.

In contrast, the competitors are very open on perceived risks and threats. If they see problems, that affect their bidding price negatively, they want to make sure that the other competitors see it as well and take it into account in their offers. Together with the large sums of money involved, this makes the competition in CD-procedures fierce. Competitors are willing to spend some resources to come to a winning bid. It is therefore no surprise that the compensation offered by the contracting authority is perceived as insufficient.

Trust

The competitive dialogue procedure has led to increased trust between the public and private parties involved. The necessary exchange of information provides the parties with an understanding in each other's position and insight in the grounds for certain behaviour. Although the public-private contact in the procurement procedure leads to increased trust, it is hard to maintain this in an environment driven by competition. In this respect, also the strong focus on maintaining the level playing field plays a role.

Dialogue

The strong competitive forces that play a role in the CD-procedure make that the dialogue gets a judicial character. The contracting authorities are fuelled by fear of breaking the guidelines for applying the procedure. This puts a strong focus on maintaining the level-playing-field. The contracting authority is afraid of unconsciously giving a competitive advantage to one of the contenders. Therefore, interaction in the dialogue rounds is limited. At the contracting authority, there is a risk that a conservative attitude is stimulated that is reflected by the statement "just say nothing, so that there is no risk of saying something wrong".

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded that although the competitive dialogue has proven to be a useful procedure to procure complex projects, the ideal situation of an open public-private dialogue has not yet been realised. Strong competitive forces and risk avoidance limit the openness of current dialogues, strengthening the judicial character with a focus on maintaining the level-playing field and limited innovation possibilities. Competition makes parties more reserved, it stimulates strategic behaviour and has a negative effect on trust-building. A successful CD-procedure is therefore dependant on an open attitude of the parties involved.

It is recommended for public authorities to provide more possibilities for innovation by not specifying the desired end-result in detail beforehand. This will stimulate real interaction on the basis of sincere questions, instead of the strategic masquerade that is sometimes currently taking place. Furthermore, openness of private competitors in the dialogue should be rewarded. This can be put into practice by partly selecting bidders on the basis of their cooperation. Also past performance could be taken into account. Another recommendation is

to limit the dialogue to the complex issues for which public-private interaction can lead to added value. Only the aspects that need discussing in the dialogue, because they are complex, should be discussed. This will prevent the CD-procedure from being penny-wise and pound-foolish.

Applying these recommendations could lead to less (unwanted) strategic behaviour, decreased transaction cost and an open dialogue with a focus on seizing chances and possibilities. This will also change the competition in the CD-procedure. Decreased transaction costs will allow smaller size competitors to join in the procurement. It will help the European Commission in reaching all the goals for innovation, trust, competition and dialogue.

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SCHEDULING PROCESS: USING ONE-DAY SCHEDULING ON MULTI-FAMILY PROJECTS TO REDUCE DELIVERY TIME

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Abstract
The past fifty years has seen many changes in the construction process, but little has changed in the area of scheduling for most projects. There have been advances in the software used to manage schedules, but the same theories and practices have been used for decades. This process works well and will continue to be norm on most projects. Some home builders have incorporated a process "one-day scheduling." The process views the project as a linear sequence of days and identifies what activity is start and finish on that day. Several large home builders have found that the number of calendar days to construct an individual home as part of a large development has been reduced significantly, giving them a strategic advantage in the market. The following study looks at the implementation of a combination of traditional and "one-day scheduling" on multi-family residential projects as a method of schedule management, resource management, and cost control. The study reviews the management of the schedule during construction as well as the scheduling process. The end goal of any construction project is to deliver a project of the greatest value to the owner for the defined cost. The implementation of a method of scheduling which delivers a product more efficiently will conserve resources and enhance the goals of sustainable construction.

Keywords: Scheduling, Multi-family, Linear Scheduling

INTRODUCTION

Schedules and schedule management the core of the management process for construction projects. Activities are identified, defined, assigned durations, and linked by relationships to create a work flow and a critical path through the project that is effective and manageable. The Critical Path Method (CPM) works well on most projects and will continue to be norm.

Some residential contractors have changed their method of scheduling in an effort to be more competitive in the market. These contractors have adopted a scheduling method similar to production line scheduling, but instead of the product moving through as series of operations, the operations are moved through the product. The process is similar to the Linear Scheduling Method (LSM) and requires re-evaluating activities and the defining of activities and their durations (DiVosta Homes, 2002).

Proponents of LSM feel that the Critical Path Method (CPM) is not well suited to repetitive work, such as multiple housing units. The goal of LSM is to prevent interference between repetitive activities that progress linearly through the project. Interference is avoided by scheduling only one work process at a time in a defined area (Nunnally 2011).

One Day Scheduling (ODS) is derived from LSM. The following examines the development of ODS and its application in conjunction with CPM scheduling. Although residential construction is used as the context for the discussion, the principles can be applied to any repetitive process, whether there are several repetitive projects which stand on their own, or there is a group of similar and repetitive activities which are integral parts of larger projects.

BACKGROUND

LSM is based on the manufacturing process. In manufacturing, a product, such as a car or washing machine, would start out on the assembly line as one component, and move through the assembly line with additional components added until the final product is completed. The components are added during an operation (activity), and the operations (activities) are arranged in a sequence, with each operation completed before the next operations are started.

Although the current discussion is focused on residential construction, any repetitive function could benefit from LSM type scheduling. A recent hospital project in Florida had one hundred and seventy-eight patient rooms that were exactly the same. The contractor used prefabrication of components at an outside warehouse to facilitate the schedule. The assembly of the components used LSM type scheduling. The net result was valuable to the schedule and saw increased productivity of the workers. Part of the increase in productivity had to do with one trade not conflicting with another, as well as the repetitive nature of the work, and the ready access to all necessary materials and tools (Post 2010)

Since the manufacturing process is continuous, the movement of the line must be uniform. The uniform movement requires that each operation is performed in the same amount of time, referred to as standard time. Not every operation in the assembly process takes the same amount of time, so the activities need to "balanced" Balancing is the process of dividing up activities into multiple activities, all of which have the same duration as the standard time (Milas 1990). For example, if it takes two minutes for a worker to put on windshield wipers and eight minutes for one worker to put on the tires, the standard time could be placed at two minutes. The tire installation needs to be divided into four activities for the line to run smoothly. The four activities could occur sequentially or concurrently.

The speed is defined by the "standard time". The standard time is what is needed to complete each activity. The duration of the standard time is not the average time for an operation. Using the average time would result in about half of the operations failing to complete in the allotted time. The standard time is the duration required for the successful completing of each operation most of the time. As a result, the total time of production is longer than the minimum time that the product could be manufactured. The standard time is a balance between keeping the line moving all the time by have no time failures and line stoppage, and acknowledging and accepting some line stoppage to have a shorter standard time. The total duration of the assembly process is the total of moving and stationary time (Milas 1990).

There are three recognizable types of progressive assembly lines. The first is where the same product is produced. The second type is where two or more models an intermixed and run at the same time and use a predetermined and fixed sequence. The third type of progressive assembly line intermix two or more models, using varying sequences (Milas 1990). Construction of residential units would usually fall in the second category. Units may differ in many ways, but the sequencing would stay the same.

The LSM uses three steps in developing the schedule.

1. Determine the work activities
2. Estimate activity production rates, the same as in the CPM but the LSM uses the durations and the production rates to match the activity scope to the standard time.
3. Develop and activity sequence, similar to developing logical relationships. (Mubarak 2005)

The activities have a defined duration, and the activities are re-accruing. Over time, the productivity of crews may change, so adjustments are made to keep all the crews on schedule. Adjustments may involve extended hours, reduced hours, or adjusting the crew size (Mubarak 2005).

One-Day Scheduling (ODS) is an adaptation of LSM where the typical standard time is one work day, so activities have one day duration. Many construction operations take over one day to accomplish, so they must be broken down in separate activities, such as putting on the car's tires. Manufacturing refers to the process of breaking down activities as Dividing "Indivisible" Elements in order to create a standard time (Milas 1990). The defining of activities to be performed in a standard time of one day is accomplished through the collaboration between the general contractor and all the subcontractors.

A good example of how ODS works is shown by the experience of a construction company which has used the ODS since 2004. The example looks at how the company changed the way they schedule the gypsum installation and finishing in their homes.

Installing and finishing gypsum walls and ceilings have the following four elements:

- Hang
- Tape and bed
- Second coat of mud
- Finish coat
  (Gypsum 2007)

The company's previous scheduling method acknowledged that each element took about one day, and they allowed a fifth day to be sure that the gyp was completed before the next trade began their work. The gyp contractor agreed to provide more labor for larger homes to maintain the schedules. The gyp activity had a five-day duration on the schedule. Frequently, the gyp contractor failed to complete in five days and thus compromised the schedule.

Under ODS, Hunter Homes changed the schedule for gyp to:
Day 1 - Hang
Day 2 - Tape and bed
Day 3 - Second coat of mud
Day 4 - Finish coat
Day 5 - The trim carpenters begin

The subcontractor was required to be on schedule every day, and crews were adjusted by the subcontractor to make sure that the crews were successful every day. The change to ODS resulted in the gyp subcontractor completing their work in four days instead of five and being successful most of the time. Hunter Homes did not have statistics on the percent of successful completions for particular operations (Hunter Homes, 2006).

The previous example could have been accomplished by simply requiring the subcontractor to finish in four days, but the process was facilitated by the addition of more detailed control. Under the old system, the gyp contractor was not behind schedule until the end of the fifth day, which allowed little time for over-schedule work to be performed. Gyp work continuing into the sixth day would interfere with the trim carpenters. Under ODS, the contractor did not allow scheduled work to roll into the next workday. The process works for this contractor because of the commitment of the subcontractors and suppliers. The scheduling technique has resulted in advantages to the general contractor, the subcontractor, and the owners.

Advantages to General Contractors

There are several advantages that have been realized by companies who have adopted ODS. Traditional scheduling uses a heuristic approach to setting durations because of the number of variables that are present. The heuristic approach may actually be better that compiling large volumes of historic data and extrapolating durations, because the average duration will only be nearly correct, statistically, about 10% of the time. The heuristic approach lets the scheduler take into account some of the most important or predictable variables. ODS is used on repetitive projects, so historic data becomes more accurate.

Using shorter durations of one day, gives management a daily evaluation of the progress of each activity in the schedule, from first day until last. Inspections and jobsite monitoring are performed daily. Superintendents are able to look at a schedule and know what activity is being performed in each unit. The overhead is cut for the general contractor as managers and superintendents are able to manage more units in a year. The faster turn-around time improves the cash flow, which results in lower cost of internal financing. Finally, but most importantly, the subcontractors can charge less because the ODS increases the productivity of their crews and lowers their overhear cost.

Perhaps the greatest advantage to the process on One-Day Scheduling is the management process. The creation of detailed schedules which attempt to control the activities of all subcontractors on a daily basis would appear unmanageable. ODS allows this level of control only because of the repetitive nature of the subcontractors work and the involvement of the subcontractor in defining the activities to be performed in the standard time of one day.

Advantages to Subcontractors

The successful implementation of ODS requires coordination and cooperation from all subcontractors. As noted above, the subcontractors are a part of the decision process for setting the scope of the daily activities. This allows the subcontractors to allocate required resources. Subcontractors need to have sufficient resources to maintain the work flow as it is specified in the schedule. There are several benefits that the subcontractor receives for making the commitment to maintain the schedule.

First, the subcontractor builds a long term relationship with the contractor. Second, the repetition allows the subcontractor to identify costs and lower the risk due to unknown circumstances. Third, the subcontractor knows they will not have conflicts with other subcontractors trying to complete work on the same unit concurrently. Fourth, the subcontractor is able to level their resources and maximize the productivity of all the crews.

Leveling resources allows the subcontractor to have a defined number of workers for the general contractor. There is inefficiency in having to continually move workers from one

project to another. Having level resource requirements allows the subcontractors to keep workers productive and reduce turn-over due to changing labor needs.

Productivity of the workers can be increased. The elements that impact productivity are discussed in a following section, including the influence of ODS on some of the elements. The gyp subcontractor example shows the value of reduced duration on the calendar of five days to four days, allowing crews to complete five homes per month instead of four.

Advantages to Owners

There are two primary advantages that are received by the owners. First, and perhaps the most important, is that stringent schedule management promotes on-time delivery of the product. One of the accepted components of customer satisfaction is timely delivery. (Business Bear, 2011) The second advantage is the cost savings that can be passed down to the owner. The competitive nature of the construction industry requires successful companies to pass along savings realized through progressive management practices, while maintaining their profit margin which insures long term success.

Productivity

Since much of the strategic advantage of the ODS relies on the increased productivity of the workers, a discussion of productivity is in order. Since labor is about 33% of the construction cost, decreasing labor cost will benefit the project costs (Haskell 2004). The productivity of the workers has a direct impact on the cost and schedule, but the number of variables makes the measurement of productivity on construction projects is difficult.

"Send one boy to do a job and it will get done in one day. Send two boys and it will get done in a day. Send three boys and it will not get done at all." Lord Snowdon

Lord Snowdon points out that the allotment of additional resources may not increase productivity. The scope of work did not change, but the allocated resources changed with no increase in productivity. In fact, the productivity declined with the increase in resources.

Construction trades average about 32% productive time. The rest of the time is spent:

- Waiting 29%
- Traveling 13%
- Instructions 8%
- Tools and materials transportation 7%
- Late starts and early quits 6%
- Personal breaks 5%
    - (McCarthy 2008)

Productivity provides the greatest opportunity to reduce costs and reduce the schedule duration. A study in the United Kingdom was published through the Office of Government Commerce, showed that incorporating certain techniques resulted in efficiency gains of thirty percent in some public sector operations, while 30-50% improvements have been known in the private sector. (Clark 2010) Note that the gains were on specific projects not averages, but the study showed that significant gains are possible.

The methods used in the study are summarized by Sir Peter Greshom. "This is not rocket science - the basic principles are to: do the right things... (Eliminate unnecessary work), the

right way… (Use standard, streamlined processes), with the right people… (right skills, availability, location), using the right tools and equipment." (Clark 2010).

The *Mechanical Estimating Manual* lists sixteen factors that can impact labor productivity in construction (D'Amelio 2006). Examining several in relation to the four principles identified in Clark's study gives some reference in how some of the factors can be impacted by ODS.

- Stacking of trades – ODS is very specific about only having one trade in a unit on any day.
- Morale and attitude – There is difficulty in quantifying morale and attitude, but there could be qualitative assessment based on stacking of trades, crew size efficiency, concurrent operations, site access, fatigue, overtime, logistics, and supervision. Improvements in one or more of these areas could improve morale and attitude.
- Reassignment of manpower (change orders) – Change orders cause a disruption in any schedule. ODS is as susceptible to disruption as any other scheduling method.
- Crew size inefficiency (over manning) – The basis of ODS is the adjustment of crew size to maximize production during a defined duration.
- Concurrent operations – ODS is resource centered, so crews are assigned to a single operation at any time, avoiding division of resources and lowering productivity.
- Dilution of supervision – Supervision is critical in any scheduling method, but ODS sets daily goals for each crew which is well communicated to each crew.
- Learning curve and Errors – ODS incorporates crews moving from one location to another and repeating the same tasks. Keeping continuity in the people in the crew keeps the learning curve low and minimizes errors. Errors may appear as successor activities are accomplished, but the errors will be related and adjustments made quickly.
- Site access – Site access is the key element in ODS as each trade will enter an area that is prepared to receive their work with no encumbrance.
- Logistics – The Logistics become more important but should be easier, because the rate of production is defined and the dates of material delivery can be verified by the schedule.
- Fatigue and Overtime – Fatigue is always a consideration for workers because the work is all physical. Crew sizes may need to be adjusted based on the time of year because productivity will change on extremely hot or cold days. Without a change in the crew size, overtime may be necessary, which is not productive over long periods of time.

The gains in productivity realized by users of ODS were primarily from:

- Not stacking trades
- Using proper crew size
- Lowering the learning curve
- Ensuring site access
- Standardizing logistics.

CASE STUDIES

There are three case studies that follow. The first two are brief commentaries on two home building companies that currently employ one day scheduling. The third is a case study showing how ODS can be used in conjunction with CPM scheduling for a multistory residential condominium project.

Case Study: DiVosta Homes
DiVosta Homes uses One-Day Scheduling, and has found the construction time has decreased, quality control is up, and costs are under control. The company builds single family homes in their own developments in Florida. In 2003, one of their subdivisions was starting two homes per day using ODS. The homes were in the $400,000 to $450,000 range, with limited options on the overall design.

The company has identified 45 distinct work activities (operations) on homes, from beginning to end. Each operation has one day duration for a crew, except for some short duration activities. On certain short duration activities, the crew was given two houses per day, so only one crew was needed. Activities that normally take multiple days are divided into two or more operations, using multiple crews moving each day or rotating starts. The company incorporates pre-planning and extensive staging to facilitate the crews' success. DiVosta Homes uses a combination of in-house forces and subcontractors. Each are managed as separate entities', with the expectations for both to meet the schedules and provide profit for the general contractor.

DiVosta Homes has been able to consistently deliver homes in 45 working days from the start date. The shorter delivery time cuts the management time on each home so each superintendent and project manager can oversee more homes in a year, cutting overhead for management of the projects. Subcontractors are able to train crews and maintain consistent work forces on the project, without having significant overtime or battling the stacking of crews. The company is also to turn over the projects to customers faster and improving the cash flow. Cash flow is very significant when the company is finishing two $450,000 homes per day. (DiVosta Homes 2002).

Case Study: Hunter Homes
Hunter Homes is a medium sized homebuilder in Huntsville, Alabama. The company sells homes from $125,000 to $250,000 and starts two homes per day for all their subdivisions. All the subdivisions are within the same geographic area, so the same subcontractors are generally used throughout the company. All work is subcontracted, and the total duration of the projects is 48 working days. The activities are all one day long, although, like DiVosta Homes, one contractor may accomplish short duration activities is less than a day, such as attic insulation, which is not critical on the schedule for other operations.

The management of Hunter Homes feels strongly that the schedule is key to their competitive edge in their market. Before using ODS they were at the same price per square foot as other builders in the area, but now have a lower base cost due to several factors, most notably the schedule (Hunter Homes 2006).

Case Study: Eagles Nest
A schedule for the Eagles Nest project uses a combination of CPM and ODS. The Eagles Nest is a six-story, eighteen units, residential condominium building with mid-range finishes. The frame of the building is structural steel with precast hollow-core concrete elevated decks. The CPM scheduling technique is used for the foundation, frame, windows, exterior doors, skin, elevator, and mechanical, electrical, and plumbing services that serve the entire building.

The interior build-out and finish of the units is scheduled as eighteen activities, one for each unit, and each activity is twenty-one days in duration. The first activity, or unit one, begins

when the exterior is closed in from the weather. Unit 2 will start on the next working day, and the start dates for each subsequent unit will start on succeeding days.

Activities for each unit – each activity has a standard duration of one day.

1. Interior Partitions
2. Ductwork for HVAC Main Ducts (Two Days – two crews)
3. Ductwork for HVAC Branch and Return Ducts (Two Days – two crews)
4. Plumbing rough-in
5. Electrical RI- Place device boxes, Meter Base, Panel and feed Panel (Two Days – two crews)
6. Electrical RI- Pull wire to boxes and home runs (Two Days – two crews)
7. Insulation
8. Hang Gyp (Gyp Contractor has a crew for each of the four steps)
9. Tape and Bed Gyp
10. Second Coat Gyp
11. Finish Coat Gyp
12. Interior doors, base, and window trim
13. Prime walls and trim (Painting - Three Days – Three crews)
14. First Coat of paint on walls and trim
15. Bathroom and Kitchen Cabinets
16. HVAC finish
17. Electrical Finish
18. Plumbing Finish
19. Hard flooring in kitchen and Bath (One Crew – second day requires only one hour labor)
20. Grouting Flooring (one hour labor – 24 hour duration for setting)
21. Finish coat of paint on walls and trim

When two crews are specified, such as for the HVAC contractor, the activities can be handled in two ways. The first day's activities are completed by the first crew and the second day's activities completed by a second crew. Alternatively, crew one could work both days and complete the entire scope for the two days, while the second crew comes in the second day and completes all work in the second unit. The crews would leap-frog through the schedule completed every other unit.

The schedule for the interior of the building is a very simplistic schedule which shows the activity by number, which is being performed in each unit on each day. Table 1 shows part of the ODS for the eighteen units. The actual dates for the activities would be added from the master CPM schedule. The duration of the interior work would be eighteen consecutive work days, with the last unit starting on day eighteen and continuing for twenty-one days, for thirty-eight work days to completion.

The simplicity of the schedule creates the power as a management tool. One immediately notices that there is planned activity in each unit each day. Although this may be the goal of many builders, ODS provides a tool to manage the performance of the subcontractors. The methodology of creating the ODS from the manufacturing standpoint, where failure to meet the schedule and stop the assembly line is the unusual, not the norm, is based on the buy-in from all subcontractors, starting with the input on the activity creation and continuing to the commitment on the success.

Table 1
One-Day Schedule for the Build-Out and Finishes

Unit	Activity in Each Unit Each Day																					
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
2		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
3			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
6						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
7							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9									1	2	3	4	5	6	7	8	9	10	11	12	13	14
10										1	2	3	4	5	6	7	8	9	10	11	12	13
11											1	2	3	4	5	6	7	8	9	10	11	12
12												1	2	3	4	5	6	7	8	9	10	11
13													1	2	3	4	5	6	7	8	9	10
14														1	2	3	4	5	6	7	8	9
15															1	2	3	4	5	6	7	8
16																1	2	3	4	5	6	7
17																	1	2	3	4	5	6
18																		1	2	3	4	5

CONCLUSION

One-Day Scheduling is not revolutionary and it is not applicable for every type of project. ODS does work for large residential contractors and is applicable for other types of project that contain many highly repetitive sequences of activities. Traditional construction scheduling defines activities to be accomplished by in-house forces or subcontractors, without defining the resources required to accomplish the work in the time frame defined. ODS has an understanding of the crew sizes and equipment required and uses that information in setting the work required for the day in the schedule.

The work to be accomplished on any day in the schedule is agreed upon by the subcontractor and the general contractor to assure that the production required is achievable every day. It is possible to reduce the duration of the building process due partially because there is progress every day. Additionally, subcontractors are the sole trade in the unit during the activity, which, along with additional benefits, improves productivity. With increased productivity come lower costs and shorter schedules. There are benefits to the general contractor, the subcontractor, and the owner, which result from the schedule management and productivity.

The critical component to the success of ODS is the collaboration of subcontractors and subcontractors on the design of the schedule and creating the scope of work for each day. Upfront planning can be the key to success. Low bid contracting may not be a successful model. Negotiated bidding would provide a better contracting platform for success, as the schedule and activities are part of the contractual agreement.

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DEFINING THE ECO-CITY: A DISCURSIVE APPROACH

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Abstract
This paper presents the results of a discourse analysis of documents describing six different eco-city projects: Dongtan Eco-City, Masdar City, Sonoma Mountain Village, Hammarby Sjöstad, Eco-village Ithaca, and Malmö bo01. The aim of the research was to uncover the diversity underneath the various uses of the term eco-city, and to determine the extent of convergence or divergence in the way projects conceive of what an eco-city should be. The research looked at five categories of urban sustainability discourse: the aspect of sustainability emphasised, whether eco-city projects saw themselves as a model for future urban development or as an educational tool, the way in which eco-cities proposed to make urban living more sustainable, the extent to which projects looked at achieving sustainability by design or through governance and management, and the type of actors that play a role in the eco-city. The results suggest that there is a great deal of diversity among projects considered to be eco-cities. In this sense, we argue, it is better to think of the eco-city as an ambition or objective which there will be multiple ways to achieve.

Keywords: Eco-city, discourse, sustainability, planning, environment

INTRODUCTION

With both the rapid growth of the world's urban population and increasing concern about the environment, the challenge of making urban living more sustainable is in the forefront of the minds of many designers, academics and government officials. In recent years, one response that has gained increasing prevalence is the idea of the 'eco-city.' Richard Register, a California based architect widely credited as the first to have coined the term defined an eco-city in 1987 as "an urban environmental system in which input (of resources) and output (of waste) are minimized" (Register 2002). As the term's usage has become more widespread, so too have the meanings associated with it and the diversity of projects adopting the label. Already in the late 1990s, Roseland argued that there was no single accepted definition of the eco-city. Rather, he proposed, it was more a collection of ideas about concepts such as urban planning, housing, transportation, and economic development (Roseland 1997).

Reading these early writers on eco-cities it is difficult to develop a clear, comprehensive vision of what an eco-city actually looks like. This began to change in the early 2000s when a number of ambitious plans began to emerge for brand new sustainable urban districts and cities. High-profile examples include Hammarby Sjöstad, in Stockholm, Sweden and Masdar City, in Abu Dhabi, United Arab Emirates (UAE). China in particular, through the State Environmental Protection Administration (SEPA), has supported the development of a number of eco-city projects around the country. Tianjin Eco-city, which is currently under construction, is due to be complete and home to 350,000 people by 2020.

Yet as the usage of the term spreads, what exactly constitutes an eco-city seems to be even more unclear. Today an ever-increasing range of existing cities and new urban projects, from minor retrofits to large-scale new-towns, call themselves, or are labelled, eco-cities. The most comprehensive survey of eco-cities to date was carried out in 2009-10 by Joss. Joss admits that the conceptual diversity and plurality of initiatives using the term makes it difficult to develop a meaningful definition. He ultimately questions the usefulness of attempting to define eco-city narrowly. Instead he elects to define the term using three analytical categories. Thus according to Joss an eco-city must be a development of substantial scale, occurring across multiple sectors, which is supported by policy processes (Joss 2011: 12).

This paper accepts Joss's definition as a starting point. However it will also question whether in the search for similarities among eco-cities, Joss glosses over substantial differences between these projects. The purpose of this paper is to use a discourse analysis to test the hypothesis was that there is a substantial diversity in the way eco-city projects promote themselves and are written about. The paper begins with a brief overview of the value of discourse analysis as an analytical tool in the social sciences. It then puts forward a set of categories of environmental discourses that are often used in discussions of urban development and sustainability. It then presents the methodological approach followed by a discussion of the results of the analysis. The findings are presented in tabular and descriptive format. This is followed by a discussion pulling out the points of convergence and divergence among the case studies, and a conclusion discussing the implications of the findings for future research on eco-cities.

ECO-CITIES AND ENVIRONMENTAL DISCOURSES

Much of the broader literature on sustainable cities is analytical, attempting to test various propositions about what makes a city sustainable. Work on eco-cities, however, tends to either attempt to describe the phenomenon (Roseland 1997; Joss 2010) or focuses on normative prescriptions for achieving eco-city status (Register 2002; Girardet 2008; Kenworthy 2006). From this prescriptive literature it appears that the eco-city could be understood as a way of practically applying existing knowledge about what makes a city sustainable to the planning and design of new and existing cities. However what is 'known' about the relationship between planning and urban design interventions and sustainability objectives is a subject of much debate (Bulkeley & Betsill 2005; Williams 2009). This means that realizing an eco-city requires making countless decisions about sustainable technologies, urban form, building design and governance.

How, though are these decisions made? Many contemporary scholars and theorists of urban and environmental planning processes argue that this occurs through a social process consisting of complex negotiations, and often disputes (Flyvbjerg 1998; Hajer 1995; Healey 2007). This paper adopts this perspective and hence views eco-city initiatives as socially constructed through design and policy-making processes. Thus the eco-city is not a model or a template, but the outcome of a social process involving numerous stakeholders. From this perspective it is easier to make sense of the diversity of different eco-city initiatives. The eco-city is the solution to a problem; perhaps the diversity of eco-city initiatives reflects different ideas of what exactly the problem is. Looking for the broader discourses behind the solutions proposed in different eco-city initiatives may reveal these different ideas.

The discourse of the eco-city

Hajer (1995) defines discourse as "a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is giving to physical and social realities" (44).

In the social sciences, discourse analysis is used to study the way in which issues and understandings are socially constructed. It does so through the analysis of both statements, and the context in which those statements are made (Hajer 1995). A number of authors have demonstrated the value of discourse analysis to understanding how planning decisions are made (Kumar & Pallathucheril 2004; Portugali & Alfasi 2008). Similarly, in the field of environmental sociology, discourse analysis is used to explore the way that actors construct environmental issues (Dryzek 2005; Hajer 1995).

Discourse analysis can reveal the way in which problems are constructed. In the study of eco-cities then discourse analysis can reveal the basis of their claims that they can make cities more sustainable. Does the answer lie in particular aspects of their design? If so, which ones? Or does it lie in the way they are governed, or their citizens involved in decision making? All of these issues are subject to significant debate. How do the designers of eco-cities answer these questions? And, among eco-cities, is there any convergence around a particular set of answers? If there were, this would help identify what exactly it means to be an eco-city. These questions are pursued by looking at five categories of discourse about urban development and sustainability, each of which is explained below.

Category 1: Type of sustainability: economic, social or environmental?

Much of the discourse about sustainability talks about it as consisting of three dimensions: environmental, social, and economic. Ideally, for sustainability to be achieved, these dimensions need to be in balance. Is that actually the case in eco-city projects or does one dimension dominate?

Category 2: Which actors drive the eco-city?

The question of who should be involved in the development of an eco-city is also central to understanding its vision. Several categories of actors are frequently involved in large-scale planning projects. These are the private sector, individuals, civil society and community groups, government actors and expert advisors. What role do different types of actors play in shaping, developing and operating the project?

Category 3: Eco-city as a model or eco-city as an educational tool?

Given that the eco-city is a relatively new and ambitious model of urban development, one could anticipate that the actors involved would see it as more than just a place to live. On the one hand the eco-city could be about presenting a new model of sustainable urban living to the world, something to be replicated in other locations. On the other hand more emphasis could be put on using the eco-city as an educational tool. In this case the eco-city could, for instance, be used to increase the awareness of local residents and / or the public about sustainability.

Category 4: Behaviour change as solution or technology and design as solution?

How can an eco-city help achieve sustainability? In considering existing sustainable urban projects, there appear to be three ways for it to do this. First, inhabitants can be encouraged to change their behaviour in order to live more sustainably. The other possibilities are connected to technological solutions, which can be used in two different ways. Production focused solutions incorporate technologies to generate renewable energy into an eco-city.

Consumption focused solutions use technology and design to decrease the demand for resources, for instance through passive ventilation.

Category 5: Sustainability by design or management and governance?
Following from the above, the last category suggested relates to the role given to design versus governance in reaching sustainability in eco-cities. On the one hand, eco-cities may see sustainability as resulting from efforts made during the design phase: a city is an eco-city because it has been designed as such. On the other hand, being an eco-city may also depend on the way it will be managed and governed after project completion: a city is an eco-city because it is governed as such.

METHODOLOGY

The approach taken in this research was to analyse a set of documents for six different eco-cities in order to identify how and whether they talked about each of the issues identified above.

Selection of cases

In this paper eco-city is used as an umbrella term. As such, some projects labelled "eco-district" or "eco-village" are also considered here as eco-city projects. Joss's list of 79 was the starting point in selecting the cases for analysis. We then shortlisted projects on the basis of project type, size and ambition, and document availability. We eliminated eco-city initiatives in existing urban areas, focusing instead on urban projects that were developed from the beginning with strong eco or sustainability objectives. Projects also had to house at least 100 people and have a minimum of two land uses (i.e. residential and commercial). Having narrowed down the list, we then looked for a range of sizes and geographical locations. Through this process of elimination we were able to shortlist Joss's list to 22 projects. The next step was to identify the projects for which there was sufficient information available in the public realm and in English to do an analysis. This was to ensure that we had an adequate number of documents to analyse. Through this process we were also able to eliminate a number of projects that were clearly highly speculative. Ultimately, we settled for six eco-city projects. Table 1 lists each of the selected projects as well as some basic information about them.

Selection of documents for analysis

We selected three documents to analyse for each project. To ensure that the analysis would evaluate the projects on the basis of their basic characteristics and perceived virtues, we ruled out any documents that were critical, and used only documents that described the projects in neutral or positive terms. The documents range in length from 360 words to over 2000. The sources used also varied, and included professional magazines, online databases about sustainable planning, project websites, academic publications, and online magazines. A list of the documents used to analyse each project is presented in table 2.

Table 1: Summary of projects analysed

Project	Location	Description	Status
Dongtan Eco-City	Shanghai, China	Dongtan, promoted as the world's first eco-city, was planned for an 86 km^2 site near Shanghai. The British engineering firm Arup designed the city for the Shanghai Industrial Investment Corporation (SIIC), a public-private partnership and the commercial enterprise arm of the Shanghai municipal government.	Unbuilt
Masdar City	Abu Dhabi, United Arab Emirates	Masdar City, planned for a 1,483-acre site in Abu Dhabi, was designed by a consortium of British firms led by Foster and Partners Architects, for the Abu Dhabi Future Energy Company. The city, which originally aimed to be zero-carbon and zero-waste, will provide a home and testing ground for Abu Dhabi's Masdar Initiative, which aims to develop Abu Dhabi as a major energy research centre.	Under construction
Sonoma Mountain Village	Northern California, USA	Sonoma Mountain Village is a 200 acre mixed-use development on a former industrial site in California. It is initiated and financed by the investment holding company Coding. The project aims to integrate the principles of New Urbanism with the One Planet Living framework developed by the environmental charity BioRegional.	Under construction
Hammarby Sjöstad	Stockholm, Sweden	Hammarby Sjöstad is a 200 hectare development initiated and steered by the City of Stockholm. When complete the development will have about 10,000 residential units and 350,000 m^2 of commercial space, with about 35,000 people living and/or working in the area. In the district strong efforts have been made to close the material and energy cycle.	Mostly completed
Eco-Village at Ithaca	State of New York, USA	A small cohousing scheme of 96 homes in Ithaca, New York with shared facilities, collaborative decision making and energy efficient buildings.	Completed & being expanded
Western Harbour, Bo01	Malmö, Sweden	This district of 160 hectares is built on reclaimed industrial land and has room for 600 dwellings, offices and shops. It was developed in the context of the European Housing Expo that was held in Malmo in 2001.	Completed

Table 2: Documents analysed for each project*

Project	Documents analysed
Dongtan Eco-City	• (Bullivant 2007): *Professional magazine / journal* • *(Hart 2007): Professional magazine / journal* • (Danish Architecture Foundation n.d.): *Good practice database*
Masdar City	• (Masdar n.d.): *Project website* • (Foster & Partners n.d.): *Website of the designing firm* • (Nader 2009): *Academic publication by a project backer*
Sonoma Mountain Village	• Peters 2009*: Online magazine* • McCabe 2010: *Professional magazine / journal* • Langdon 2010: *Professional newsletter*
Hammarby Sjöstad	• Fränne, 2007: *Brochure developed for the city* • Pandis and Brandt, 2010: *Academic publication* • Nattrass, and Altomare, undated: *Good practice database*
Eco-Village at Ithaca	• ecovillageithaca.org: *Project website* • Jackson, undated: *Professional magazine* • Fellowship of intentional community, 2009: *Online magazine*
Malmo Western Harbour, Bo01	• Beer, undated: *Online magazine* • EnergyCite, undated: *Good practice database* • City of Malmö, undated: *Project website*

* for full bibliographic information refer to the references at the end of this paper

Search terms

To help identify statements expressing each of the discourses developed above, we developed a list of words that, if used, were likely indicated the presence of that discourse. For example, for eco-city as an exemplar project, we searched the text for words such as model, exemplar, template, replicate, and first. Using a simple software tool, Textstat, freely available from the Freie Universität Berlin, we identified how many times each of these words was mentioned. This helped us identify each instance in which that particular discourse was mentioned. A full list of all search terms is included in table 3. Each time we saw a word mentioned, we then checked the context in which they were used to make sure that only those that had a connection with the discourse were counted. Moreover, we also made sure that words would not be counted twice (e.g. renewable technology). This enabled us to compile a database of all instances in which each project was discussed (for instance) as an exemplar. For the category "behaviour as change" however, a different methodology was followed. Identifying in the various discourses attempts at behavioural change would be too limited if the analysis was restricted to specific words such has behaviour or consume. Instead, we undertook a manual content analysis, carefully reading through the documents and looking for instances where behavioural change was suggested.

From this database we compiled a frequency table (see table 4). From the relative frequencies with which each discourse was mentioned, we then were able to make some initial conclusions about the ideologies of each of the eco-city projects analysed. It is important to note that these are general conclusions based on a qualitative approach and should not be interpreted as having undergone tests for statistical significance.

Table 3: Search terms used for the analysis of the eco-city projects

Category 1	Search terms
Environmental sustainability	Environment, nature, ecology, preservation, wildlife, biodiversity, green, renewable, efficient, reduce, passive
Social sustainability	Social, accessible, affordable, culture, diverse, attractive, equity, participate, health, spirituality
Economic sustainability	Economy, industry, commercial, employment, company, business, work, financial, job
Category 2	Search terms
Actors: private sector	Company, business, industry, developer, private, architect, contractor
Actors: individuals	People, residents, inhabitants, public, individual, society, everyone
Actors: community / civil society	Participation, resident, community, involvement
Actors: government	State, government, authorities, official, politicians
Actors: experts	Expert, consultant, university
Category 3	Search terms
Eco-city as exemplar	Model, exemplar, template, first, replicate, prototype, inspire, paradigm, experience, communicate, demonstrate
Eco-city as education	Educate, teach, workshop, training, student, campaign, information, tour, engage, visit, course, knowledge
Category 4	Search terms
Behaviour change as solution	Manual content analysis
Technology & design as solution: production-focused	Generation, renewable, technology, CHP, solar, wind, biomass, design infrastructure, photovoltaic, production
Technology & design as solution: consumption-focused	Efficient, reduce, design, needs, diminish, insulate, minimize, saving, passive
Category 5	Search terms
Achieving sustainability through design	Architect, engineer, design, plan, masterplan
Achieving sustainability through management and governance	Manage, operate

FINDINGS

Table 4 presents a summary of our analysis of the sets of documents for each of the six projects. For each project it lists how many statements we found that reflected each discourse. The type of statement that was dominant in each category is indicated by putting the relevant number in bold.

Table 5 summarises the results in each category for the six projects. We concluded that a particular discourse could be seen as dominant if that discourse was used at least twice as often as the others in that category. Dominant discourses are identified by the words in bold text. Table 6 presents the same results summary, however here the highlighted terms are those two categories that were mentioned most *overall* in the texts. The results are discussed in more detail below.

Table 4: Frequencies

	Dongtan	Masdar	Sonoma Mountain	Hammarby Sjöstad	Eco-village Ithaca	Western Harbour, Bo01
Category 1: Type of sustainability						
Environmental	**37**	24	**28**	**76**	28	**64**
Social	8	1	10	12	**33**	5
Economic	12	**26**	13	8	6	11
Category 2: Actors						
Private sector	5	5	**30**	16	2	**34**
Individuals	9	3	18	**37**	12	23
Community / civil society	1	0	0	4	**59**	0
Government	6	**6**	3	16	0	12
Experts	**16**	0	8	0	4	1
Category 3: Model or Educational tool?						
Model	**17**	**4**	**9**	10	18	**21**
Education	2	0	1	**28**	**51**	13
Category 4: Solution focus						
Technology & design: production	**24**	16	**17**	**110**	8	**53**
Technology & design: consumption	15	**26**	15	51	**23**	8
Behaviour change	2	0	1	5	0	0
Category 5: How to achieve sustainability						
Design	**21**	**16**	**8**	**39**	**20**	**37**
Management	0	0	0	0	0	0
Total amount of words in the text	About 4100	Almost 3000	Almost 3200	Almost 11,000	About 6,700	About 6,000

Table 5: Dominant sub-category in each area

Discourse	Dongtan	Masdar	Sonoma Mountain	Hammarby Sjöstad	Eco-village Ithaca	Western Harbour, Bo01
Type of sustainability	**Environmental**	Economic	Environmental	**Environmental**	Social	**Environmental**
Actors	Experts	Government	Private sector	**Individuals**	**Community / civil society**	Private sector
Model / educational tool?	**Model**	**Model**	**Model**	**Education**	**Education**	Model
Solution focus	Technology & design (production)	Technology & design (consumption)	Technology & design (production)	**Technology & design (production)**	**Technology & design (consumption)**	**Technology & design (production)**
How to achieve sustainability	**Design**	**Design**	**Design**	**Design**	**Design**	**Design**

Table 6: Most frequently discussed themes for each project

Discourse	Dongtan	Masdar	Sonoma Mountain	Hammarby Sjöstad	Eco-village Ithaca	Western Harbour, Bo01
Type of sustainability	**Environmental**	**Economic**	**Environmental**	**Environmental**	Social	**Environmental**
Actors	Experts	Government	**Private sector**	Individuals	**Community / civil society**	Private sector
Model or Educational tool?	Model	Model	Model	Education	**Education**	Model
Solution focus	**Technology & design (production)**	**Technology & design (consumption)**	Technology & design (production)	**Technology & design (production)**	Technology & design (consumption)	**Technology & design (production)**
How to achieve sustainability	Design	Design	Design	Design	Design	Design

Economic, social or environmental sustainability?
In four out of six projects, discourses of environmental sustainability clearly dominated over economic and social. For three projects, Hammarby, Dongtan and Malmo, it was strongly dominant, and even for the two projects where it was not mentioned most, it was a close second. Its appears then that the environmental dimension of sustainability is important to the eco-city. Looking at the text, the importance of decreasing the environmental footprint of urban areas is a clear theme. For instance, for Hammarby Sjöstad, the goal for the district is to be "twice as good in relation to what goes for the best applied technology in today's new building design."

Masdar & Ithaca are interesting in their emphasis on different aspects of sustainability. Masdar's frequent mention of economic issues makes sense given that the city is presented as a vehicle for developing a renewable energy industry in Abu Dhabi. In this case, sustainability starts to be seen as a source of economic development. Ithaca's emphasis on social sustainability also seems to derive from the underlying aims of the project. The Ithaca website states that "as residents, [they] are engaged in a fascinating social experiment." This emphasis on social issues was unique among the cases studied.

Which actors drive the eco-city?
In the case of the actors that are playing a role in the eco-city, we found very few similarities among the projects. Each project seemed to focus on different actors. One interesting outcome was the impact that having a particular actor associated with the project had on the results. This can be seen in the case of Dongtan, where the designers Arup were mentioned many times and contributed to the dominance of the expert category. This was also the case for Sonoma Mountain Village, where the developer, Codding Enterprises, was also mentioned frequently and contributed to the dominance of the private sector as actor in the results for that project.

Mention of a category of actor did not necessarily seem to indicate it would be involved in shaping the project. In Hammarby the category the most frequently mentioned was individuals (37 times). For instance, one text stated that "all solutions have to be adapted to the needs of local residents." This seems to indicate that the future residents played a central role when designing the district and that it is built for them. However, the involvement of residents or inhabitants in the design of the district is only mentioned 4 times.

In this category Ithaca again stands apart from the other projects, with the community / civil society category coming up most frequently. Moreover, out of the 14 sub-categories of discourses examined in the analysis, it is the one most often used in the texts about Ithaca. From this it would appear that in projects where social sustainability is central, community groups might be more involved in the project.

Eco-city as a model or eco-city as an educational tool?
Each of the six projects is described multiple times as a model or example. A text written by the builders of Ithaca states "Our goal is to build a replicable model of a cooperative, environmentally sensitive village." In the case of Malmö, one text states that "the aim is to make Västra Hamnen an international leading example of a densely populated, environmentally sound neighbourhood." Masdar City is described as "a model for future development" and "the role model for the world," Dongtan as "a global template for sustainability in urban planning," and a "prototype for the future of all cities."

When talking about the eco-city, four cities see themselves mainly as an exemplars (Dongtan, Masdar, Sonoma and Malmo) while Hammarby Sjöstad and Ithaca are more focused on education. Somewhat surprising given that the Masdar Institute is heavily focused on research into renewable energy is that for this project the eco-city as an educational tool is not mentioned a single time. The project with the strongest emphasis on education is Ithaca, where this discourse was the second most mentioned of all the categories searched for. The eco-city as an educational tool appears as a crucial element of the discourse of the project. Actors involved in this project even talk about their "educational style."

Behaviour change as solution or technology and design as solution?
The use of technology and design are among the most frequently mentioned categories for all of the projects. In fact, every project studied mentions using technology and design as a way of achieving sustainability. However there was some variety in emphasis between projects when it came to whether this was for the production of renewable energy or the reduction of consumption. For four of the six projets, the use of technology and design was focused on developing more sustainable means of energy production. The two projects where environmental sustainability did not dominate over all the other dimensions, Ithaca and Masdar, were also the two most focused on using design and technology towards reducing consumption.

That said, Masdar and Ithaca have different ideas about how to reduce consumption. Intelligent design, the "latest high-tech monitoring systems" and "cutting edge technology" are described as helping to ensure that "Masdar City's use of resources will be far lower than that in conventionally designed communities." In Ithaca however, "passive solar design" or "south-facing arbours with deciduous vines minimiz[ing] overheating in warmer months" are mentioned as "strategies to achieve high energy efficiency." These extracts also highlight another point. When discussing reducing consumption, the texts focus on doing so through design. The need for residents to change their behaviour almost never came up in any of the texts. Instead, there is a recurring theme of making sustainable living effortless for residents. A text about Sonoma Mountain village for instance says that "the community is based on the premise that an ordinary resident will be able to live there sustainably with little extra effort."

Achieving sustainability through design; achieving sustainability through operation / governance
The one consistent result emerging out of the entire analysis is that in all of the cases, design is much more frequently mentioned than management as a driver of sustainability. Even in the case of Ithaca, while the texts suggested that governance is also important, it was not specifically mentioned.

DISCUSSION

The sheer diversity of approaches to creating an ecological or sustainable urban development found even in this small study would seem to indicate that, for the moment, there is no standard definition of what an eco-city is. Despite this diversity, it is still possible to draw out a few commonalities between all the projects. First, there was the overwhelming focus on

achieving sustainability through technology and design and the lack of attention paid to the ongoing government and management of these projects. That the notion of governance is not even mentioned in any of the cases studied is interesting when considering the increasing body of literature dealing with the notion of governance for sustainability. This may be related to the preference for a design-led approach to developing an eco-city. This leads to the question of whether the entire proposition of the eco-city is based on an excessively physically deterministic approach to planning.

Regarding strategies for achieving sustainability, again the projects' focus on design and technology dominated, this time over strategies to change the behaviour of inhabitants. Technology is in all cases used to deal both with consumption and production. However, no real patterns emerged about which of the two should be focused on. Finally, in most of the cases, one or both of these clearly appeared as one of the main discourses used to describe the project. This seems to indicate that technology is an inherent aspect of eco-city development and that it is seen as having a crucial role to play in achieving sustainability.

A third point of convergence among the projects studied was that they all aimed, in some way, to be seen as models or examples of urban sustainability. In some cases this ambition was more pronounced than in others but it was nonetheless always present. Additionally, the projects often discuss an ambition to be seen as models on a global, not just local scale. While most projects did not speak about education, in this sense they could all be seen as wishing to educate the world at large on what a new breed of ecological urban development looks like. This fits with a growing trend where places like Hammarby are becoming case studies of 'good practice' and field trip destinations for students of sustainable urbanism.

Finally there was the emphasis on environmental sustainability. Even for the two projects where other types of sustainability were more frequently mentioned, the environment was still a strong theme. This could reflect the challenge of incorporating economic and social issues into a design-led approach. Perhaps the designers of eco-cities are simply more experienced with and knowledgeable about how to address environmental issues. In the documents on Dongtan, which discuss environmental issues with great confidence, social and economic proposals are often couched in speculative language, e.g. the planners 'envisage' that local employment will be generated and 'feel that the Chinese should maintain local fishing and farming.'

The results presented in this paper are very preliminary and based on an analysis of only six eco-city projects, and there are some limitations to the methodology used. First, the requirement that documents be available in English limited the selection of cases. Second, the total amount of words analysed for each case differed quite significantly with the largest nearly 11,000 words and the smallest only 3,200. This was in part due to difficulties finding a balanced array of documents for each project. Despite these limitations, we believe the insights gained form this study can help progress an understanding of the ideologies behind of eco-city projects, and hope that the study has produced results which will be useful in directing further research.

CONCLUSION

The analysis in this paper demonstrated that there is a great deal of diversity among projects considered to be eco-cities. By looking for particular themes in the discourse about these

projects, we have demonstrated that this diversity goes beyond just their size, location and ambition. Indeed, it expands to their vision of what a sustainable urban future looks like, the techniques that planners and designers should use to achieve it, and the actors who should be involved.

We propose that this diversity may in fact be a good thing. As much as each of these projects wants to be seen as a model, perhaps it is better to accept that there is no single solution for making urban living more sustainable. In this sense, it is better to think of the eco-city as an ambition, an objective that there will be multiple ways to achieve. Many lessons can be learned from studying each project, both in isolation and in comparison with others. As time goes on and more eco-city projects are actually built, this diversity will allow for interesting and instructive comparisons.

The above may make it seem that we are remaining somewhat agnostic about the quality of these projects in relation to their sustainability goals. While our objective was to revel rather than judge, we can make what we hope will be some critically constructive comments about the projects studied. We are concerned about the lack of attention to ongoing governance and management of projects, and to the idea that people might need to change their behaviour. These characteristics could reflect a hesitance to engage with the more challenging and aspects of making urban living more sustainable. Perhaps the designers and developers behind these projects believe that these issues are beyond their remit, but we would counter that those interested in a comprehensive approach to sustainability must take them into account.

We hope that this paper will provide the grounding for further more in-depth research on eco-cities. We would particularly like to encourage qualitative analyses of the type that we have attempted, which try to uncover some of the underlying assumptions behind high profile projects. One reason for this is that as the demand for practical ideas about how to make urban living more sustainable increases, these projects are likely to get increasing attention from policy makers and practitioners around the world. Further research should focus on providing the information that these people will need to make informed decisions about how to achieve the eco-city objective in their own context.

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SYSTEMS INTEGRATION: CONDITION FOR SUCCESS
THE CASE OF HAMMARBY SJÖSTAD AND EVA-LANXMEER

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Abstract:
Today, many new urban areas, such as cities, towns, villages, or districts, are being built worldwide and their completion requires the development of a number of infrastructures. Traditionally, these infrastructures are planned in parallel. However, increased environmental awareness is pushing cities to improve their environmental performance. One way to do so is by systems integration (e.g. connecting drinking water pumping with energy production).
The aim of this paper is to show how different actor networks lead to different process of integration. We especially focus on the influence of actor participation during the design phase. To do so, two case studies are presented: Hammarby Sjöstad in Sweden and EVA-Lanxmeer in the Netherlands.

Keywords: systems integration; sustainable urban development; techno-economic network

INTRODUCTION

When new urban areas are being built, their completion requires the development of infrastructures necessary to meet a number of societal functions. Among others there is a need for energy and drinking water provision, waste management and wastewater treatment, or transport facilities. Each of these functions can be conceptualized as being produced by separate socio-technical systems. Traditionally urban planners consider each of these socio-technical systems independently from each other. Infrastructure for wastewater treatment is developed separately from that for transport for instance.
In the last decades, increased environmental consciousness has been pushing cities and municipalities to minimize the environmental footprint of (re)developed urban areas. In

parallel to that, a number of academics have been advocating that in the quest for the sustainable city a transition should be made from linear to circular systems of production and consumption. This is expressed under concepts such as circular urban metabolism (Girardet 1996), cities as sustainable ecosystems (Bossel 1998; Newman and Jennings 2008), urban symbiosis (Van Berkel et al 1009) or symbiocité (Gontier 2005). Behind these concepts lies the idea that interconnections should be developed between different material and energy flows in order to improve efficiency and reduce waste. This kind of thinking is also promoted by scholars from the field of industrial ecology (McDonough and Braungart 2002; Graedel and Allenby 2003).

Therefore, the aforementioned socio-technical systems have to be locally integrated to each other. We will refer to this process as 'systems integration'. Systems integration happens when socio-technical systems initially operating as separate entities become connected. This connection results in new inter-linkages between both social and technical components of the two socio-technical systems. Among others, examples of systems integration are the use of domestic waste for energy provision or the use of the sludge remaining from the treatment of wastewater as source of energy for generating transport fuel. Systems integration is not limited to urban areas. Similar processes of integration can be observed in water management (integrating qualitative and quantitative management, navigation, tourism) industry (industrial symbiosis) or farming (industrial symbiosis in greenports).

Numerous cities and municipalities are making attempts at systems integration (see Joss 2010). However, a wide gap exists between what is theoretically possible and what occurs in practice. Outcomes highly depend on who takes responsibility for the realization of the system, which stakeholders are involved in the design process, to which degree and how. Outcome depends on the characteristics of the actor-network involved in the realization of systems integration. Moreover, the process of realizing systems integration when developing a new district goes through different phases. The system has to be designed, constructed and then operated. In this paper, the analysis will address the design phase only. In practice, it is this phase that determines whether systems integration gets implemented at all and how it will operate once it is there. Two components of the design phase will be addressed: vision building, including both developing a vision for the integrated system and gathering support for it, and the selection of technologies.

In this paper, we argue that the actor-network in the design phase shapes the integration process. This includes both the elements of integration and the extent of integration. The aim of this paper is to show how different actor networks led to different processes of integration.

In the remaining sections, the concept of techno-economic network (TEN) stemming from actor-network theory will be introduced, along with the four poles that compose it. Then, for each case, the analysis establishes which actors played a role during vision building and the selection of technological solutions. We identify whether each pole was filled and which influence this had on the realization of the integrated system. The paper ends with preliminary conclusions and suggestion for future research.

THEORETICAL BACKGROUND: ACTOR NETWORK THEORY

According to actor network theory, the existence of an innovation is bound up to the construction of an actor-world. Callon (1986) stated that "an actor world associates heterogeneous entities. It defines their identity, the roles they should play, the nature of the

bonds that unite them, their respective sizes and the history in which they participate" (Callon 1986).
Moreover, acknowledging that the process of innovation as well as its diffusion requires connection between the worlds of science and technology and the market, Callon introduced the concept of Techno-Economic Network (TEN) (Callon et al 1992). A techno-economic-network is defined as

'a collective set of actors which participate in the development and diffusion of innovation and which via numerous interactions organize the relationships between scientifico-technical research and the market place' (Callon et al 1992).
According to Callon (1992), TEN are organized around three poles:

- Technical pole: design of products and processes that have their own coherence.
- Science pole: the production of scientific knowledge. It includes institutions such as universities, or research institutes.
- Market pole: consumers, suppliers, practitioners, their needs and their preferences.

To the three poles model, de Laat (1996), later followed by Buchhorn (2007), introduced a fourth one around government agencies and public authorities. This is the political pole.

The concept of TEN has been developed in order to understand the processes through which innovation happens and diffuses. As such the scale at which TEN is applied is often rather broad, looking at processes within specific domains but in an entire country (Callon et al 1992; Buchhorn 2007). In this paper, the processes analyzed are, on the contrary, very local. However, there are some important similarities between the processes of systems integration studied in this paper and the concept of techno-economic network as defined above. Systems integration requires the development of technologies that go beyond the scale of individual buildings. A network of heterogeneous actors responsible for the introduction of systems integration will have to be formed. Its role will be about organizing, with a certain extend of political support, the relationship between science, technology and the market.
Nevertheless, we acknowledge that the characteristics of the poles playing a role in the TEN have to be adapted to that of the network studied here. For instance the role of science is fairly different as we are not dealing with science that takes place in laboratories but with the application of scientific knowledge into practice. The four poles are thus described as follows:

- Technical pole: the technologies as artifacts and the organization owning and operating them.
- Science pole: experts with access to scientific knowledge from both private and the public sector.
- Market pole: it remains essentially the same. The analysis will focus on the investors and the end-users. Depending on the size of the project investors could be private companies, and/or local authorities. However, inhabitants may also fulfill this role. The end-users would often be the inhabitants themselves but may also be private companies.
- Political pole: regional or national authorities also play a role by providing political support.

CASE STUDY ANALYSIS

The Hammarby Sjöstad case study builds upon previous research done by one of the authors (Pandis, upcoming) on the development of the Hammarby Sjöstad district. In addition, four semi-structured interviews with people personally involved in the formation of the Hammarby Model and a literature review were conducted. Regarding EVA-Lanxmeer, data presented here are the result of a literature review including a number of reports, brochures, business plan and communication documents written between 1993 and 2008, nine semi-structured interviews and two follow-up interviews.

Hammarby Sjöstad

Hammarby Sjöstad literally means the city around the Hammarby Lake. The district covers an area of 200 Ha. Its development should be finished by 2015. When completed, about 35,000 people would be living and/or working in the area (Fränne 2007).

In the 1990's a number of semi-legal or illegal small scale industries and storage facilities were present in the area which came to be known as the Shantytown (Bodén 2002). Over time the desire to redevelop this area grew stronger in the municipality. At the end of 1995 the city of Stockholm decided to make a bid for the Olympic games of 2004 and to propose Hammarby Sjöstad as Olympic Village (Stockholm Stad 1996). The high environmental performance of the district started to gain importance because the International Olympic Committee was calling for an environmental focus in the applications. This also increased the political interest in the district (Bodén 2002; Green 2006; Enberg and Svane 2007).

Vision building:

In 1996 the City of Stockholm developed an environmental program for Hammarby Sjöstad. In this plan an overarching vision for the district was specified. It stated that *"The environmental performance of the city district should be "twice as good" as the state of the art technology available in the present day construction field (Stockholm Stad 1996 p4)"*. Of more importance for this study is the vision concerning the use of energy and material in the district that was also specified. It stated that *"The city district is to be planned and built in accordance with the principles of the natural cycles, the kretslopp."(Stockholm Stad 1996 p4).* It is on this aspect of the vision that we will be focusing. From now on when referring to the vision, we will only be referring to the vision for the integrated technological system in development (the Hammarby Model) and not for the district as a whole (the Hammarby Sjöstad).

Vision building for the Hammarby Model was an interactive process between the City of Stockholm and the local infrastructure companies (referred to as the eco-cycle companies). In 1996, the City invited the eco-cycle companies to propose technological solutions that would materialize their vision. However, they contested this vision and showed little interest. The City and the eco-cycle companies both had different interpretations of the vision. On the one hand the City wanted the companies to develop solutions specifically for Hammarby. On the other hand for the eco-cycle companies closing the loop made sense only if their existing infrastructure could be used. During an interview, the head of the Chief Administration Office, stated that "*the [companies] thought the project was fuzzy and that there already existed a well-functioning infrastructure in Stockholm. Why mess with it?"*

The first proposition made by the eco-cycle companies turned out to be rather "business as usual" and for that very reason was rejected by the City (Pandis and Brandt 2009). In order to push the companies forward, the City made clear that the companies risked losing their share in the project. The eco-cycle companies started mobilizing new employees and made a more

innovative proposition. It was based on their existing infrastructure however, individual components would be further improved and new components added in order to better close the eco-cycle. The City embraced this new proposition and encouraged the eco-cycle companies to work further in that direction. A consensus was reached. This also marked the birth of what would later become the Hammarby Model.

Selection of technologies:
Once the vision is developed and has gained support, technological options have to be selected. In Hammarby Sjöstad, some options had already been mentioned during the vision building process. However, they still had to be developed further before they could actually be realized.

Biogas as transport fuel:
Biogas for transport, integrating the sewage system and the transport system is one of the most successful innovations implemented in Hammarby Sjöstad. Biogas is produced in Hendriksdal, the local wastewater treatment facility. Since 2003 the biogas is also upgraded to transport fuel quality in a nearby site.

Pole	Actor involved	Role	Position
Politics	The City of Stockholm	Provide political support	Collaborate
Market	Stockholm Water The City of Stockholm SL (Stockholm public transport company)	Invest Creates a local market, provide subsidies Buy the product	Lead Collaborate Collaborate
Science	Employees from Stockholm water	have knowledge from previous demonstration project	Collaborate
Technical	Stockholm Water	Owner of the wastewater treatment facilities; responsible for the previous pilot project	Collaborate

***Table 1**: biogas for transport: actors involved in each pole, their role and position.*

- Political pole: interest in clean vehicle dates back to 1994 when the City of Stockholm had taken the political decision to promote and invest in clean vehicles (Stockholm Stad 2004). In 1996, it also started supporting a pilot project in Bromma where biogas was upgraded to transport fuel.
- Technical pole: Stockholm Water is both owner of Hendriksdal, the plant where biogas is to be upgraded and of the plant where the aforementioned pilot project took place in 1996 (Energie-cites 1999; Held et al 2008).
- Market pole: first, the success of the pilot project encouraged Stockholm Water to invest further in that direction. Second, the City of Stockholm took the resolution to convert its own fleet into non-fossil, providing a market for biogas (Stockholm Stad

2004). Third, the City introduced programs to promote the use of biofuels in the city slowly creating local demand for biofuels (Stockholm Stad 2004). Fourth, SL, Stockholm's public transport company, started considering biogas as a potential fuel in 2002. The company had been previously focusing on ethanol but started having some difficulties with its supplier and decided to diversify its supply (Stockholms Lokaltrafik 2002). In 2003 an official contract was signed with Stockholm Water regarding the supply of biogas (Hallgreen undated).

- Science pole: Stockholm Water had knowledge about biogas upgrading.

PV:
PV integrating buildings and the electricity system were extensively discussed in the early plans about Hammarby Sjöstad. Their large scale introduction was even discussed. However, only very few have been installed and some of those installed are not performing as expected. Looking at the pole, we can see that some instead of working for the technology actually worked against it (see table 2).

Pole	Actor involved	Role	Position
Politics	The City of Stockholm	Provide political support	Support
Market	Fortum	Invest in the technology	Initially interested, then arguing against
	Constructors	Invest in the technology	Limited interest
Science	Fortum	knowledge of solar energy, its costs and efficiency	Contest
Technical	Fortum	Owner of the district heating company	Limited interest
	PV	The technology exists	Readily available

***Table 2**: PV: actors involved in each pole, their role and position*

- Political pole: the City of Stockholm wanted to introduce technologies that were new to Stockholm in Hammarby Sjöstad. PV fell into that category. However, as the project evolved, political support for alternative technologies that did not play a central role in the Hammarby Model diminished (Pandis upcoming). This is partly due to the City losing the bid for the Olympic Games.
- Technical pole: First PV are readily available in the market and show decent performances even in the Nordic Stockholm region (Brogren et al 2004). However, very few PV were present in Stockholm at the time. Another aspect worth mentioning is that most of Stockholm is connected to district heating network and so would the Hammarby Sjöstad. However, Fortum, the company owning the district heating which is mostly based on combined heat and power, saw PV as a competing technology. During an interview, the environmental manager in Stockholm Energi (that would later become Fortum) stated for instance that "*solar energy pushes away cogeneration or other useful techniques*".
- Market pole: Initially Stockholm Energi was interested in investing in PV on a large scale. However, the company later on changed its mind arguing that they were not

competitive. The privatization of Stockholm Energi in 1998 could partly explain this change of attitude. Moreover, the City of Stockholm provided only limited support for project developers to introduce PV who showed little interest. Moreover, when they did, PV were installed according to aesthetic criteria rather than optimal electricity production. The function of the building, in which aesthetics was a primary element, was not effectively reconciled with electricity production (Brogren and green 2003).

- Science pole: Fortum had access to knowledge about PV, their efficiency and their cost from existing project done by other companies but did not have in-house know how. Fortum actually contested that PV were an interesting alternative for Stockholm. During an interview, the environmental manager in Stockholm Energi said that *"during the formation of the Hammarby Model PVs and solar panels were discussed as an alternative, but we knew this was not economically realistic"*.

EVA Lanxmeer

EVA Lanxmeer is a sustainable urban district of 24 Ha developed in the municipality of Culemborg in the Netherlands in the mid 1990's. This municipality is part of the province of Gelderland. In total about 800 people live in the area. Moreover, a number of office buildings are also present on site combining living with working.

The district, which development was initiated in 1993, is the result of an initiative taken by Marleen Kaptein. She was triggered by the momentum developing around sustainability, the Bruntland report had just been published, and by the lack of success from the Dutch government to involve citizens in their environmental policy (Kaptein 2010). Initially, the idea for the district was not bound to any specific location. To be able to enter in negotiations with a municipality she created the EVA-foundation. Using her personal network she gathered renowned Dutch academics and political figures with direct connection to the ministry of Housing, Spatial Planning and the Environment around the project. To show their support they became members of the EVA-foundation.

<u>Vision building:</u>

The process of vision building and support in EVA-Lanxmeer happened very differently from that in Hammarby Sjöstad. The vision for the district to be was entirely developed by experts, including national and international academics and experts from the private sector, free from the influence of local policy makers. The vision included the following elements: an architecture in harmony with the existing landscape; integration of functions: living, working, recreation; reduced use of cars; use of ecological building materials; and most importantly for this paper sustainable water- and energy resource management and the involvement of future inhabitants; education & advice via the EVA-center (Stichting EVA 1995).

The next step was for the EVA-foundation to find a municipality that was willing to realize a district based on this vision. People interested in living in such a district were also looked for. The foundation found support from the Alderman responsible for spatial planning and the environment in Culemborg and from the head of the department of urban development. The municipality already had experience with sustainable building, citizen participation and management of green areas. They had the ambition to go further with urban sustainability and saw the EVA-foundation and its vision as an opportunity to reach that ambition (Stichting EVA; Goed 2010; Kaptein 2010).

Furthermore, Marleen Kaptein also found 80 families that signed a document stating that they would like to live in such a district wherever it would land (Stichting EVA; Goed 2010; Kaptein 2010).

Later on companies were also invited to join in the discussions concerning the specific solutions to be implemented in the district. However, to be able to actively participate in the process, they had to agree with the overarching vision. It was not going to be revised in the process. In fact the EVA-foundation was actually assigned the role of concept keeper by the city and would be guarding the concept or vision throughout the development (Stichting EVA).

Selection of technologies:
Before describing in detail the selection of specific technological solutions, we will first introduce the context in which these solutions were chosen. In 1997, non-professional workshops were organized where inhabitants could express how they wished their future district to look like. Later on, representatives of the inhabitants brought these ideas to professional workshops where they actually influenced the design of the urban plan (Stichting EVA). Even if this does not have a direct influence on the choice for specific technological solutions, this participation is still important to mention. Indeed, the inhabitants participated throughout the process in the design of their neighbourhood and were kept informed by the experts of the technological solutions that were being discussed.

Blackwater treatment and the production of biogas:
Early in the process came the idea to separate blackwater (toilet waste) from greywater (water coming from the kitchen and the shower), to treat it locally using biological processes and to use the remaining sludge to produce biogas integration of wastewater treatment and energy production (Stichting EVA; van Timmeren 2004; van Timmeren 2006). Organic waste produced in the district was also planned to be added to the sludge in order to increase biogas production. These two elements were both planned to be part of the EVA-Centre (see vision) (Kaptein 2010). However, the centre was never realized and with it these two technological solutions did not materialize. A summary of the results of the analysis can be found in the following table.

Pole	Actor involved	Role	Position
Politics	The municipality of Culemborg	Provide political support	Initially interested then released all responsibility
Market	GGR Gas Nuon	Invest in the technology Consume the biogas	Initially interested, then stopped supporting Reject
Science	Energy expert Architect	Knowledge of the treatment of blackwater, the production of biogas and its integration into a building	Provide information
Technical	GGR gas Blackwater treatment and biogas production	Operate the technology	Initially interested then released all responsibility Available

***Table 3**: blackwater treatment and biogas: actors involved in each pole, their role and position.*

- Political pole: the municipality of Culemborg initially supported the project. It was part of the vision for the district and the municipality had embraced this vision. However, over time interest diminished and in 2003 the municipality released all responsibility for the project (Kaptein 2010). This can partly be explained by the fact that the civil servant initially supporting the project left the municipality, and partly because during the time frame of the project, different municipal councils succeeded one another. New council members did not understand what was going on in EVA-Lanxmeer anymore (Kaptein 2010). The project leader for EVA-Lanxmeer employed in the spatial planning department also mentioned that "*the project was too ambitious for somewhere like Culemborg*".
- Technical pole: the company "GGR gas" was initially expected to operate the biogas installations. However, the company later on stopped its support (Bonouvrié 2010; Kaptein 2010). Moreover, for biogas to be produced blackwater treatment had to be done locally. The two technologies were intimately connected to each other. However both had already been introduced elsewhere in more or less large scale.
- Market: Large amount of biogas were expected to be produced and a market had to be found outside the district. One solution considered was to send (part of) it back into the gas network. However, Nuon, a Dutch energy company responsible for the gas grid in that area, rejected the idea (Bonouvrié 2010). There were thus many uncertainties regarding the availability of a market for biogas that was to be produced. This also partly explains why no large investors could be found for the project.
- Science: energy experts and architect worked on the EVA-concept. Scales models were made, together with a number of calculations and academic publications (van Timmeren 2004; van Timmeren 2006; van Timmeren 2007). Technical knowledge was thus available during the process.

Local treatment of greywater:
Part of the water concept was to locally treat the greywater produced in the district integration of wastewater treatment and aquatic ecosystem. This includes water coming from the kitchen and the bathroom. This was one of the solutions successfully implemented in the district (Stichting EVA).

Pole	Actor involved	Role	Position
Politics	The municipality of Culemborg Water board Rivierenland	Provide political support Provide support	Support Collaborate
Market	Future inhabitant Water board	Produce the greywater Financing and maintain the system	Participate Collaborate
Science	Academic and private experts Arcadis	Provide information Provide information	Inform Inform
Technical	Brinkvos water	owns the technology to build the system	Available

***Table 4**: local treatment of greywater: actors involved in each pole, their role and position.*

- Political pole: First the municipality of Culemborg supported the idea from the very beginning. Second the Water Board Rivierenland, a regional government body responsible for maintaining the level and the quality of the water in the area also supported the project (Bonouvrié 2010; Kaptein 2010)
- Technical pole: greywater treatment in Culemborg was new. However similar systems had already been built elsewhere. In EVA-Lanxmeer, technical calculations were done by Arcadis, a Dutch engineering firm.
- Market: First the Water Board Rivierenland played an important role here by allowing such an experiment to be realized (Verhaagen, 2011) and by financing it (Bonouvrié 2010; Kaptein 2010). Second the future inhabitants were kept informed of the technological solution chosen and their implications (Stichting EVA). This has been very important as for the biological treatment of greywater to function properly, chemical products such as bleach can't be thrown into the sink. Inhabitants thus have to adapt their behavior to the system in place.
- Science: academic and private experts, and Arcadis all provided information about the greywater system (Stichting EVA).

DISCUSSION AND CONCLUSION

The aim of this paper was to show how different actor networks led to different process of integration. The focus was on the influence of actor participation during the design phase, including vision building and selection of option. We used the concept of Techno-Economic Network developed in order to understand innovation processes to analyze attempts at systems integration in two case studies: Hammarby Sjöstad in Sweden and EVA-Lanxmeer in the Netherlands. It total four different attempts at systems integration were studied. A summary of the results can be found in table 5.

First, our results show two very different approaches to vision building. In Hammarby Sjöstad, as initiator, the City of Stockholm developed a vision and then tried to get support from local infrastructure companies. However to do so she had to both pressure the companies and agree to make some compromises. In fact, vision building was not a purely separated process but was also influenced by the initial selection of technological options. Moreover, we can see a dominance of two groups of actors: the City of Stockholm and the eco-cycle companies. We can also note that technology related actors have a prominent role while future inhabitants did not have a say in the process. We can observe that discussions focused on closing material and energy cycles through technological solutions.
In the case of EVA-Lanxmeer however, a number of experts developed a vision and looked for partners interested in working with that vision. The partners they sought were a municipality and future inhabitants. In this vision, the technological component only played a marginal role. No location was known when the vision was built so it had to be stated rather general to give space for local specificities to be expressed. Moreover, technical partners were later invited to join in the discussions but on the conditions that they agreed to work with the vision. It is the process through which these technological solutions were to be chosen, in interaction with the inhabitants that was given the most attention.

Regarding the specific technological solutions chosen, our analysis unsurprisingly shows that the two cases where implementation was successful had all the poles filled and often by more than one actor. Concerning biogas production in Hammarby Sjöstad, a variety of partners with different expertise gathered around the project. They all found interest in biogas either

as a way to expend their market, or to help meeting their corporate ambitions. The market and the science pole were filled by more than one actor ensuring the availability of knowledge and the presence of a future market for the product in development.
In EVA-Lanxmeer, generally speaking, the context in which the district developed was favourable for experimenting. Actors with political power were inclined to support, politically and financially, innovative solutions such as greywater treatment. The science pole was strongly represented giving credibility to the solution and its feasibility. The market pole, through the future inhabitants, was also well represented. This was especially important given the role that inhabitants have in ensuring the proper functioning of the system. However, this raises questions regarding the long term operation of such a system as new inhabitant have to be kept informed of the existing rules. This is especially challenging in situations where there is no formal institutional setting and where responsibilities are not clearly distributed. In EVA-Lanxmeer, it is the inhabitants themselves that, out of their own will, are organizing knowledge diffusion in the district.

Stage	**Pole**	**Hammarby Sjöstad**		**EVA-Lanxmeer**	
Vision building	Politics	Yes		No then yes	
	Market	No then Yes		No then some yes	
	Science	Yes		Yes	
	Technology	Yes		No	
Choosing specific technologies		Biogas	PV	Biogas	greywater treatment
	Politics	Yes	Yes	Yes then No	Yes
	Market	yes	No	No	Yes
	Science	Yes	No	Yes	Yes
	Technology	Yes	Yes	Yes and No	Yes
Final result		Introduction successful	Introduction very limited	No introduction	Introduction successful

***Table 5**: Summary of the findings. The words "yes" and "no" are used to express whether the pole is filled or not.*

Concerning solutions that were not realized, our data also tends to show that independently, political support (political pole), technological feasibility (technical pole) and knowledge availability (science pole) are not sufficient for systems integration to be realized. Moreover, in the two cases where implementation failed, the market pole was very weak. In the case of PV in Hammarby Sjöstad, the technology was readily available. However, it did not fit in the portfolio one of the key actor who even contested the usefulness of introduction. Moreover, shifting political support failed to create a real market for PV in the district.

Looking at backwater treatment and biogas production in EVA-Lanxmeer, out of the four poles, only the science one was actually fully represented and was actually driving the realization. The market was rather insecure and uncertainties remained around who would be building and operating the system. Political actors provided insufficient support, unconvinced of the economic feasibility of the project.

To conclude, results presented in this paper show that, as expected from the theory, all poles need to be filled for a successful implementation to happen. Results also show that partial implementation can be realized with only a few poles active. Moreover, the analysis suggests that the market pole is difficult to fill and that market actors are difficult to convince to join in systems integration practices.
These results also raise a number of questions. First, in this paper the analysis only shows the final results of various attempts at systems integration. A chronological analysis showing how the poles get filled from the moment when the idea was developed to its realization (or abandonment) would better reveal which pole drives the process and the dynamics behind systems integration. This may also reveal when and under which condition does the market pole start being filled. Moreover, the analysis done here shows what happens but does not explain why actors decide to join the process or not. Each actor, whether they are doing public transport, wastewater treatment, district heating, etc. is part of a socio-technical regime. This regime sets the norms and routine that drive actors and their activities. Including a more in-depth investigation of the actors and the regime to which they belong would give explanatory power to the analysis.

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THE RISE OF THE ZZP'ER (SELF-EMPLOYED PROFESSIONAL) IN THE DUTCH CONSTRUCTION INDUSTRY

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Abstract
55% of all carpenters are self-employed (zzp'er), 37% of plasterers and wall-/floor finishers is zzp'er, and 28% of the bricklayers and interpolators is zzp'er. Of all the work in the construction sector, zzp'ers now do 15%. Is there something special about these people or the construction industry and where do these characteristics originate in?
In this paper we will show a zzp'er is a hard working professional with a lower to secondary education, having an average age of 44: he is a former employee and has a desire to run his own small business. He wants to take his own decisions en he is proud of his craftsmanship. But, he lacks recognition of human needs in construction companies.
We will show you main differences in needs and thinking between zzp'ers and the construction companies. Zzp'ers look for freedom, autonomy, respect, and recognition. They are anti hierarchical, and prefer integration of thinking and doing, and collaboration based on friendship. Construction companies want to be in control, there structure is pyramidal, and the way they organize is based on a strict separation of thinking and doing; collaboration is forced. We think that (major) construction companies should ask themselves whether they want to continue their present policy with more all round professionals leaving or retain their people for which investments in a better place to work are required.

Keywords:
zzp'er=self-employed professional; labor relations; HRM policy

THE RISE OF THE ZZP'ER (SELF-EMPLOYED PROFESSIONAL) IN THE CONSTRUCTION INDUSTRY

Introduction

55% of all carpenters are self-employed (zzp'er), 37% of plasterers and wall-/floor finishers is zzp'er, and 28% of the bricklayers and interpolators is zzp'er. Of all the work in the construction sector, zzp'ers now do 15%. (Berkhout en Kok, 2010) These figures reveal a real innovation in Dutch labor relations, where people – to the 90s - were used to life time employment.
Zzp'ers value freedom at work more than the certainty of being a payroll employee. This raises questions. Is there something special about these people or the construction industry and where do these characteristics originate in?

Background

At the time we started the research on zzp'ers in construction in 2009, the number of zzp'ers was growing spectacular and the topic was frequently discussed at meetings and parties. Everyone noticed the increasing number of zzp'ers and everyone knew someone working as a zzp'er. People were speculating about the motives of becoming a zzp'er: was it trendy, did it earn more money, was it the status of independent worker, was it because people had lost their job and could not find a new regular position or was it a devious attempt by employers to reduce their risk by replacing full contracts by temporarily hiring zzp'ers? Or could it have been our society's individualistic culture? The absence of hard facts preserved a good discussion, but prevented an increase in knowledge.

Curiosity about the exact causes and the identity of the zzp'er lead to a first explorative study. This study quickly revealed that zzp'ers were not only largely represented in the construction industry, but also in other sectors, with as clear outlier the professional services sector. The CBS (Statistics Netherlands) presents the following data in 2009.

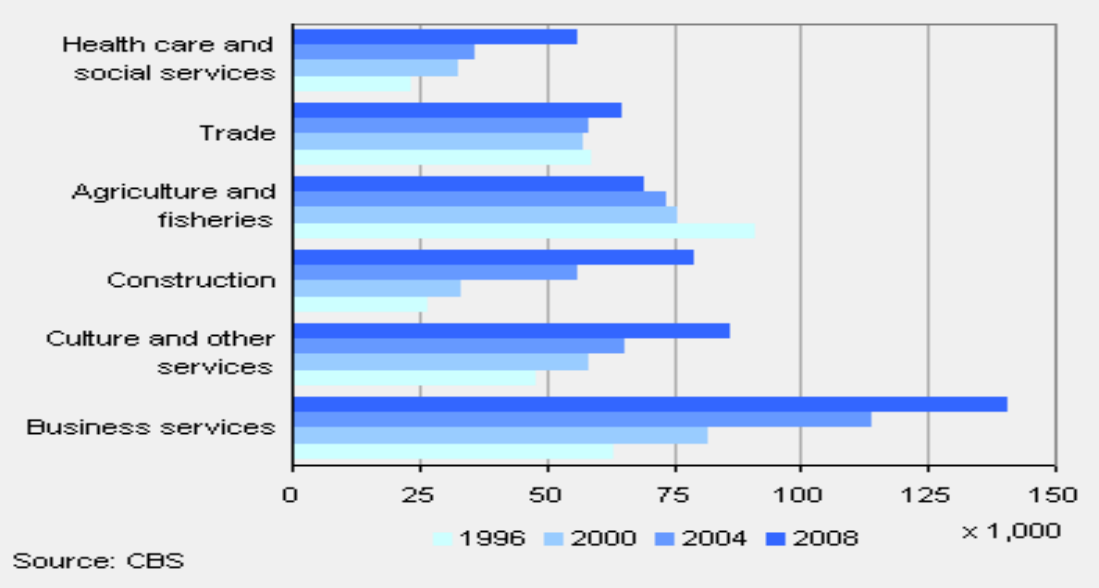


Figure 1: Self-employed without personnel in various sectors, CBS, sept. 2009

Remarkably the construction sector shows the highest growth rate in number of zzp'ers: a tripling since 1996. This growth rate is unknown to other branches and explains why the topic attracts this much attention in the construction industry.
Meanwhile a variety of studies on the zzp'er are published with telling titles such as *Van onbemind tot onmisbaar* (from unloved to indispensable) (EIM, 2007), and *De zzp'er lijkt ineens overal. Werken voor jezelf is ook een optie* (the zzp'er seems to be everywhere. Self-employment is an option, too) (CWI, 2008). In 2009, Arjan van den Born is the first in the Netherlands to get his PhD on the topic zzp: *the drivers of career success of the job hopping professional in the networked economy*.

At the end of December 2010 there are 704,000 zzp'ers in the Netherlands, an increase of 24,000 compared to the previous year (CBS, Dec. 2010). 704,000: that is around 10% of the labor force.
A certain aversion against working in large organizations, perceived as bureaucratic, seems to evolve (Van den Born, 2009). This is especially true for the younger generations, who think in terms of networks and cooperation without hierarchy (Boschma en Groen, 2007).

Everything points towards the zzp'er not as a passing phenomenon, but as the result of changing beliefs about organizing and labor relations.

Methodology
We decide upon a detailed exploration of the zzp'er and his working environment in general and the zzp'er at the construction site in particular (the construction-zzp'er) with at stake a qualitative exploration of the zzp'er and the context of his rise.

We perform the general exploration by means of a literature review. We choose a social-organizational perspective with the search terms: zzp'er, Human Resources Management and Labor relations and we use the expert network of the HU-professorship Cultural Change in the Construction Sector which encompasses among others Bouwend Nederland (Dutch Construction and Infrastructure Federation) and FNV/Zelfstandigenbond voor Bouw en Hout (labour union for zzp'ers in construction and carpentry) (around 12,000 construction-zzp members), and HRM-directors

In-depth interviews are conducted with 6 bouw-zzp'ers, 3 employers, 1 project leader, 1 team leader and 1 works preparation engineer. All interviewees are randomly selected out of the region Mid/West Netherlands.

We follow-up the interviews with a small survey among zzp'ers associated with the FNV/Zelfstandigenbond. Finally, we link our sample to an EIB research encompassing around 1800 respondents, which allows for generalization of certain parts of our research.

Literature research: Looking for the drivers behind the rise of the zzp'er
As to answer the questions who the construction zzp'ers are, what explains the increase of zzp'ers, and what in the construction industry makes that everybody seems to begin his own business, we start with looking of drivers on general societal level. Subsequently we focus on companies in the construction industry. As explained above we do will do this in a social organizational perspective.

The end of traditional labor relations?

When studying the literature on the rise of the zzp'er, we silently assume that work is being done in organizations and owner/manager and employee agree upon a labor relation. Legislation and branch specific regulations (collective agreement) apply, core to which are the employer offering labor and the employee offering his services; as well as the employer paying a wage for performed labor and the employee acknowledging the employer's authority.

Kluytmans (2010) points out that the employee does not have a free choice of co-workers. He has to align with the design and direction of the organization. Finally, an individual labor agreement determining working hours, free time, company car and other secondary or tertiary fringe benefits is drawn up at the company level. This is the traditional labor structure in the Netherlands.

The rise of the zzp'er appears to disrupt this pattern. Zzp'ers do not choose a labor contract, but a project-based contract. Conditions are fixed in a contract to accept labor or offer services; traditional labor legislation does not apply. From this perspective the zzp'er is an entrepreneur. The interpretation of the word zzp'er is diffuse, as it is not legally established, which induced different definitions and views on the zzp'er. We have chosen the definition provided by CBS Statistics Netherlands:

Self-employed without personnel (zzp'ers) are individuals who carry out work on their own account and at their own risk in their own business or practice or work in an independent professional setting without personnel.

There are more indications that the traditional labor relationships are on its way back. In the late 90s Hamaker, 1998) predicted the rise of the 'werkondernemer' (a contraction of employee and entrepreneur, roughly translated as working entrepreneur. In English I will use the word "Employneur"). In his book 'de kunst van zinvol werken' (the art of working meaningfully) he outlines a return to the pre-industrial era, when it was common to work at home as a self-employed professional. Hamaker introduces this new word "employneur" to stress that we can neither speak of an entrepreneur nor an employee, but something in between. This is exactly what we nowadays call a zzp'er.

His prediction has turned into reality. Increasingly more people market their competencies and (have to) use them as a starting-point to find new projects. The upcoming phenomenon of looking for work yourself is illustrated in newly published books such as 'het merk ik' (me – the brand) (Van Zwieten and Van de Grift, 2009),

The rise of ICT

Castells (2000, 2010) shows that the need for independency, and more broadly formulated the need for a new organization of labor and labor relationships, is strongly correlated with the rise of ICT. ICT allows labor to be time, place and distance independent. People can quickly exchange information online, worldwide and 24/7, which is why tasks can be performed at home, in train or car, in the office, anywhere abroad or wherever. There is no need for a place to go to every day on fixed times to perform your job.

In his PhD study Van den Born (2009) names ICT one of the structural drivers of the rise of the zzp'er. At first sight this development seems to be less relevant in the construction sector, but realizing how much administration and organization a zzp'er does with his mobile and

computer it is evident that even in industries largely relying on physical labor ICT influences its organization.

Cultural change: Individualization
Ever since the 60s of the 20th century Dutch people increasingly want to be seen and approached as an individual. The young baby-boomer growing up in the 60s wanted to realize himself, dismissing the background of the 'collective' 50s dominated by a 'rebuilding ideology'.
Development and self-realization, a humanistic psychology and new ideals such as equality, participation, having a say and democracy lay the foundations of an upcoming Ik-tijdperk (Me-era) (Van Galen, 1980). All supported by a strong economy and increasing welfare.

In the 80s a liberal range of thoughts replaced the dominant social thinking of the 60s/70s: the market as well as the free individual increasingly become the foundation of social and economic policy. The welfare state with its abundance of collective agreements is converted into a system of minimal facilities for the individual. Several studies by academic authors (Schnabel, 1999; Nagelkerke en De Nijs 2009, Mak, 2004, Felling, 2004) underline the big influence individualization has on many different aspects of life, such as ethics, religion, housing, working life, labour relations and trust.

Since the last decade we have been confronted with a new generation, grown up with the computer. They ask for new labor relations. Why go to the office, if you can do it at home? (Boschma en Groen, 2007)
The modern worker, employee or zzp'er, is critical. He uses social media for friendship and work, and organizes power on the internet. The network = power.
Today, managers in the office are confronted with many more workers, higher educated and they can rely less on authority as basis of power. They demand integrity, respect for their competence, co-creation, challenging tasks, and want to be part of a Hot Spot (Linda Gratton, 2010),
Meanwhile a variety of publications about 'new labor' and the 'new employee' appear.

Economical developments
For the last decennia Dutch economy, with exception of a few setbacks, has been flourishing and growing for almost every year. Good and well-organized relations between government, employers and employees certainly contributed to this consistent strong performance of Dutch economy. Good labor relations contribute to economical health.
The government played an active and stimulating role in the rise of the zzp'ers. These were psychological (growing the status of entrepreneurs) interventions, but also financial contributions and supporting tax regulations. ZZP'ers have been exempted from many of the normal employer's obligations.
Both the strong economy and the support by the government created a positive environment to start as a zzp'er

Why do organizations work with zzp'ers? Flexibilization and indivualization of labor relations on the organizational level
Anno 2010 a lot of labor organizations stopped functioning as some kind of 'plant' with standard hours, fixed work spots and collective agreements. Without much fuzz employees and other participants have adjusted collective agreements to individual wishes. In a study on collectivism versus individualism in labor relations, De Leede and Looise (2004) talk about a pragmatic method of designing decentralized and individualized labor relations. The use of a

wide range of different contracts and relationships became common practice. De Korte (2009) mentions fading organizational boundaries and the variety of individuals he interacts with.

Organizations have a stake in individualization. Their environment has become more dynamic, complex and competitive since the 80s and they need the individualization in order to successfully compete in this new context. Competition is not only located around the corner, the whole world is now their playing field.
To adjust to these development organizations had to thoroughly reorient. Core questions: what businesses do we do, does this fit our core competencies; what do we want to do ourselves and what do we want to outsource? The idea that an organization should conduct all activities itself was released and the new motto became: do what you do best.
Organizations started to reinvent themselves. Structures were flattened, processes more client-focused, departments and organizational levels dismantled and responsibilities decentralized.
Changes in the way of organizing had a large impact on staffing. Lifetime employment disappeared. Both the job and the employee could suddenly be sold off or contracted out, and internal job security was permanently at stake.
Human Resource Management (HRM) had to be reinvented as well. Inspiration was amongst others provided by Atkinson's (1984) model of the flexible firm. This model distinguishes employees according to their relative importance to the organization: in the center the core group, around that 2 layers of easily replaceable personnel. The outside layer contains groups with temporary contracts due to their specific expertise or flexibility. This approach provides the organization with the flexibility to adjust to economic cycles.
Flexibility became a key competitive advantage and Atkinson's model provided two different types: quantitative and qualitative flexibility. Quantitative flexibility means an in- or decreasing number of people, whilst qualitative flexibility stands for people able to perform more different tasks. An example would be the shelf-stacker who mans the counter during peak hours.

Atkinson's model implicitly breaks the equality principle that used to be at the foundation of HRM. This first shock in the system of labor relations opens the way to further differentiate personnel. Among others Schoemaker (1998) elaborates on this by identifying different types of labor in relation to management. Blue, silver, white and gold workers were born. Additionally, HRM instruments were reviewed or newly designed based on the idea of an employee's own responsibility for his career, facilitated by his employer. Investing in the employee made him more employable in the organization, increased organizational flexibility and strengthened the individual's position on the labor market .
In summary we argue that labor relations between employer and employee have become more flexible and individual. This has been caused by economic, technological and cultural developments. The philosophy of employees being all equal has been replaced by differentiation. Job security at one employer disappeared; at stake is job security through personal development. Life time employment has been replaced by life time employability.

Construction: a sector in change
The construction industry is changing significantly. This is not only caused by changes in society but also by the dynamics in the construction industry itself. In this context we can mention:

1) The need to conduct business in a transparent and integer way as a consequence of the findings of a Dutch Parliamentary Committee "Enquete commissie" especially installed to research fraud in the construction industry.
2) As criteria of sustainability have become more important in the Dutch society, also the construction industry will have to adjust into this direction.
3) Construction activities have more and more moved from the "meadows" to the inner cities. Where in the past 70% of construction work was taking place outside the cities nowadays 70% is being done in inner cities with significantly increasing complexity.
4) Renovation as percentage of all construction work is increasing and has already passed the 50% mark
5) Increasing and more complex legislation
6) The end user's demand to influence the product
7) On many construction sites productivity is below 50%
8) Cooperation both in the chain as well as on company level can improve significantly also by taking back fragmentation
9) Main construction companies are moving from "offering Capacity" to "offering products and concepts".

From this list possibly point number 8 is the most interesting for our research. Very significant division of labor anchored in a structure with contractors, sub-contractors and zzp'ers characterizes the construction industry. The leading business concept is that maximum division of labor is the most profitable.. Profitability is measured on the level of execution in numbers of meters… Taylor's Scientific Management is still well alive here.

This drastically division of labor has many negative consequences both on organizational as well as a human level although this seems not be known or to be dealt with in the industry. This is quite remarkable as a huge complain in the construction industry is that employees on the construction site are not involved. Also costs of failures are very high. There is not a common definition of cost of failure, but there is a general agreement that these costs include costs caused by failure in work coordination. It is also in the "genes" of the construction industry. Pries (2008) mentions the construction paradigm characterized by a typical engineer's philosophy; ration, analytical, control oriented, and 'what cannot be measured does not exist'.

In this culture people only exist as labor, which is a necessary means to deliver a product. In Taylor's thinking as well as in the construction paradigm mentioned above it is an advantage that people can be replaced easily. This decrease vulnerability in case of illness. However, this thinking also creates a self-fulfilling prophecy; As the human being is not important, he will not emotionally connect and because he does not do this, it is better not to count on him. The increased complexity and the very large fragmentation require the construction industry to renewal.. However, the construction industry's patterns and paradigms remain. They want change, but do not know how. (Pries, 2010)

It is in this context that the number of zzp'ers have been growing from 30'000 to 79'000 (2009) and a share in employment rate of 15%. The European Institute for the Construction Industry expects the speed of growth in number of zzp'ers to slow-down, but can continue to a level of 125'000 zzp'ers (Berkhout and Kok, 2010)

Research: What does the construction-zzp'er think himself?

Information out of the interviews

When we commenced our research in 2009 there was little hard data available on construction-zzp'ers. The goal of our interviews was gaining a clear picture of the zzp'er: core questions encompassed: what characterizes him as a person, including social context, what inspires him and how is it being a zzp'er?

The first step in our research was talking to the zzp'ers. Through a local soccer club we got in touch with six zzp'ers in the region mid-west Netherlands. Their occupations were painter, carpenter, tiler, handyman and bricklayer. We had a 2-hour conversation with each of them in their respective home situation. This lead, roughly categorized, to the following overview:

Name	**MvE**	**RvdrH**	**SdJ**	**PvM**	**MO**	**AR**
Age	36	42	37	38	47	31
Sex	M	M	M	M	M	M
Education	Mavo	LTS	LTS (geen dipl)	LTS	Mavo D	Mavo/MBO
Profession	Bricklayer	Painter	Tiler	Handyman	Painter	Carpenter
Zzp since	2006	2006	1996	2002	2002	2006
Marital stage	Married, child 9, 13	Married, child 12, 16	Married, child rond 7	Married,. 2 kids	Married, 2 kids	Married,. 5 kids

Figure 2: personal data interviewees

The overall picture is: the zzp'er is a married, male professional with a working wife and children attending school, aged about 40 with a low to average education. He started as zzp'er between the age of 30 and 40. Although no interviewee gets warm feelings for IT, they all make extensive use of their mobile/smart phone. Furthermore they are and have to be entrepreneurial, but do not want their own business. They deliberately have chosen to be a zzp'er.

Motives: why becoming a zzp'er?

MvE	*They said he had the competences for teamleader, but he didn't get the job. It's not because of you, they said. But still it is a disappointment..* *It characterizes M. he gave his career another direction. He decided – with full agreement of his wife – to start as a zzp'er*
RvdrH	*Together – R & wife - they made up their minds. My wife has a stable income, and I am able to run my own business. I start as zzp'er Just like his friends always advised him. Now I can combine work and private life better.*
SdJ	*My father died when I was 24. My mother, brother and I took over the business. We divided the tasks; working as a tiler was the best for me.*
PvM	*The work became boring monotonuous, and as a zzp'er there is more alignment between work and private life..*
MO	*The pressure to work faster grew and grew. And the qualitiy of work lowered and lowered .On top of that I hardly spoke my boss. For him I was a figure. He was always on the run, or just giving orders. I didn't want to work that way any longer. I wanted to give the customer a better quality, and to work in a more rewarding environment.*
AR	*It's a boys dream. I didn't want to speak it out loud, but there was always the hope to run my own business.*

Figure 3: motives

All interviewees started their career as an employee. They mastered their profession at one or more employers, but somewhere between the age of 30 and 40 they could not realize their full (growth) potential at their respective employers.
A second important motive seems to be the inability to combine a full-time contract with their family life, where wife and kids increasingly require more flexibility.

What inspires the zzp'er, gives him satisfaction?

MvE	*The most important is the project; getting things done. Maybe that's the main difference with an employee. An employee stops when the clocks strikes four.* *M. is ambitious in a positive way. He wants to be more than just an employee, working for a boss, waiting for another day with the same job*
RvdrH	*The freedom. To manage your own life; to decide yourself when private or work things come first. That;s the best of being a zzp'er.* *The acquiring of work is fun. (….) and it gives me a good feeling when I am asked to give an advice*
SdJ	*My satisfaction in being a zzp;'er is most of all being my own boss, and being able to decide when and how I am doing my project.*
PvM	*He loved to work hard, and to learn on the job. So he had different professions and different employers in different branches. He learned by doing, he was a real self made*
MO	*To work in line with your needs, and to get recognition form your customers. That's most emportant..*
AR	*(…) the variety in work(...)t the responisbilty. .It is my job, and if I do well, than it is by me. If it's wrong, it is because of me Freedom is important, although freedom is relative. You have to work, but as a zzp'er you can manage it yourself.*

Figure 4: inspiration and satisfaction

The key answer to what inspires the interviewees circles around aspects such as attention, appreciation, recognition and development/growth. Zzp'ers get it from the private persons, Large construction projects lack these aspects and turn employees into numbers.
Money does not seem to be a driving factor and is only mentioned when asked.. It is appreciated to earn a nice salary, but the work is hard. Zzp'ers work 24/7, also on Saturdays; life has not become easier. However, being able to choose what projects to accept, and how and when to do them makes up for all of the disadvantages.

How does the zzp'er acquire jobs?
There is unanimity among zzp'ers on how to get work: quality sells itself. It might take several additional hours of work, but it is still cheaper than advertising. Your name will be mentioned at birthday parties; mouth-to-mouth will do the work. Additionally zzp'ers work with flyers, which offer their services: one of the painters used this to gain publicity whenever he started working in a new neighborhood.
However, the general line of thought is that acquisition is not needed. Mouth-of-mouth advertisement will gain us new clients.
A few of the interviewees indicated they operate in a network of zzp'ers, passing work on. These networks consist of friends who exactly know each other's strengths and weaknesses and trust each other. Together a network can do larger projects, such as the renovation of an old farm. The competitive force of such a network is large and can be a threat to small construction firms due to their lack of overhead costs.

Overall picture
The interviewed zzp'ers became all frustrated in their jobs and companies around the age of 30. A start as zzp'er offers a great solution because of the possibility (and necessity) to be entrepreneurial. On top of that, they get appreciation and recognition for their professional skills from private persons, who act as their new principals; and there is room for a personal opinion and creativity.

Information out of the FNV/Zelfstandigenbond survey
The survey contained questions similar to the interviews conducted by ourselves. We used a large sample to generalize findings to construction and carpentry. As the overall response rate was too low, we also used EIB data (Berkhout and Kok, 2010) on zzp'ers in construction to ensure the representativeness of our data.
We first discuss the FNV/ZBO survey data to sharpen our picture of the zzp'er and will get back to the EIB research later.

Personal characteristics
Again we see the zzp'er is a man; his average age is 43, he has primary to secondary (professional) education, and his average tenure as a zzp'er is 5.5 year.

But what characterizes him further? Along the career anchors by Schein (1977) the respondents indicated to what extent the aspects entrepreneurship, security, craftsmanship, independence and leadership marks their personality.
Their answers show that security least represents their personality. Entrepreneurship, craftsmanship and independence characterize the true zzp'er.

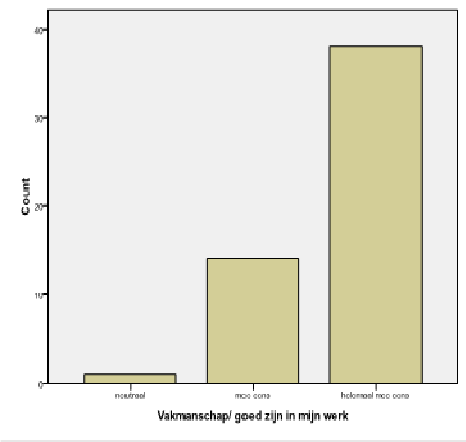


Figure 5: Craftsmanship

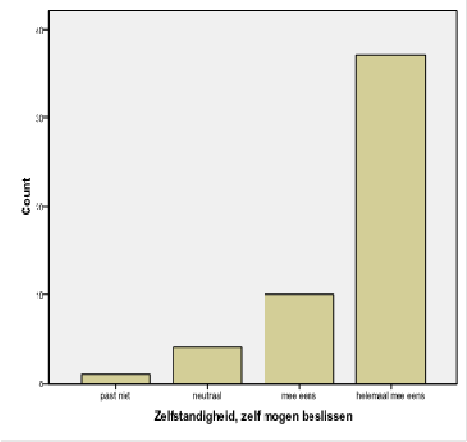


Figure 6: independence

A large majority answers they agree or fully agree to the proposition: I prefer to work alone. This does not allow us to conclude that zzp'ers are soloists, but does allow to conclude that there is a large chance on solo behavior in their work. When asked who they prefer to cooperate with, over 80% indicates to prefer to work with other zzp'ers.

Motives to become a zzp'er

The interview round taught us that money is only mentioned when asked for and is of secondary importance. Money is no decisive criterion, but who does not want to be better off? One does not become zzp'er to be worse off.

The survey indicates that more than half of the respondents mark the opportunity to earn more as a motive. Is this in line with the interview results? We do not see a fundamental difference. We do think we can add to our analysis that money is an important motive for zzp'ers in the age of 20-30.

	Responses		
Motives to become a zzp'er	N	Percent	Percent of cases
I can earn more money	28	18.8%	52.8%
I can align work and private life better	22	14.8%	41.5%
I became unemployed	10	6.7%	18.9%
I prefer to be my own boss	22	14.8%	41.5%
I had not enough freedom in the organization	7	4.7%	13.2%
I get more appraisal and recognition	27	18.1%	50.9%
I needed the adventure	26	17.4%	49.1%
Miscellaneous	7	4.7%	13.2%
Total	149	100%	281.1%

Figure 7: motives

Of all respondents, 50.9% mentions appreciation and recognition as zzp'er as a motive. This is in line with our interview round. Especially in large construction companies employees feel treated as a number in the organization. Contact is impersonal and whether A or B does the task is indifferent to the organization, as long as it is performed. Personal appreciation and recognition for the delivered achievement is missing.

Here, the interviews indicate that the customers of zzp'ers (private persons) score well. They show appreciation and recognition.

Finally, 49.1% says to seek adventure. An answer that suits entrepreneurship and independence and is confirmed by the fact that over 40% prefers not to serve under a boss.

Main concern

The last question in the survey considered the zzp'ers main concerns. The high response on maintaining sufficient work reflects the economic downturn, which greatly reduced employment in the construction sector.

Remarkable is also the high score on the ability to '*maintain physical health.*

	Responses		
My main concern is	N	Percent	Percent of cases
Will there be work enough in future?	30	35.7%	65.2%
How do I realise time for myself?	15	17.9%	32.6%
Will my craftmanship meet future requirements?	5	6.0%	10.9%
Will my physical condition stay steady in future?	25	29.8%	54.3%
Does being a zzp'er fit with my personality?	1	1.2%	2.2%

My administration	8	9.5%	17.4%
Total	84	100%	182.6%

Figure 8: Main concern

Additional data
Over 70% of the respondents work for private persons most of the time. Acquiring jobs: 65% is asked, nearly 30% actively searches and only 6% offers his services through mediating organizations.

Information out of EIB research
The focus of our own research was largely on the identity of the zzp'er, his inspiration and realization of his goals, which is more specific than the EIB research. However, the similarity in the survey sample on hard aspects such as age and education allows us to exchange data between the two studies.
From the EIB/Kok and Berkhout research we take the information that the average bouw-zzp'er is a 44 year old male with an average gross annual income of €42,000 (2007). He works a lot more (2175 hours per year) than his colleagues employed at a construction company. Over 80% of the zzp'ers followed primary to secondary (professional) education.
Zzp'ers are professional; at the average age of 35 they (83%) ended their payroll agreement and started as zzp'er. 80% works for private persons and for over 50% private persons are the most important principals. There they earn 1 euro per hour extra (compared to earnings at construction companies)

Kok en Berkhout indicate that experts in the construction industry cannot unanimously explain what caused the sudden growth in the number of zzp'ers. The main motive for the main contractors seems to be the increased flexibility. This limits the financial risks.
Summarized they conclude: the abolition of the 'Vestigingswet' combined with economic prosperity and greater flexibility at employers as the most important drivers of the rise of the bouw-zzp'er.
Derived from the EIB-study, we would like to mention a number of other drivers that are important in the context of this paper:

- Advancing IT offers opportunities for small sized companies.
- Not all employees value collective agreements and perceive these as obligations they do not have as zzp'ers.
- There is a need for modern labor relations with flexible working hours and part time jobs. Fixed hours are an obstruction and independence is a solution.
- People long for freedom: organizations with increasing bureaucracy and management layers create feelings of restriction.
- More skilled craftsmen can earn more as zzp'er than on payroll.

The employer and the rise of the zzp'er
Bouwend Nederland, the employer's association in the construction sector, acknowledges the rise of the zzp'er and the need to create a vision on this phenomenon. The zzp'er is irreplaceable in the flexible layer organizations required for continuity of their business (Bouwend Nederland, framework 2011-2013).
A vision on how to deal with this phenomenon has not yet been developed.
To the contrary, one of the largest construction companies in the Netherlands does have a clear vision, represented in a recent interview: *the zzp'er allows a company to align with the*

state of the economy. There is no fear of problems in times of tight labor market. *Technology can assist us and we can always make use of foreign employees. However, there is a discrepancy between Lean working, which largely requires commitment and brains and the use of zzp'ers who are more difficult to influence by the organization.*

Conclusions and discussion

Starting point of this paper was the rise of the construction zzp'er. Leading questions were: who is the construction zzp'er, what are his motives and how does he realize these? We were also interested in finding out the motives of construction companies to work with zzp'ers. Finally we put the question why so many people in the construction industry choose to be a professional zzp'er.

In general

The literature study shows that the rise of the zzp'er fits into the pattern of increasing individualization of Dutch society. Autonomy and freedom become more important
Entrepreneurship is stimulated and ICT developments technically facilitate this process.
From an organizational point of view zzp'ers limit financial risks caused by a decrease in demand. It also meets the desire for customization in labor relations.

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Zzp'er profile

A zzp'er is a hard working professional with a lower to secondary education, having an average age of 44, is a former employee and has a desire to run his own small business. It is important to him to be able to ake his own decisions en he is proud of his craftsmanship. He slightly prefers individual jobs and if necessary he prefers to collaborate with other zzp'ers. From the interviews we learn that his partner has an own income, which makes it easier to decide to change to zzp'er.

Motives and satisfaction

People move to become a zzp'er on average at age 35. By that time he has developed himself, in the construction industry, as an all round professional. He has no opportunities to further develop professionally unless moving to leadership positions. As a zzp'er he creates significant personal growth opportunities.
The zzp'ers motives tell us a lot, directly and indirectly, about working at a construction company:
He lacks attention and recognitions as well as growth opportunities in construction companies
He lacks independency
He lacks room for creativity and influence

From his choice to work for private persons it becomes clear that he believes that this is a better place to work, despite they make only 1 Euro more per hour.

The construction company and zzp'ers

Construction companies basically work with zzp'ers to limit their financial risks. From literature and interviews with employers we learn that the human being is seen as cost, afterthought in the entire design process, labor.
The social psychological nature of human mankind is disregarded by the construction industry. This is characterized by the keywords: world of engineers, rational, analytical, hierarchical and control.

From the zzp'ers and literature studies we learn that construction business has far too little attention for the needs of human beings. The building business and zzp'ers think differently.

ZZP'ers	Construction company
Freedom and autonomy	control
Anti hierarchy/networking	pyramidal organization
Thinking and doing together	strict separation of thinking and doing
Collaboration based on friendship	forced collaboration

(Major) construction companies should ask themselves whether they want present developments to continue with more all round professionals leaving or retain their people for which investments in a better place to work are required.

Discussion:
It seems that companies break into networks, the zzp'er being the smallest element of the network. Working in projects is the favorite working method. But, is that a sustainable way of organizing? What are the drivers for collaboration, for friendship and teamwork?

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THE INEVITABLE AND CONTINUING GROWTH OF REGULATIONS FOR PLANNING AND BUILDING

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Abstract
This paper aims at answering the question: How can we explain the evidently unstoppable growth of regulations for planning and building? The answer to this question is of relevance, since we have been (and still are) confronted with the negative consequences of an overly complex and comprehensive legal framework for planning and building. This does not only apply to the Netherlands but to many (if not all) other countries as well.
This paper shows that a variety of factors is responsible for the ever growing complex of rules for planning and building. Important reasons for growth of regulations are: (1) the liberal interpretation of the principle of legality, (2) the rise of the welfare state, (3) the failure to deregulate and (4) the law of increasing complexity.
The prospects of limiting or reversing the growth of regulations are bad. According complexity theory any addition to the system will make it more complex and instable. This will eventually lead to a collapse of the system. Only once that has happened, a new and less complex system may be established.

Keywords: regulations, legislation, deregulation, complexity theory, legality principle.

INTRODUCTION

Traditionally, governments have felt the need to regulate *land-use*. The (local) government wants to determine the purpose for which a certain piece of land can be used, with examples including agriculture, housing, streets, public green spaces, industry or flood defence. Likewise, the government also wants to exercise its influence on *building plans*, which apply to, for example, permitted building height, structural safety and fire safety of buildings, aesthetic appearance and building physics features (daylight access, ventilation, heat regulation, and moisture and noise reduction). The motivation for regulations surrounding land use and building plans were, and still remain, grounded in the public interest.

In the course of the decades, this regulatory framework started to grow and continued to grow. In recent years, the growth of the regulations more and more is seen as a problem. The problems typically relates to matters such as:

- regulations contradict each other;
- regulations are too complex for private building initiators;

- regulations are too complex for governmental bodies as well;
- the abundance of regulations causes unnecessary bureaucratic delays;
- regulations require overly detailed and costly research reports (regarding for instance archaeology, energy performances, nature compensation) from building initiators.

At the same time, initiatives to cut regulations (deregulation) seem to be of limited success. In that context, the research question of this paper is: *How can we explain the evidently unstoppable growth of regulations for planning and building?* Even if we know that the size and complexity of the regulatory framework for planning and building has negative consequences, its growth seems unstoppable. Which forces are at work here? The method of literature review will be used to answer these questions.

HISTORIC GROWTH OF REGULATIONS: EXAMPLE OF THE NETHERLANDS

Historically, building regulations in the sense of legal instructions have existed in the Netherlands for a long time. In fact, they have been around since the first cities were established in the Low Countries around the year 1200. Kocken recently wrote an interesting monograph about the first period of Town Planning Law (Kocken, 2004). It is amazing how wide-ranging the motivation was for the regulation of the city, even in the Middle Ages. Kocken (2004: 69) lists such motives as:

- the defence of the local community;
- the fire safety of the buildings;
- the structural reliability of the buildings;
- the concern for the appearance of city and land (building aesthetics);
- the provision of necessary living space (making land available for building);
- residential protection (i.e. protection against trouble resulting from the building activities of neighbours);
- traffic safety considerations.

Many of these regulations are staggeringly topical; they are just as relevant today as they were then. To give a concrete example in relation to the *public thoroughfare*: in 1413, awnings in Amsterdam could be no more than 7/4 ell wide and had to be at least 8 feet above the ground (Kocken, 2004: 172).

In modern times, the *1901 Housing Act* (Dutch: Woningwet) provided the impetus for the preparation of urban development plans that had legal significance. This Act contained a regulation relating to the 'expansion of built-up areas'. The Municipal Council was given the authority to prohibit the construction of buildings on land that was intended for a street, canal or square. The plans to set aside public spaces sought to prevent poor living conditions. For councils with more than 10,000 inhabitants or a strong growth it was compulsory to adopt an *expansion plan*, in which land was designated that would be used for streets, canals and squares in the near future. Expansion plans could be combined with a building ban. Bregman labels this a case of a legally binding regulation for particular types of (infrastructural) works (Bregman, 2001: 34).

An important amendment to the Housing Act came in 1921, when the expansion plan was no longer limited to streets, canals and squares. The scope of action expanded into a plan

'whereby the use in the near future of land included in the plan is allocated.' From that moment, the expansion plan could regulate the nature and location of permitted structures (Van Buuren et al., 2006:14). This expansion plan was, in fact, the predecessor of the current land-use plan.

Another important aspect of the 1921 amendment concerned the building permit. Conflict with the expansion plan became compulsory grounds for the rejection of a building permit application (Bregman, 2001: 35). The connection between the building permit and the statutory urban development plan that was established then still exists today. (The 'statutory urban development plan' refers to the urban design in its statutory form. Based on the 1901 Housing Act, this is an expansion plan; based on the Spatial Planning Act, this includes the land-use plan.)

Since the 1901 Housing Act took effect, the expansion plans had been regulated in a paragraph concerning urban planning. In 1962, an Act was drawn up exclusively for statutory development plans: the *Spatial Planning Act* (Dutch: Wet op de Ruimtelijke Ordening). This act introduced the local *land-use plan* as the successor of the expansion plan. Since then, the Spatial Planning Act has been changed on several occasions, but the core has always been the power of the Municipal Council to adopt a land-use plan.

Nowadays the Constitution (article 21 of the Constitution of the Kingdom of the Netherlands 2002) refers to planning tasks of government:

> *It shall be the concern of the authorities to keep the country habitable and to protect and improve the environment.*

The *conclusion* of this very brief historical exploration is that (spatial) planning has always gone hand in hand with rules and regulations. Furthermore, since the first cities were established, regulations regarding planning and building started growing. I used the example of the Netherlands, but other countries have gone trough a similar process of growth of regulations.

Planning & building on the one side and law on the other side turn out to be inseparable phenomena. In the next chapters of this paper their relationship will be further explored.

THE ORIGINS OF REGULATORY POWERS: THE PRINCIPLE OF LEGALITY

With regard to existing land-use, landowners as a rule already concur with the public interest, as specified (in a plan) by the (local) government. Should existing land-use not be in accordance with such a plan, many landowners are prepared to adapt the land-use voluntarily, with or without financial help from the government. The same applies to building plans. Initiators are usually willing to comply with the building regulations proposed by the government of their own accord.

However, it is also possible that the current use of land is not in agreement with what the government considers to be in the public interest, and landowners may have no intention of changing their plans. Furthermore, it is also possible that the initiators of building plans (building planners) do not intend to comply of their own accord with building regulations concerning, for example, the aesthetic appearance of a building.

The government would be fairly powerless to implement its plans and regulations if they were solely dependant on the voluntary compliance of citizens and companies. Public interest, which after all constitutes the foundation of regulation, would be poorly served as a consequence. Private interests, in the case of landowners and initiators of building plans, could then thwart the public interest. To prevent this, the government must be able to require compliance from citizens and companies, which it cannot do without good cause. Landowners and initiators of building plans cannot be forced to comply with governmental plans and building regulations just like that. This is interrelated with the operation of a crucial cornerstone within a constitutional state: the *principle of legality.* The principle of legality is also known as 'the rule of law'.

This principle holds that the government is only authorised to intervene in and determine limitations on the freedom and property of its citizens on the basis of statutory power (P. de Haan et al., 2001:21). Without such a statutory basis it is not allowed for government to determine limitations on freedom and property. When applied to land use and building plans, this principle signifies the following: we cannot prohibit an individual or organisation from building on or using their land as they see fit, unless a democratically ratified act is in place that regulates the issue. The principle of legality, therefore, relates to the *powers* of public bodies (Michiels, 2006: 10).

The principle of legality expresses two core values: (1) universal equality before the law, which means that the law applies equally to everyone, and (2) legal certainty, which means that the powers of public bodies are predetermined (Boon et al., 2005:4).

Currently, the principle of legality is interpreted liberally in the Netherlands. The belief is that government action *in general* must be founded on statutory power. This, therefore, includes not only actions of a restrictive, authoritative or prohibitive nature, but also actions of a favourable nature, such as the granting of benefits or subsidies. This results in a growing number of laws and other regulations (Herweijer et al., 2005:12). This also applies to the realm of spatial planning.

Following on from the principle of legality, there are acts in a constitutional state that regulate 'land-use' and 'building regulations.' In this case, there are acts that give the government the authority to terminate land use that is in conflict with the governmental plan. Likewise, acts are in place that authorise the government to require initiators of building plans to obtain a permit before commencing with construction. Should the building plan fail to satisfy the building regulations, the permit will be denied. In point of fact, the principle of legality contains the rationale behind the many laws concerning planning and construction. Without such statutory foundations, the government is not authorised to require compliance from its citizens, organisations and companies.

We can draw as a *conclusion* that the use of the principle of legality and especially the liberal interpretation of the principle of legality is one of the factors responsible for the enormous growth of regulations.

THE RISE OF THE WELFARE STATE: PROACTIVE LEGISLATION

Powers in the field of spatial planning and building, which are attributed to the government by law, fall into two categories: reactive powers and proactive powers. The difference made here between reactive and proactive powers is inspired by the distinction Buijs made between two basic functions of spatial planning: the regulatory function of planning (reactive) and the development function of planning (proactive) (Buijs, 2000).

Reactive powers

Reactive powers are powers with which the government reacts to private sector development initiatives, which generally mean building activities. The government reacts to development initiatives from individual citizens, companies or organisations. The key reactive governmental power is based on the Environmental Licensing (General Provisions) Act (Dutch: Wet algemene bepalingen omgevingsrecht) and requires initiators of building plans to be in possession of an environmental permit. The government makes a preventive assessment of private sector development initiatives. Private parties require governmental *permission* before the initiative can be carried out. Permission is only granted after certain predetermined criteria have been satisfied. These criteria make up the assessment framework.

Proactive powers

Proactive powers are powers that enable the government to take development initiatives, which may concern urban expansion, infrastructure construction, land development and hydraulic engineering works, for example, but also the development of a buffer zone. This type of development always requires a certain form of control over the use of land. Sometimes the government already owns the land, which negates the need to arrange for control.

However, the land is often owned by someone other than the government, necessitating that it gains some form of control. Sometimes 'absolute' governmental control of land is necessary in connection with intended developments, such as the construction of new roads. In this case, the government can *purchase* the land under private law. Land can also be acquired by exercising what are known as *pre-emption rights* (Dutch: voorkeursrecht), which are based on the Municipal Pre-Emption Rights Act (Dutch: Wet voorkeursrecht gemeenten). This gives the municipality the right to be the first to enter into negotiations with a seller who intends to sell land and buildings. A forced means of acquiring land is via *expropriation* on the basis of the Expropriation Act (Dutch: Onteigeningswet).

In most cases, absolute governmental control of land (ownership) is not necessary to achieve planning objectives. The government can limit itself to stipulating to the landowner what the land can be used for, in combination with issuing building regulations applicable to that land (such as maximum building heights). This is done in a *land-use plan*. The municipality's power to determine land-use plans in their territory is laid down in article 3.1 of the 2006 Spatial Planning Act. More accurately, the municipality not only has the power, but is obligated to do so. It is easy to see that land-use plans can significantly influence the financial and economic value of property by allowing or denying development possibilities. The municipality's authority to determine land use by means of a land-use plan therefore comes with the duty of the Municipal Executive to award (on request) damages to parties that have suffered financial losses in specific cases. This falls under *the right to compensation* (Dutch: tegemoetkoming in schade).

After the Second World War the *welfare state* came to a rise. In the welfare state, the state plays the primary role in the protection and promotion of the economic and social well-being of its citizens. In the welfare state, the state actively seeks to promote public goals. Thereby, the welfare state has led to a strong growth in the field of 'proactive' legislation.

PUBLIC LAW AND PRIVATE LAW PLANNING INSTRUMENTS

The discussion of the growth of regulations for planning and building cannot be limited to *public law* regulation. To get a full grip on government's steering of planning and building, we should include government's use of *private law* instruments.

The law that is mostly relevant to planning and development can roughly be divided into two parts: public law and private law. Public law and private law differ from each other regarding the topics that are regulated, the way of enforcement and the interests that are served and protected.

Public law is that part of the legal system that regulates the structure of the state and the relationship between the state and individuals (citizens, companies). This includes constitutional law and administrative law. Examples of public law acts in the field of urban planning and development are: the Spatial Planning Act (Dutch: Wet ruimtelijke ordening), the Environmental Licensing [General Provisions] Act (Dutch: Wet algemene bepalingen omgevingsrecht) and the Expropriation Act (Dutch: Onteigeningswet). Many of the public law acts relate to the powers of government towards citizens.

Private law is that part of the legal system that involves relationships between individuals, without direct involvement of the state. This includes the law of contracts, property law and family law. Examples of private law in the field of planning and development are: the Civil Code (Dutch: Burgerlijk Wetboek) and public-private partnership agreements.

We can simplify the differences between public law and private law as follows: public law focuses on the state itself and of issues that affect the general public. Private law focuses on issues affecting private individuals and corporations, without direct involvement of the state.

Governmental bodies, for instance municipalities, can make use of private law. For example: a municipality commissions a contractor to build a new city hall. In this example the municipality concludes a contract. In this case the municipality acts just like a private person would: concluding a contract with a contractor. The contract between municipality and contractor therefore falls under private law.

The description of public law and private law shows the differences in the topics that are regulated and differences in the interests that are served and protected. Further, both parts of law differ in the way of enforcement. In private law, enforcement is in the hands of the interested parties themselves. If necessary for enforcement, or if the law says so, the help of certain bodies – for instance the judge – can or must be called in. If, for instance, a contract is not properly executed, the injured party may call in the judge to force correct implementation of the contract.

In public law, however, government lays down a set of (general or specific) standards. Government then is the only party that has the power to change the standards and – if the

standards are not observed – the power to enforce them. The justification of laying down standards by government and enforcement of standards usually lies in the fact that government must look after the public interest. By example, suppose a permit is granted by the municipal executive to a company in order to build a new office. If the conditions to the permit are not observed, only the municipal executive has the power to withdraw the permit.

Public law planning instruments

Dutch municipalities, as said, have the most important powers in Dutch spatial planning. Seen from the viewpoint of statutory law (and in practice) national and provincial governments have less power than municipalities. Municipalities have control of many *public law* instruments for spatial planning and development. The powers relate to both development *projects* and spatial *plans*.

Private law planning instruments

Apart from public law instruments, government – particularly municipalities – may also use *private law* planning instruments. For example, municipalities have the power to purchase land, on which 'private objectives' are planned, such as residential areas or office areas. Municipalities can buy undeveloped land, prepare it for construction and then sell it to developers. The developers, subsequently, realise the houses and offices. In this way, municipalities can make substantial profits. Furthermore, Dutch municipalities are allowed to participate in public-private partnerships by which market risks are carried by government. In the Netherlands, public-private partnerships in the form of a legal entity in which (financial) risks are shared between the public and the private parties, are legally allowed and commonly used. This demonstrates that the Netherlands, unlike Anglo-Saxon countries, does not follow the principle of a strict division between the public and private domains. With that is meant here that in the Netherlands local government in principle can act as a market party. Municipalities can, as it were, act outside the public domain and inside the private domain.

COMPLAINTS OF OVER-REGULATION AND ATTEMPTS TO DEREGULATE

For many years, different parties in planning and construction in the Netherlands (particularly developers, designers and contractors) have expressed their discontent about the number of permits required to build and the complexity of the permit assessment framework. To draw attention to their problem, regular actions are held: hand trucks filled with building regulations are literally put on stage in the presence of an outraged public. The complainants do have a point – building regulations are extensive and quite complex. Various governments have made deregulation of the planning and building regulations into policy objective, which has been successful in several areas. The introduction of the environmental permit in 2010 has – in any case for developers/applicants – brought a major simplification.

The new environmental permit replaces around 25 previously existing permits. This one permit holds permission for demolition, as well as building, renovation, causing environmental nuisance (for instance noise, bad smell, air pollution) and other activities. The former situation, in which an applicant needed to collect all kinds of different permits, has come to an end. The former permits that have been replaced by the environmental permit include, amongst others, the building permit (Dutch: bouwvergunning), the environmental permit of the Environmental Management Act, the demolition permit, the construction permit

(Dutch: aanlegvergunning), the felling license (Dutch: kapvergunning) and the monuments permit. All these permits do not exist anymore. They are replaced by the single environmental permit as regulated in the Environmental Licensing (General Provisions) Act. However, not all previously existing permits have been replaced by the environmental permit. Some separate permits still exist, for instance for projects in nature conservation areas.

The single environmental permit can be seen as a successful example of deregulation. However, given the enormous amount of regulations in the field of planning and building, it can merely be considered to be a relatively small success. At the same time it appears that our highly developed, complex and demanding society continually sets new and even stricter requirements. These are then laid down in regulations. Deregulation is difficult, because 'behind' every rule there is an interest and, most likely, a special interest group to 'protect' this interest. Complaints from an overly regulated planning and construction will, therefore, continue to exist.

GROWTH OF THE REGULATORY SYSTEM AS A RESULT OF THE LAW OF INCREASING COMPLEXITY

Another explanation for the growth of regulations can be found in 'complexity theory'. My summary of this theory is based on the discussion of complexity by Janssen (2010). Janssen refers to W. Brian Arthur. Arthur explained (Arthur, 1993) that every system is subject to 'the law of increasing complexity'. This also goes for legal systems. Every system has the inclination to connect to its surroundings. New functions are added to the system and adjustments are made to the system, in order to push out frontiers or to cope with changing conditions. Thus, new elements are added to the system, in order to improve it. This results in extension of the legal system and further refinement (Demeersseman, 2011).

At a certain point in time, new additions only complicate the system and do not have any more added value. Under those circumstances, usually radical attempts are made to 'save' the system. However, chances are that this will not succeed and people lose their trust in the system. This may eventually lead to a collapse of the system (Arthur, 1993). In that case the legal system would become unmanageable. A legal problem than has more and more aspects, solutions will require more and more intermediate steps (Demeersseman, 2011). The legal system would be trapped in its own size and complexity. This would severely affect the implementation of planning policies and building projects.

My assessment is that - in the Netherlands - we have not (yet) reached the point of collapse of the legal system for planning and building. Indeed, radical attempts are made to save the system. An example can be found in the Dutch Crisis and Recovery Act (Dutch: Crisis- en herstelwet). This act aims at reducing complexity and shortening of procedures for new large infrastructure and major urban developments. However, by adding new instruments, it further complicates the system.

CONCLUSION

This paper aims at answering the question: *How can we explain the evidently unstoppable growth of regulations for planning and building?* The answer to this question is of relevance, since we have been (and still are) confronted with the negative consequences of an overly

complex and comprehensive legal framework for planning and building. This does not only apply to the Netherlands but to many (if not all) other countries as well.

The analysis in this paper shows there a multiple explanations:

- The use of the principle of legality and especially the liberal interpretation of the principle of legality is one of the factors responsible for the enormous growth of regulations.
- The rise of the welfare state has led to a strong growth in the field of 'proactive' legislation. In the welfare state, the state actively pursues goals in the public interest. The legitimisation of the powers to do so, requires legislation.
- Deregulation is proven to be difficult, because 'behind' every rule there is an interest and, most likely, a special interest group to 'protect' this interest. Deregulation requires that legislators in parliament will have to 'hurt' these special interests. Doing so is, in essence, opposite to nature of politicians since it may cause the loss of voters.
- The legal system is, just like every system, subject to 'the law of increasing complexity'. There is no escape from this law. Only after the collapse of a system, a new and less complex system may be established.

It may be argued that at this moment in the Netherlands radical attempts are made 'to save the system'. However, according complexity theory this type of attempts eventually will not solve the problems, since every new attempt further complicates and thereby destabilised the system. If that is true, we are close to the collapse of the legal system for planning and development and a new and less complex system can be established.

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SUPPLY CHAIN INTEGRATION CHALLENGES IN PROJECT PROCUREMENT IN MALAYSIA: IBS CONTRACTORS' PERSPECTIVE

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Abstract
The Malaysian Construction Industry Master Plan (CIMP 2006-2015) identified the innovative approaches of Industrialised Building Systems (IBS) and its supply chains as having important roles in improving the productivity and quality of construction processes. However, the fragmented scenario in the construction industry leaves the IBS supply chain players with noticeable difficulties in terms of competitiveness and efficiency. Supply chains in IBS involve relationships between many organisations and processes, with the evolution of many specialised roles and embedded relationships. The procurement method is utilised as a mediator tool and as the means of controlling integration between players. Although efforts have been undertaken to enhance the IBS practice in Malaysia, various integration challenges have risen from amongst the IBS players. The purpose of the research is to identify the challenges of IBS supply chain integration with regard to existing project procurements. The methodologies involved a thorough review of literature and the qualitative method of using semi-structured interviews which were conducted amongst IBS contractors in Malaysia. The findings reveal role and responsibility, understanding the knowledge, risk liability, financial and contract matters and attitude and relationship are the challenge factors that hinder the successful integration between the contractor and other related parties. Such issues require much attention in pursuance of greater integration within the supply chains in the Malaysian construction project.

Keywords: Industrialised Building System, Integration, Malaysia, Procurement, Supply Chain

INTRODUCTION

The construction industry has commonly been plagued by fragmentation issues. These issues are attributed to the fact that the industry is made up of separate parties from diverse

professions that operate by their own rules. An analysis of the key characteristics of the construction industry indicates that the problems facing construction can be categorised into five broad areas (Morledge et al. 2009) which are: fragmentation, adversarial relationships, project uniqueness, separation of design and production and competitive tendering. In addition, weaknesses are caused by the increase in organisational complexity and contractual adversity which influence the efficiency and effectiveness of construction project teams (Dulaimi et al. 2001). Its complexity has been deemed to be very disintegrated and a more integrated approach to supply chain has been identified as a solution to various problems (Vrijhoef and Ridder, 2007).

Thus, in today's increasingly globalised economy, managing the entire supply chain has become vital to the successful completion of a construction project. Competitive global markets which result in increasing supply chain integration make it imperative for the construction industry to change, so that improvements are made to the relatively disconnected and fragmented construction supply chain. The strategy to manage economic demand through construction will be more effective when projects are implemented innovatively and speedily. Furthermore, for Malaysia to be a productive and high-income nation, Malaysians must be globally competent and competitive. This necessitates the Malaysian government to embark on rigorous initiatives and adopt the Industrialised Building System (IBS) as an innovative approach.

As a consequence, the IBS Roadmap (2003-2010) has been taken as an initiative to move forward. IBS provides speedier work completion due to the introduction of components replacing on-site construction. The use of IBS assures valuable advantages in context of the local construction scenario but new innovative management and procurement in IBS have still not been fully realised by the industry players. This is especially so in terms of good Supply Chain Management (SCM), the basic principle of which is rarely based on 'integration' approach. Thus, such initiatives may be hindered by the non-integration and adversarial relationship modes currently practiced in construction.

A number of case studies have shown that managing the entire supply chain has become a major factor in delivering a successful IBS approach (Blismas and Wakefield, 2009; Faizul, 2006), with the procurement method arrangement being utilised as a mediator tool and as the means of controlling integration between players (Pan et al. 2008; Gibb and Isack, 2001). A good supply chain integration practice will lead to good integration amongst players. This new way of working has to be related to the current trend in the Malaysian construction to move towards a more innovative and competitive scene. While much effort has been taken to enhance the IBS practice in Malaysia; establishing integration between IBS players is still a major hindrance, due to the lack of supply chain procurement practices (Faizul, 2006; Kamar et al. 2009). Therefore, the challenges in achieving successful delivery of IBS projects would be looking at encouraging integration through supply chain integration, which may have a value-added impact on the success of IBS project implementation and delivery.

This paper is structured into three parts. Firstly, the review covers a broad range of literature, providing a concise overview on the general approach of IBS in the Malaysian construction industry, challenges in supply chain integration and reviews on the supply chain, SCM, integration and procurement. The second part discusses the methodology adopted to collect data, including the choice and size of the samples. The final section includes a discussion and conclusions derived from evidence from the literature review and the qualitative semi-structured interviews.

IBS AND THE SUPPLY CHAIN INTEGRATION CHALLENGES: AN OVERVIEW

In today's global business, with regard to the development of technology and characterised by its great degree of repetitiveness and mass production, off-site manufacturing or IBS has been widely adopted across the globe. IBS is deemed to offer many advantages in overcoming problems such as influx of foreign labour and in enhancing the productivity and the quality of the construction industry. While IBS is being acknowledged generally as the term representing the prefabrication concept in Malaysia, various definitions have been offered to IBS over the past years. Warszawski (1999), defined IBS as a set of interrelated elements that act together to enable the designated performance of the building. In addition, Leesing et al. (2005) asserted IBS as an integrated manufacturing and construction process with well-planned organization for efficient management, preparation and control over resources used, activities and results supported by the use of highly developed components. While CIDB (2003), defined IBS as a construction system where components are manufactured in a factory, either on or off site, positioned, or assembled into place with minimal additional site work.

In this research the present authors emphasis IBS largely as construction process and an approach on manufactured components off or on site. Therefore, the understanding and interpretation of IBS is very important before its implementation. Following new emerging technology, the components of IBS in Malaysia can be categorised into five major types (CIDB, 2003): Precast Concrete Framing, Panel, and Box Systems, Steel Formwork Systems, Steel Frame Systems, Pre-fabricated Timber Frame Systems and Block work Systems.

Even after IBS had long been introduced in the Malaysian construction industry, it appears that the implementation of IBS is still low compared when compared to other developed countries. To cope with these challenges, the IBS Roadmap (2003-2010) was designed to assist Malaysia to move forward and capitalise on new technologies for the construction sector. One of the approaches taken by the Malaysian government to increase the level of IBS usage is by demanding more IBS approaches to be used in the construction industry. These initiatives can be seen through a series of developments starting from the provision of IBS in annual National budgets. In the 2005 budget, policies were outlined to give full exemption of levy imposed by CIDB for housing projects with IBS content of more than 50 percent. In the 2006 budget, IBS manufacturers were given Accelerated Capital Expenditure with a maturity period of three years on moulds. Then, in the Ninth Malaysian Plan Report and Treasury Circular, public projects were made to adopt or contain up to 70% of IBS construction approaches. This is further enhanced by the establishment of the National IBS Secretariat as the Coordinator through the Ministry of Works and an IBS Centre as the One Stop Centre.

Even with much support, encouragement and directions in Malaysia, the usage of IBS is currently much lower than it could be. These problems demonstrate that although the long introduced IBS has promised to solve and improve the current construction process, these practices have characteristically been facing a difficult task to establish integration and cooperation between parties involved (CIMP, 2007; Faizul 2006). Abd Shukor et al. (2009) conducted research to identify the key problems in the construction industry in general and IBS in particular. They classified possible problems into 16 significant themes and revealed that both the industry and the IBS players had not been very successful in their attempts to find the right solutions to the challenges encountered whilst indicating that the supply chain and procurement to be the root of most problems.

Among the challenges encountered were communication in terms of flow of information, conventional mindsets, problems in terms of coordination between various works and funding factors where the process of payments were not in order (Abd. Shukor et al. 2010) and through their research, they also revealed that there are a range of procurement stages that have prominent problems which make it difficult to integrate people. The same problems apply to the 'Design' stage and among the prominent problems encountered were the lack of coordination in design management among architects and engineers (discrepancy in design), lack of resources and budget limitations**.**

CIMP (2007) highlighted poor knowledge and unfamiliarity with IBS concepts and its benefits as one of the factors hindering integration among IBS players. In order for IBS to succeed, construction professionals should support and understand the construction and product delivery of IBS. Lack of integration among relevant players in the design stage has resulted in the need for plan redesigning and additional costs incurred if IBS is adopted. The disintegration happens because IBS manufacturers are involved only after the design stage (CIMP, 2007). Rashid (2009) in his statement argued that the possible mis-match between the design capabilities of the local engineering consultants and the manufacturing capabilities of the local building product manufacturers will disrupt or create upheavals to the IBS project delivery.

Therefore, the establishment of the IBS provision in the integration of the construction supply chains must take place. The challenges of integration amongst the IBS chain players need to be assessed in relation to the working practices in the current project procurement delivery arrangements approach in order to ensure cooperative working relationships that will lead to supply chain excellence.

SUPPLY CHAIN INTEGRATION THROUGH PROJECT PROCUREMENT

A review of literature indicates that the productivity and performance of the construction project is achieved by positive integration of supply chains involved. Thus, at the global level, managing and integrating supply chains has become a major factor in delivering successful construction projects. The term Supply Chain (SC) is usually informed by a wide range of definitions. Various definitions of SC exist in literature and have risen to prominence over the past several years. A review and analysis of the generic SC definitions from the early 1990s uncovered the definition of SC as interdependence of activities or process (Simchi-Levi et al. 2007; Lin and Shaw, 1998) as the linkages of companies (Samaranayake, 2005; Trent, 2004) and as a network of facilities or organizations (Mabert and Venkataramananrt, 1998; Christopher, 1992). It was agreed that all these definitions are relatively similar, with an emphasis on the linkages or networking of organizations or activities connected by demand and supply flows that are supported and accomplished by people.

The complexity of SC may vary greatly from organization to organization and activity to activity. It exists in both service and manufacturing organizations. Typically on larger construction projects, SC consists of a large number of players and involves a number of activities within each tier of players (Dianty et al. 2001). However, SC can be scoped in terms of the number of firms, activities and functions involved (Cooper et al. 1997). But, the integration and management of those supply chains in any situation is very important (Mentzer et al. 2001) and is promoted as a way to achieve supply chain success and

consequently, the success of the project delivery. SC and its management are vital for gaining competitive advantage in the globalized economy. Supply Chain Management (SCM) represents a new way of managing the business and relationships with other members of the supply chain. The concept offered by SCM has been recognized over the past several years as a tool, which will lead to a better integration amongst the construction industry players. A key word and basic principle of SCM is 'integration'. The focus of SCM in this research is on supply chain integration, a word that is rarely associated with the construction process as it is characterised by fragmentation.

Difficulty to integrate is attributed to the variety of professions and skills involved in the project delivery. The present authors also reviewed and analysed generic integration definitions in the literatures from 1973 – 2006. Definitions of integration were used to describe a sharing of knowledge, data and information (Vincent and Kirkpatrick, 1995; Funk and Wagnalls, 1973) a flow coordination (Fergusson, 1993) a merging of different disciplines and organizations (Jaafari and Manivong, 1999) a cooperation and working together (Barkley, 2006; Baiden et al. 2003; Strategic Forum for Construction, 2003; Austin et al. 2002; Moore and Dianty, 1999).

In today's scenario, competition in the construction industry is no longer between one-on-one organization but rather by their supply chains (Tommelein et al. 2009). In order to enhance the competition, the organization should work on integrating supply chains rather than executing tasks single-handedly. Furthermore, they must work in a cooperative manner (Zhendong and Zhenmin, 2010). This will enable the supply chains to focus on shared goals and objectives, leading to mutual benefit for individuals, organisations and society, but without undermining the ability to advance and compete by differentiation of skills, products and services (The Strategic Forum for Construction, 2003). Therefore, Vrijhoef and Ridder (2005) agreed that supply chain integration should be more successful in delivering construction projects and in granting more value and profitability. Clearly, there is a need for a mechanism through which these supply chain can be integrated.

The introduction of varied project procurement systems was brought on by the transformation of technology and the industrialisation scene. This was to ensure efficient and innovative project delivery systems and better performance aimed at meeting the changing demand of clients or customers. Saad et al. (2002) noted, alternative procurement routes, which include (Two-stage Competitive Tendering, Design & Build, Management Contracting and Construction Management) represent some differences in relationships, roles and power between design and cost consultants and the main contractor, and between the main or managing contractor and the specialist and trade contractor. These new approaches to procurement have resulted in some potential for greater collaboration and integration. Baiden et al. (2006) conducted research on the integration of project delivery teams by looking at the practices that took place within the context of procurement approaches because the current practice and arrangement of the players within the construction project supply chains helped to integrate the activities of the various players. Thus, procurement routes appeared as one of the enablers of supply chain integration because they provide the formal links within which supply chain integration is accomplished and prolonged (Hall et al. 2000).

Poor performance has been attributed to the continued use of procurement practices that do not encourage integration of the parties involved (Love and Gunasekaran, 1998). Traditional procurement method is usually competitively tendered to a contractor before work starts. The design must be completed before the commencement of construction. Each construction

process is undertaken by different parties, where individual parties are mainly concerned with their own interests. The Design and Build procurement method provides a single point of responsibility by the contractor and the client has only to deal with one person if faced with any problems. In Malaysia, the arrangements of IBS supply chains in Design and Build involve either in-house manufacturers who employ external designers and quantity surveyors or outsourcing to IBS manufacturers to precast and install and employing of external consultants to carry out design (Abd Shukor et al. 2011). Khalfan et al.(2005) described both procurement approaches varied in their roles and responsibilities but one of the key elements in all procurement methods is the management of the supply chain.

In the context of this research, integration of supply chian could be summed up and viewed as "bringing together a series of different organizations consisting of IBS key players (client, designer, contractor and specialist/manufacturer) which are linked by a flow of practices, information, financial and contractual relationships. This is to allow them to work together towards design and construction practices within the context of the project procurement delivery arrangement approach with the same common goals and objectives". In order to achieve effective integration, an assessment of the challenges faced by contractors in supply chain integration has to be conducted, in context of the Malaysian IBS construction project.

RESEARCH METHODOLOGY

Literature review and qualitative semi-structured interviews with consenting respondents were used in data collection. By interviewing a variety of IBS key players (clients, contractors and manufacturers), challenges of supply chain integration were identified. However, only the perspectives of IBS contractors are presented in this paper since all interviews were still ongoing as this paper was being written. Therefore, the data presented in this paper is only a portion of that which was collected and the conclusions presented here are based on interim findings to date.

Literature review was the first phase of the research with the secondary data derived from relevant books, journals articles, thesis and dissertations, conference proceedings and reports. The second phase involved the collection of primary data, wherein the information was collected through semi-structured interviews. A semi-structured interview approach was employed to achieve the aims of the study. All interviews were recorded and transcribed verbatim, each interview lasting approximately ninety minutes.

The respondents of these qualitative semi-structured interviews were selected from the IBS public projects provided by the Public Works Department. The respondents were selected on the basis of their experience on IBS and their interactions with other IBS players in the project. Letters were posted and e-mailed to the IBS contractors. Then, follow-up telephone calls were made for the interview arrangements. Accordingly, there are nine (9) contractors "Class A" under the Contractor Centre (PKK) and "Grade 7" under Construction Industry Development Board (CIDB) who were involved in IBS public project and have agreed to be interviewed.

FINDINGS AND DISCUSSION

To begin with, the interviewees were asked about their basic background, brief description of their position in the company's organisation and basic characteristics of their projects. Table

1 exhibits the respondents' current positions, experiences, types of IBS components and procurement adopted and project categories. The majority of the interviewees were in the top and senior management level and were very experienced. Their designations and experiences portray their high level of authority in strategy and decision-making processes. This indicates that the data obtained are quite reliable and accurate. The various projects that have been undertaken in Malaysia using IBS can be arranged according to the categories of buildings constructed. The results revealed that the majority of the interviewees undertake precast panel as the most familiar type of IBS involvement and that the Traditional procurement and Design and Build procurement were the common types of procurement used in IBS in the Malaysian construction industry.

Company	Current Post	Experience (years)	Type of IBS components	Types of procurement	Project Categories
A	Manager Design Management	15	Precast Concrete Panel	Design & Build	Schools
B	Senior Manager Business Development & Contract	11	Precast Concrete Panel	Design & Build	Residential Buildings
C	Senior Manager Procurement	9	Precast Panel	Traditional	Commercial Buildings
D	General Manager Contract	12	Precast Panel/Shear Wall	Traditional	Commercial Buildings
E	Project Manager	19	Precast Panel	Design & Build	Residential Buildings
F	Contract Manager	18	Precast Panel	Design & Build	Schools
G	Senior Project Manager	15	Precast hollow system	Design & Build	Hospital
H	Senior General Manger	13	Precast Concrete Panel	Design & Build	Schools
I	Project Manager	10	Precast Concrete Panel	Design & Build	Schools

Table 1: *Current Post, Experience and Project Characteristics.*

In order to identify the challenges that prevent integration amongst contractors, the interviewees answered questions on how they interacted with other IBS members in the supply chain of a particular project within the procurement arrangement they adopted. Based on the results of the interviews the perceived challenges to their integration were presented as follows:

Roles and Responsibilities

More than half of the interviewees claimed that everyone especially the designer should be aware of the responsibilities of the project and fully understand the way of work. Seven out of nine interviewees mentioned that the designers are not fully aware and fail to understand

the implications of their design choices. This results in the contractors themselves having to do extra work to solve the conflict and to find solutions to their construction methods and choices of IBS components. Furthermore, Interviewees B and C raised the problems of interdependencies in traditional delivery entrenched the problems of integration between IBS players. The problem occurs as everyone does not work on the basis of what is actually needed by the person who is going to use their works (Nicolini et al., 2001). Moreover, Nicolini et al., (2001), highlighted that the interdependence issues are aggravated by traditional rigid demarcations between designers and builders. Simarly, the other five interviewees who adopted Design and Build procurement with design and construction under one responsibility, declared the same challenges.

Knowledge and Understanding

More than half of the interviewees claimed neither the architect, mechanical, structural engineer nor the client themselves understood or were familiar with the process and components of IBS. Four out of seven interviewees claimed that the architects' drawings did not match with the structural engineers' drawings, and this was made worse when the mechanical engineer came over to match their services. Besides, interviewee H stated that they are limited specialists/manufacturers in the market and even though they are experts, they do not have any experience in handling school jobs or the big volume. Thus, they fail to advise suitable solutions for the right type of design component. Furthermore, interviewees B and H, also highlighted in Design and Build procurement detail client requirements should be considered at the early stage before construction starts, because the IBS approach will incur more cost if there is failure in design which will create more problems during installation. Out of seven, the other two interviewees stated they do not have any problems with regards to knowledge or interdependencies, because they have their own group of consultants who understand each other's capabilities. Furthermore they claimed they have knowledge and experienced in IBS. Lack of knowledge or understanding of IBS by other players will hinder interaction between the main contractors with their supply chain, whether in traditional procurement methods or design and build project delivery. This is supported by the research done by (Blismas et al. 2009; Blismas and Wakefield, 2008) who assert that the strong theme for the drivers and constraints in offsite manufacturing both concern skills and knowledge.

Risk Liability

Risk liability between structural designers and specialists/manufacturers is very important in manufactured components. Hallowell and Toole (2009) pointed out that the manufactured component must have a proper engineering design because each of these components has a direct impact on the performance of the final structure. Interviewee H claims that they have problems on design and supervision issues between their structural engineer and specialists/manufacturers since most of the structural elements are designed by IBS specialists/manufacturers. He further explained that even though under Design and Build procurement, the contractor is the leader, they have difficulties to work together and coordinate with their team. This is because the structural engineer declined to verify and be responsible for the drawing that has been designed and produced by the manufacturer although it has proper engineering design. The engineer even refused to supervise the work although this has been accounted for in their professional fees. Meanwhile, the specialists/manufacturers also refuse to supervise the work on site because they are not paid for that supervision. This has been supported by (Thanoon et al. 2003) who found that IBS implementation has been heavily criticised by lack of coordination among parties involved.

Financial and contractual matters

Financial and contractual issues appeared to be important matters for the main contractors. Interviewees B, C and D claimed that under client related causes, the traditional method of payment seemed to present challenges. A major reason posited among the contractors to adopt IBS is that IBS construction project delivery is seen to be more expensive than the conventional method. IBS is seen as incurring high initial and set-up costs (Blismas and Wakefeld, 2008; Badir et al. 2002). The procurement of construction material is the responsibility of the contractor. Once the materials are already on site, the contractor is paid 75% for materials on site in their progress payment, which are not incorporated in the permanent works, to ease their financing costs or cash flow. However, the IBS set-up is different; the contractors have to pay the specialists/manufacturers huge amounts of payment at the initial stage in order for the manufacturer to proceed with their precast component order. Thus, this shows that IBS involves factory-produced building components where their material on site (precast component) is ready at the manufacturing site. This scenario is identified as one of the hurdles of IBS adoption for the contractor whether in Traditional method or Design and Build delivery, because they need efficient management and planning of their finances. This is more so as delays occur under certain circumstances.

As highlighted by one of the interviewee: "*….the client should be aware our problems, especially on precast product, the client should consider our material (precast product) at the manufacturing factory as material on site."*

It was thought that, in order to improve IBS project delivery and enhance their working relationship the client should trust the contractor to undertake the task and responsibilities or any win-win situation between them through improvement of their method of payment. This is also supported by Bilsmas and Wakefield, (2009) and Kamar et al. (2009) who revealed that IBS players need more reliable payment mechanisms and contracts. They added if they change conventional methods to IBS; the payment mechanism for IBS should be duly reviewed.

A second financial and contractual challenge is due by client and consultant factors. According to interviewees F and H, the problems arise when the client amended their original concept of design and build where client pay direct fees to the consultants (direct payment concept). This will discourage cooperation and disable response and the consultants will not readily adapt according to the main contractor's needs. Design and build entails the sole responsibility of the contractor to carry out and be responsible for not only the construction but also the design of the works including engagement of the design team who are, therefore contractually linked with the contractor and not the client (Molenaar and Gransberg, 2001; Ndekugri and Turner, 1994). The challenges of misunderstanding and conflicts that occur during the design and construction stage hinder integration amongst them.

Communication and Information

As the integrator of numerous supply chains, problem related to communication and information flow is identified as crucial to the main contractor. Most of the interviewees claimed that communication problems form an important part of the challenges they face in IBS construction supply chain. Some of the contractors complained about enforcement of "Forced Marriage" between consultants and contractors by the client under design and build as this impacted on the quality of communication and information of their integration. Unfamiliarity with each other causes problems arising from the lack of cooperation between the contractor and consultant. Problems include inaccurate design information, reluctance to

accept other members' opinion, inaccurate data, late updating of the required information and late submission to the local authority. This indirectly influences the quality of their IBS project delivery.

Interviewee C who procured through Traditional procurement highlighted that: *"they can communicate well, very good communication but everybody think about dollar and cent, limited transparent of information….there is hidden cost from the manufacturer/precaster…"* In design and build procurement, Interviewee F highlighted that, *"…even though the manufacturer have done business relationship with them but there seem no trust element between them…for example…photo cannot be taken while visiting their factory*" . He claimed that there is no sharing of information and the manufacturer is not ready to share their technology. He further explained that unfamiliarity hindered their shared interest to complete a project as one integrated supply chain. Developing efficient communication throughout the tiers of the supply chain will ensure superior and reliable flows of information (Briscoe and Dianty, 2005).

Attitude and Relationship matters

Generally, attitude of the designers were criticized by the main contractor as one of the factors that challenge the integration between IBS supply chain. For example, the architects pride and arrogance about their design concept to protect their professionalism. They were reluctant to change their designs even though the designs will cause difficulties in the mould system of IBS components. Moreover, the main contractors who procured under design and build complained that the architect acted as the leader and held no respect for them, as the main contractor. There is no respect, understanding and commitment amongst IBS players. Furthermore, the majority of the main contractors interviewed felt that the designer was reluctant to change and stuck with their old mindsets as with the conventional process. This is supported by Kamar et al. (2010) who revealed that there is critical need to manage the design and manufacturing differently from the traditional way as IBS is different and needs a different mindset along with the right environment. This attitude impacted the time in designing and delivering the IBS project. Rethinking the old processes is now critical if the industry is to move forward (Kamar et al. 2010)

INTERIM CONCLUSIONS AND FURTHER RESEARCH

The research reports the data based on findings to date through literature review and semi-structured interviews on the challenges faced by IBS contractors on the integration of the IBS supply chain with regards to the existing procurement methods that they undertake. Role and responsibility, understanding of knowledge, risk liability, financial and contract matters and attitude and relationship are established as the challenges that hinder the successful integration of the contractor with the parties involved. The same problems are also experienced in UK, Dianty et al. (2001) and Millett et al. (2000) addressed the significant barriers exist to main contractor and supplier integration within the UK construction industry are the lack of knowledge and information, lack of trust and negative attitudes. These findings are in tandem with the thorough literature reviews conducted. The research findings also confirm that the IBS contractors whether procured through Design and Build procurement or Traditional procurement face similar challenges. This is justified because there are various supply chain arrangements in Design and Build procurements that might influence integration and the performance of the IBS project delivery. Thus, the issue of better integration is important to be addressed within the IBS construction. More extensive empirical research work on these areas is needed, especially on the appropriate practices and

the success and barriers factors of integrating the supply chain players with the arrangements of project procurement delivery. Finally, the study presented in this paper is part of an ongoing research, which will eventually attempt to further enhance the practices and implementation of Supply Chain Integration in relation to procurement systems, particularly in the IBS project delivery in Malaysia. Such developments augur well in support of the government's aspiration in moving towards a more efficient IBS construction approach.

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STIMULATION OF PROJECT COOPERATION BY PROCUREMENT PROCEDURES AND PROCUREMENT CLIMATE

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Abstract
In The Netherlands, public works are contracted more and more in integrated ways. In recent literature, it is argued that procurement procedures will influence project performance. Even more, the procurement climate itself is found to influence the project performance by strengthening or altering the relationship between procurement procedure and project performance. In this paper, the relationship between procurement procedures and –climate and project cooperation is defined, project cooperation being an important indicator for project performance. The results of the literature study and the qualitative survey show a clear need for a procurement procedure not merely based on the project itself, but also on collaboration and soft parameters. In-depth case studies are used to analyze abovementioned relationships and find more detailed descriptions. The procurement procedure, procurement climate and project cooperation of three projects were assessed: KOSMOS STAKAN, 2nd Coen Tunnel, Houten-Castellum alliance. The added value of a collaborative procurement climate is emphasized by the in-depth case study results. Based on those results, suggestions for further research are given.

Keywords: project cooperation, procurement procedures, procurement climate, project performance, coopetition.

INTRODUCTION

Since the eighties of last century, three main developments have propelled changes in Dutch construction industry. The combination of increased project complexity (Baccarini, 1996; Laufer et al., 1996; Alderman et al., 2005; Walker, 2007), a changed role of the government (Blanken, 2008) and the sector's poor professional functioning (Egan, 1998; National Audit Office, 2001) form the context in which several changes in the construction industry are embedded. These changes are twofold: on the one hand they are aimed at new structures (formal processes and contracts) and on the other at new working relationships (informal processes and understandings).

Due to the mentioned developments the tasks and roles of market and government have become different. Public clients have less influence on the contents of works, yet are striving after 'professional commissioning', leading to more and more outsourcing to market organizations (Huque, 2005). The public client confines itself to monitoring and checking from the public matter (Blanken, 2006, p. 181). Market organizations at the other hand get next to the executive- also more substantive tasks. Stemming from these changing tasks and roles, structures have been amended and are continuously developing. Integrated contract forms, PPP constructions, and active discussions about aspects like price, risks and contractual terms are more and more common during the procurement of construction projects (Bult-Spiering and Dewulf, 2006). Yet, there is also growing attention paid to the 'soft' aspects of construction. The call for new cooperation forms, increased mutual trust, improved communication and mutual understanding becomes stronger (Dorée, 2001; PEC, 2002; PSIBouw & RegieraadBouw, 2007). One is, for example, experimenting with procurement based on the orientation of candidates towards cooperation with the public authority.

The increased attention for soft aspects matches with the notion that project cooperation enhances project performance. Project performance is here defined in terms of cost, time, quality, environmental impact, work environment and innovation (Eriksson and Westerberg, 2010). Several academics have shown how cooperative behavior in projects is of positive influence to project performance. Collaboration may be regarded as "the instrument" that allows the parties to realize the project goals (Kamminga, 2008, pp. 53).

Project partnering, an elaborate way of project cooperation, is said to have several expected benefits: lower bidding prices and project costs; increased efficiency; increased opportunity for innovation; better quality products and services; improved design; better identification and clarification of project risks; better utilization of labor; better communication leading to higher levels of team member collaboration; fewer conflict, claims or disputes; improved supply-chain collaboration and, finally, more informed decision making for project participants (Crespin-Mazet and Portier, 2010).

Research has indicated as well, that project performance is influenced by choices in the procurement of projects. The use of collaborative tools during procurement, for example, is positively correlated with project performance in terms of costs, time, quality, environmental impact, work environment and innovation (Eriksson and Westerberg, 2010; Alderman and Ivory, 2007). This might have to do with the influence of usage of this kind of tools on project

cooperation. However, proper research upon the influence of procurement procedures and climates on project cooperation is lacking. Therefore, our research is guided by the central question which procurement procedures and climate are, and in what manner stimulations to project cooperation.

RESEARCH DESIGN

Answer to the central research question is sought in a two-staged research. The first stage of the research was formed by a series of interviews to provide an overview of procurement procedures and aspects of procurement climate which might be of influence to project cooperation. The interviews were conducted with procurement experts from the Dutch construction industry, whose expertise differed from scientific expertise to legal expertise. The individually conducted interviews were semi-structured: containing a number of pre-determined open-ended questions in the form of an interview schedule, which guided the researcher whilst providing the flexibility to ask additional questions. The semi-structured approach was used to obtain a general list of procurement procedures and –climate, in combination with insights into the manner in which these might influence project cooperation. Interview reflections were coded by the qualitative data analysis tool QSR Nvivo, using a bottom-up approach to classify the large number of textual data units into a smaller number of homogeneous categories. The use of software in analyzing the qualitative data allowed for a more objective assessment, and facilitated a more complex examination of the data (Weitzman and Miles, 1995; Marshall, 2002). Thus, an overview was provided of the procurement procedures and – climate aspects which might stimulate project cooperation.

The by interviews created idea of the procurement procedures and –climate which might stimulate project cooperation, were then further studied in a series of in-depth case studies. This is the most suitable research approach, given the explanatory character of the question how procurement procedures and –climate stimulate project cooperation, and the limited extent of control over procurement situations (Yin, 2009). Case study protocols were created using literature on the, by the experts identified procurement procedures and – climate, combined with specific literature on project cooperation. This grounded approach led to protocols which were combining practical with theoretical insights (Eisenhardt, 1994).

PROCUREMENT PROCEDURES AND CLIMATE ASPECTS WHICH INFLUENCE PROJECT COOPERATION

Semi-structured interviews

A series of 20 interviews with procurement experts provided us useful background information on procurement procedures and –climate aspects which might be of influence to project cooperation. Practitioners and consultants as well as researchers supported the importance of procurement procedures and climate, and their assumed effects on project cooperation and performance. 90 Percent of the experts argued that new ways of contracting (i.e. D&C, DBFM, PPP, et cetera) ask for project members with different competences than needed for traditional

contracting, and a different attitude as well. This underlines the need for well-suited procurement procedures to find exactly those people.

Two factors were found to be of importance for well-suited procurement procedures and -climate. First, they might benefit greatly from effective and open communication, resulting in an understanding of each other's risk attitudes. Second, client and contractor will have to change their attitudes to be able to act according to the new roles integrated contracts impose. Two issues though were regarded to be main impediments for a more cooperative procurement climate. First, tender teams hardly ever continue to be the final project team during realization. Contractors as well as clients assign their best suited people for each phase and tendering is something quite different from project management during realization. Second, contractors are faced with contradictory interests of competition and relationship-building. The willingness to come to a trustful relationship with the client is hampered by the competitive tender climate. Being totally transparent to a client is desirable, but often not feasible.

Practical solutions to make cooperative procurement possible without the drawbacks were found in the field of alliance contracts and Best Value Procurement procedures, to find an "expert" contractor with less transaction costs. Also, the effect of the drawbacks could be minimized by starting the team-building process only after the contract has been awarded.

Procurement procedure

Procurement by competitive bidding has lately received criticism for leading to disputes and adversarial relationships that consequently will lead to time and cost overruns, diminished quality and, eventually, poor customer satisfaction. A competitive bidding procedure, on the other hand, may significantly increase resource consumption and generate waste in the delivery process. Transaction costs that seem to be low at the start of the project, will rise due to tedious and complex change order processes stemming from too early detailed plans and specifications (Elfving, Tommelein and Ballard, 2005).

A more cooperative procurement procedure will consist of limited numbers of trustworthy and competent bidders, incentive-based compensation and careful partner selection (Pesämaa, Eriksson and Hair, 2009). Spending time on a good start-up phase (including aspects such as communication, supplier selection and relationship management) and less time on formal specifications, facilitates necessary contractor involvement and some level of co-creation for complex performance (Caldwell, Roehrich and Davies, 2009). A paradigm shift from competitive tendering to co-operative and caring environments might overhaul current public sector procedures that often work against open relationships (Ng, Rose, Mak and Chen, 2002).

Another distinction that is found in literature is between transactional and relational approaches of procurement. The transactional paradigm is focused on competition, whereas the relational paradigm stresses the importance of ongoing interaction and less formal communications (Lian and Laing, 2004). Relational contracting is also used to describe the effects of a more fluid boundary between public and private organizations when working together. It is said to reduce costs, speed up time to market and promote innovation (Parker and Hartley, 2003). The growing success of relational contracting implies the more often us of selection of team players based on their relational capabilities (Kumaraswamy and Anvuur, 2008).

Eriksson and Westerberg (2010) identify three types of procurement procedure, being competition, coopetition and cooperation. With them, we label a procurement procedure more or less competitive, coopetitive or cooperative according to the following criteria:

- The level of integration between client and contractors in the design stage;
    - Specification by supplier or client (competitive) to Joint specification with one party responsible (coopetitive) to Joint specification with shared responsibilities (cooperative).
- The number of contractors that are invited in the selected tendering process;
    - Multiple (competitive) to Selected tendering (coopetitive) to One (cooperative).
- The focus on soft parameters in the bid evaluation;
    - Low (competitive) to Medium extent (coopetitive) to High (cooperative).
- The extent to which both client and contractors are jointly involved in subcontractor selection and integration;
    - One party fully responsible (competitive) to Joint selection with one party responsible (coopetitive) to Joint responsibility (cooperative).
- The usage of collaborative tools;
    - Low extent (competitive) to Medium extent (coopetitive) to High extent (cooperative).

Opposing to Eriksson and Westerberg (2010), we argue that two criteria belong to the project cooperation phase as they do not really influence behavior during initial procurement but only when the contract is closed. Therefore, their sixth and seventh criteria, method of payment (more or less incentive-based) and method of performance evaluation (more or less by the supplier), are labeled by us as criteria of project cooperation.

Procurement climate

Eriksson and Westerberg (2010) argue that besides the procurement procedure, a more cooperative climate will also have a positive effect on project performance, whether by moderating the effects of the procurement procedure on the project performance or by mediating the effects of the procurement procedure on the project performance. The level of trust and commitment between parties are measures of the procurement climate, according to their research.

Kadefors (2004) cites three types of trust. First type is Calculus-based trust: trust, primarily based on economic incentives for co-operation or contractual penalties for breach of trust. Second type of trust is Relational-based trust: trust developing when parties obtain personal information and experience, forming the basis of trust through emotions and personal attachment. The third type of trust is Institution-based trust: trust which is created by necessary pre-conditions like legal systems and societal norms regarding (among others) conflict management and co-operation.

Real co-operation, however, will only arise if relational trust develops between people interacting directly and over a longer period of time in procurement procedures. Key personal characteristics for this to happen are individual competence, benevolence and integrity. Competence being the skills and competencies for a particular situation, and benevolence being

the attachment of the parties to each other besides economic profit motives. Finally, integrity is defined as including principles such as consistency, fairness, reliability and openness. Partnering methods can influence the development of trust, but the effects can be ambiguous as overly reliance on team building processes and monitor systems might indicate and thus initiate distrust (ibid).

Commitment in our view is a combination of intent and behavior. Often, commitment to project success is expressed by project officials at the beginning of the project. The extent to which all management levels express their commitment to the success of this particular project, is one aspect. The other aspect is the actual behavior, and the readiness to overcome problems. In other words, the flexibility with which problems are solved that are in the way of project success. Too little commitment on the side of clients and, due to commercial pressures, of contractors are found to be reasons for lacking continuous open and honest communication (Ng *et al.*, 2002).

From the above, we derive the following elements to describe the procurement climate in our case studies:

- Mutual trust during procurement; higher trust indicates a more collaborative climate:
    - Competence, benevolence and integrity of individual project officers.
    - The level to which partnering methods created trust or distrust.
- Mutual commitment during procurement; higher commitment indicates a more collaborative climate;
    - Expressed intent at all (management) levels of the project.
    - Flexible problem solving behavior.

Project cooperation

In construction projects, cooperation can differ from forms of co-creation in a design & construct project to shared service exploitation in DBFMO contracts. Project cooperation can in any case be seen as a social setting, in which client and contractor work in a multi-organizational project setting in more or less integrated ways (Cicmil and Marshall, 2005). Construction teams are often cross-functional, with members of organizations with different interests. High levels of coordination and cooperation are thus needed (Pesämaa *et al.*, 2009). Project performance is threatened if client and contractor do not cooperate adequately to meet the various challenges in a construction project. After Kamminga (2008), we consider the cooperation successful when the interaction process between client and contractor leads to achieving the project goals.

From research on alliance contracts, success factors for effective cooperation can be identified: trust, clear goal alignment, commitment, partnering tools and procedures, constant joint evaluation of team synergy and open and continuous communication at all levels in a timely manner (Rowlinson and Cheung, 2005; Black, Akintoye and Fitzgerald, 2000; Ng *et al.,* 2002). But, project partnering in a project alliance is only one of a number of ways of organizing them. Both contractor and client will borrow from this concept what they think will help them most in a particular setting (Alderman and Ivory, 2007).

Thus, we will use the following indicators to describe project cooperation in our case studies:

- The level of trust after contract close;
    - Competence, benevolence and integrity of individual project officers.

    - The level to which partnering methods created trust or distrust.
- The extent to which goals of client and contractor are aligned;
- The level of commitment after contract close;
    - Expressed intent at all (management) levels of the project.
    - Flexible problem solving behavior.
- The extent to which partnering tools and procedures are used after contract close;
- The extent to which team synergy is jointly evaluated;
- The level of open and continuous communication at all levels and in a timely manner.
- The extent to which payment is based on incentives related to project performance criteria;
    - Fixed price (competitive) to Fixed price and shared profits (coopetitive) to Shared profits (cooperative).
- The extent to which performance evaluation is based on contractors' self-control;
    - Fully by the client (competitive) to Both by client and by supplier (coopetitive) to Fully by the supplier (cooperative).

CASE STUDIES

To find an answer to the central research question which procurement procedures and climate are, and in what manner stimulations to project cooperation, we started with interviews and a literature study. As a result, we came to clear indications by which the concepts of procurement procedures, procurement climate and project cooperation can be described. Based on recent work of ours (Hoezen et al., 2010; Hoezen, 2011; Laan et al., 2011) these indicators are put in line for three case studies which were all procured by different procurement procedures by different project climates. From this, the effect of these indicators of procurement procedure and project climate on project cooperation will be derived in order to come to an indication of how procurement procedure and project climate are stimulations to project cooperation. After a short description of each case study, in Table 1 a summary is given of the project characteristics as identified from the cases.

Case study 1: KOSMOS STAKAN

The KOSMOS STAKAN project (see Hoezen, 2011 for an in-depth analysis) consisted of renovations to a large number of infrastructure objects. Construction works which needed major maintenance were bundled and contracted to the market in an Engineering and Construct (EC) contract. KOSMOS STAKAN was procured with the restricted procedure.

Procurement procedure

The level of integration between client and contractors in the design stage could be described as coopetitive. Although some of the tasks to the project were shared (problem definition, for example), the main load of work was simply divided between either the client or the contractor. With 5 selected contractors to the tendering process, the number of invited contractors is coopetitive as well. In the bid evaluation, the focus was on price, time and risk. Soft parameters were not included at all. This focus is therefore qualified as low (competitive). Subcontractor selection and integration was not influenced by the client, yet remained to the full responsibility of the contractor. Payment was mainly based on a fixed price, and collaborative tools were not

used at all. Concluding, the procurement procedure for KOSMOS STAKAN can be described as being competitive - coopetitive.

Procurement climate
In terms of mutual trust, KOSMOS STAKAN, the competence, benevolence and integrity of individual project officers was average. Partnering methods, which were practically not used, did not create extra trust nor distrust. When the construction of the project started, project officers stood neutrally towards each other. The expressed intent was neutrally as well, at all levels of the project. The roles during procurement were clear, and both client and contractors acted upon it. The problems arising were treated in line with this: the responsible party was looked at to come to solutions. Concluding, the procurement climate could be called coopetitive: project participants were not cooperating nor competing.

Project cooperation
The project cooperation within the KOSMOS STAKAN project could be characterized by medium levels of trust. Although project officers praise each other's competence, benevolence and integrity and show how they empathize with each other's situation, the created levels of trust fluctuate during construction. This mainly has to do with problems, faced in this stage of the project. Given the medium intent at all levels of the project, and the fact that problem-solving behavior was as traditional as had shown during the procurement stage of the project, problems got resolved, however not in a cooperative manner. The level of commitment was neutral, and the extent to which goals of client and contractor were aligned low. This had to do with the fact that the levels of communication were not always as open and continuous as one desired. Within KOSMOS STAKAN an attempt was made to have the contractor evaluate its own performance. Due to difficulties in achieving this, the client closely monitored as well. When the parties identified this, they started conversations to come closer to each other, however other partnering tools and procedures were not used. The team synergy is evaluated as average (not good, not bad) by all project officers.

Case study 2: 2nd Coen Tunnel
The second Coen Tunnel project (see Hoezen et al, 2010 and Hoezen, 2011 for in-depth analyses) consisted of the renovation of an existing tunnel and the construction of a new tunnel next to the existing one. Construction, reconstruction and maintenance were contracted within a Design Build Finance and Maintain contract. The second Coen Tunnel project was procured with the competitive dialogue procedure.

Procurement procedure
In the design stage of the Coen Tunnel project the level of integration between client and contractors could be described as coopetitive. The contractors were puzzling with the documents they got from the client, and although there were many detailed conversations about the project, the design task was for the contractors alone. The number of contractors was five, a coopetitive number. All parameters in the bid evaluation were hard. Although the client asked for a list of subcontractors, the subcontractor selection was the contractor's responsibility. The intensive conversations which were part of the competitive dialogue were the only collaborative tools used. Concluding, the procurement procedure for the second Coen Tunnel project could be described as coopetitive.

Procurement climate

At the start of the procurement, parties were positive about each other's competences. Benevolence was average, and integrity was not a point of discussion. However, during the procurement several issues arose. The client started to doubt the contractor's integrity, whilst the client's competence was discussed by the contractor. The partnering method used (competitive dialogue procedure) did enhance opportunistic behavior of the candidate contractors, leading to mutal distrust at the end of the procurement stage. Commitment to the project, however, was average. The parties expressed intent at most levels of the project, however their problem solving behavior was not too cooperative. Both parties were digging in and awaiting the other party to make a move. Concluding, the procurement climate in the Coen Tunnel project was competitive.

Project cooperation

During the construction stage of the project, the level of trust improved only slowly. This was not due to partnering methods, but to a change of persons involved in the project. Given that these people did not have a mutual history in the project, there was more benevolence between them than between the persons involved earlier. However, doubts about the competence of the client at the contractor's side and about the integrity of the contract from the side of the client, remained. The overall level of trust during the construction stage was therefore somewhat medium. Project performance was part of the incentive structure, although extra performance was not rewarded. Performance evaluation for the second Coen Tunnel project was on the basis of contractor's self-control. The goals of client and contractor differed and could not be brought in line. This had to do with unsolved problems from the procurement stage. The level of commitment was therefore low: there was only little intent at management level, and the problem solving behavior was stiff. This situation did cause however the use of partnering tools like meetings and the help of reflectors, to bring around more open and continuous communications. The team synergy was therefore evaluated becoming more positive as the project developed. Concluding, the project cooperation in the Coen Tunnel project was assessed as competitive.

Case study 3: The Houten-Castellum alliance

In the Houten-Castellum project (See Laan et al, 2011 and Laan, 2008 for in-depth analyses), an existing rail track in the domain of a medium-sized city is doubled over a length of about 5 km. Besides the doubling, the existing station will be rebuilt and a new one will be added, and a rail crossing auto tunnel, a bus tunnel, a pedestrian underpass, a large cycle shed and an underpass for cyclists will be realized. The client at first decided to procure the Houten-Castellum project with a design and construct contract. However, after bid evaluations it became clear that the project risks were high and hardly controllable by one of the project partners. Therefore it was decided to convert the initial design and construct contract into a project alliance contract and a construction contract.

Procurement procedure

In the design stage, initially the level of integration between client and contractor was average. However, during the contract negotiations, the integration level increased. When converting the design and construct contract into the project alliance, the client organization became more involved in the design process and the contractor organization actively thought along about how to govern the project. In the selected tendering process, three contractors were invited. In the bid evaluation, the attention to soft parameters was medium to high, since the client organization

recognized the importance of soft aspects for jointly being able to tackle possible risks. However, subcontractor selection remained for the responsibility of the contractor organization. The project alliance had strong incentives for the maximization of project performance, since financing of the alliance came from all client's and contractor's design, management and risk budgets. Of this fund, design and management costs were paid, as well as emerging risks. Savings resulting from optimizing the project design would boost the fund. Use of collaborative tools was a bit more than average during the construction stage. Besides the regular project-startups, the process of discussing the project alliance conditions helped creating collaboration. Concluding, the procurement procedure could be qualified as being coopetitive - cooperative.

Procurement climate

The procurement climate in the Houten-Castellum alliance was cooperative. Started from average perceived levels of competence, benevolence and integrity, during procurement these perceptions increased. The conversations about the project alliance brought people from the contractor and the client organizations closer together and created trust amongst them. Commitment was high, and the intent was expressed at all levels of the project. Problems were solved in a very flexible manner: one did not ask whose task it was to solve a problem. Instead, all parties involved tried their best to prevent problems to occur. The mutual commitment therefore was strong. Concluding, the procurement climate in the Houten-Castellum project can be characterized as cooperative.

Project cooperation

The level of trust, high in the procurement stage of the Houten-Castellum project, was even growing in the construction stage of the project. Under influence of joint goals and open, continuous communication, the trust level developed along virtuous cycles. When considering the project alliance as a partnering method, this method created trust to a large extent. At the end of the project, any positive or negative outcome of the alliance fund was 50/50 shared between the client and the contractor. The project performance ultimately was monitored by a team of client and contractor organization members. Goals of client and contractor were optimally aligned, and the level of commitment was high. This all resulted in a very positive jointly evaluation of the team synergy. Concluding, the level of project cooperation was assessed as cooperative.

	KOSMOS STAKAN	2ND COEN TUNNEL	HOUTEN-CASTELLUM ALLIANCE
PROCUREMENT PROCEDURE	COMPETITIVE - COOPETITIVE	COOPETITIVE	COOPETITIVE - COOPERATIVE
Level of integration between client and contractors in the design stage;	Low to Medium (competitive - coopetitive)	Medium (coopetitive)	Medium to high (coopetitive - cooperative)
Number of contractors that are invited in the selected tendering process;	Medium (coopetitive)	Medium (coopetitive)	Medium (coopetitive)

Focus on soft parameters in the bid evaluation;	Low (competitive)	Medium (coopetitive)	Medium to high (cooperative)
Extent to which both client and contractors are jointly involved in subcontractor selection and integration;	One party fully responsible (competitive)	One party fully responsible (competitive)	One party fully responsible (competitive)
The usage of collaborative tools;	Medium (coopetitive)	Medium (coopetitive)	Medium to high (cooperative)
PROCUREMENT CLIMATE	COOPETITIVE	COMPETITIVE	COOPERATIVE
Mutual trust	Medium (coopetitive)	Low (competitive)	Medium to high (coopetitive - cooperative)
Competence, benevolence and integrity of individual project officers.	Medium (coopetitive)	Low (competitive)	Medium to high (coopetitive - cooperative)
The level to which partnering methods created trust or distrust.	Medium (coopetitive)	Low (competitive)	High (cooperative)
Mutual commitment	Medium (coopetitive)	Medium (coopetitive)	High (cooperative)
Expressed intent at all (management) levels of the project.	Medium (coopetitive)	Medium (coopetitive)	High (cooperative)
Flexible problem solving behavior.	Small (competitive)	Small (competitive)	High (cooperative)
PROJECT COOPERATION	COOPETITIVE	COMPETITIVE	COOPERATIVE
The level of trust	Medium (coopetitive)	Low to medium (competitive-coopetitive)	High (cooperative)
Competence, benevolence and integrity of individual project officers	High (cooperative)	Low to medium (competitive - coopetitive)	High (cooperative)
The level to which partnering methods created trust or distrust	Low to medium (competitive - coopetitive)	Low (competitive)	High (cooperative)
The extent to which goals of client and contractor are aligned	Low (competitive)	Low (competitive)	High (cooperative)
The level of commitment	Medium (coopetitive)	Low (competitive)	High (cooperative)
Expressed intent at all (management) levels of the	Medium (coopetitive)	Low (competitive)	High (cooperative)

project.			
Flexible problem solving behavior.	Medium (coopetitive)	Low (competitive)	High (cooperative)
The extent to which partnering tools and procedures are used	Medium (coopetitive)	Medium (coopetitive)	Medium (coopetitive)
0The extent to which team synergy is jointly evaluated	Medium (coopetitive)	Low (competitive)	High (cooperative)
The level of open and continuous communication at all levels and in a timely manner.	Low (competitive)	Low to medium (competitive - coopetitive)	High (cooperative)
Extent to which payment is based on incentives related to project performance criteria;	Fixed price (competitive)	Fixed prices with project performance – related incentives (coopetitive)	Shared profits (cooperative)
Extent to which performance evaluation is based on contractors' self-control;	Shared client – contractor responsibility (coopetitive)	Contractor responsibility (cooperative)	Shared client – contractor responsibility (coopetitive)

***Table 1**: Case characteristics*

CONCLUSION AND DISCUSSION

In this paper we have made a start with researching the relationship between procurement procedure and procurement climate at the one hand, and project cooperation at the other. From the notion that cooperative project cooperation influences project performance in a positive manner, we are looking for aspects by which project cooperation could be stimulated. Literature study provided us with a range of indicators by which we have characterized three construction projects: KOSMOS STAKAN, the Second Coen Tunnel project and the Houten-Castellum project. The case study results show how project cooperation seems to be mainly influenced by procurement climate, with procurement procedure showing to be of minor influence. In all of the three cases we studied, the project cooperation which resulted from the procurement developed in line with the procurement climate rather than with the procurement procedure (see Table 2).

	Procurement procedure	**Procurement climate**	**Project cooperation**
KOSMOS STAKAN	Competitive - Coopetitive	Coopetitive	Coopetitive
2ND COEN TUNNEL	Coopetitive	Competitive	Competitive
HOUTEN CASTELLUM ALLIANCE	Coopetitive - Cooperative	Cooperative	Cooperative

***Table 2**: Indicators per case*

From the notion of Laan et al (2011) that vicious and virtuous cycles of trust development exist, we assume that these cycles are the main forces in this relationship: a trusty climate in the procurement stage of a project is likely to result in cooperative project cooperation in the construction stage of the project. Whether or not procurement procedures are of influence, remains unclear. The procurement procedure might influence the development of a procurement climate to a certain extent, yet might as well be of less influence.

Based on the study, described in this paper, we recommend further research into the relationship between the three concepts of procurement procedure, procurement climate and project cooperation. With robust operationalization of the concepts and a wide range of well-documented and accessible projects we suggest a quantitative approach to make strong conclusions. Aside from the outcome of such a research it should be said that creating a cooperative procurement procedure and –climate takes investment, both at personal level and in terms of finances. Furthermore, not all projects will need project cooperation to come to improved project performance. Implementing cooperation strategies should therefore be well-thought before.

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BUILDING RENEWAL ON SOCIAL HOUSING – CASE STUDY ON THE RUBEM BERTA SETTLEMENT, PORTO ALEGRE, BRASIL

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Abstract
This study proposes a method and presents a proposal to re-qualify social housing complexes, with diversification and expansion of units. The construction of large social housing condominiums can be criticized from several points of view. These projects has limited financial resources and there is a gap among the project and user' requirements, generating a low quality product, which have an accelerated degradation and generate more maintenance' waste in life cycle. Building renewal is a form of recycling and has influence in social, economic, and environmental issues. The aim of this paper is to propose a design methodology for the renovation, which is sustainable and oriented to value creation. It consider environmental and economic feasibility based on embodied energy in materials and hedonic price models, respectively. We conducted design simulation, focusing on a typical housing complex, located in the Rubem Berta settlement, in Porto Alegre, Brazil, and verify a potential for value adding. This work contributes to the discussion of alternatives to social housing deficit in Brazil.

Keywords: Social housing; Design; Building renewal; Sustainable construction; Waste reduction.

INTRODUCTION

There are several benefits on rehabilitate existing buildings, such as maintaining structures of social or historic value and already adapted to urban and architectural reality; take advantage of the energy involved in the existing physical structure, with less need for new resources;

maintaining social relationships, community and neighbourhood; and provide value adding in the region and the building itself (Gorse and Highfield, 2009). A part of existing social housing estates in Brazil has problems of conservation and rehabilitation is an important measure to restore the quality of life of their users. Improving the use of existing buildings reduces the need for new buildings and then decreases the need for new urban land, contributing to sustainability.

There are examples of mass housing rehabilitation on developed countries. In North America the main focus is on reducing energy consumption (retrofit). In Europe the problem is also linked to the renewal of a large number of buildings built after the II World War. The standards adopted at the time of construction are considered not suitable for the present moment, and people look for new solutions to expand the built environment and reduce energy consumption for heating in addition to value adding of the region. The low population growth in developed countries and the search for sustainability does not recommend demolition (Bragança et al., 2007; Cukovic-Ignjatovic and Ignjatovic, 2006; Giussani, 2007; Ham and Schamhart, 2006).

Developing countries have different needs, such as production to cover housing deficit, as well as economic viability. Still, part of the housing issue is linked to poor care of the demands of users, caused by deficiencies in the original design or aging buildings, in addition to the problems based on the low quality of social housing (Bonduki, 1999; Boselli, 2007).

Housing deficit in Brazil is about 10%, regarding to existing stock. A part of this deficit is inadequate housing. As well as, a family have a housing, but with lower quality or size that your needs (FJP, 2004). Rehabilitation is a way to fix this part of deficit. In Brazil, an opportunity to study is in the vertical housing complexes built in the period of the National Housing Bank (BNH), from 1964 to 1986. In quantitative terms, that production is significant in several Brazilian cities. In general, these housing complexes were originally designed to low-class or low-mid class people. Most complexes are composed of hundreds of apartments with 2 or 3 bedrooms. They have social areas and parking areas, and had at building time reasonable architectural and building standards. Projects built around the country have large similarities (Azevedo, 2007; BNH, 1979; Bonduki, 1999, Sampaio, 2002).

However, too many properties currently present a bad conservation state and lower market values. It has impact on property tax, generating in some cases a lack of interest of the public administration to invest on improvements in the region. It is also common to occur the stigmatization of the residents. There are lost in relation to the quality of life for families and beyond, in the neighbourhoods. This situation occurs in Brazil and in other countries, such as Argentina and Chile (Dunowicz and Hasse, 2005; Krasuk and Gerscovich, 2005), with some known proposals for renewal (Ganem and Esteves, 2003; Ganem et al., 2005, Rodriguez and Sugranyes, 2004).

This phenomenon occurs in Latin America and several developed countries (Brattbakk and Hansen, 2004, Hastings, 2004; Verhage, 2005). To Brattbakk and Hansen (2004), there is evidence that some of the social and economic problems are linked to the repetition of the projects. To these authors, seems to be a relationship between long sets of buildings for social housing and the existence of social problems such as segregation and prejudice. The generation of stigma is most common in large housing complexes. The media identify or amplify the problems occurred in a given set, but the population can be generalized to other sets of similar project (Brattbakk and Hansen, 2004). In addition to overcrowding and poor

quality of design and construction, many residential complexes are built on the fringes between urban and rural areas with poor infrastructure, exacerbating the problem.

Chanagnon et al. (2003) state that one of the objectives of the rehabilitation of social housing in Europe is value increasing. Another objective is to reduce energy consumption. Ham and Schamhart (2006) argue that the renewal allows the utilization of existing infrastructure and structure, with less waste generation and lower energy consumption. Camarero Martínez et al. (2008) argue that rehabilitation should include sustainable design features.

Hastings (2004) argues that urban regeneration must consider the public image of the housing complexes along with the physical renewal. There are cases of urban renewal projects developed in Britain in which the poor image remained after the completion of the works. Esteban Galarza (1989) discusses some social consequences of regeneration projects in urban areas, such as increased levels of property prices and attracting groups with higher income levels, but at the risk of displacement of the original people. One of the known consequences is the gentrification. Gentrification is the conversion of marginal properties for working class areas located in central city areas in new residential uses for middle or upper class, by reflecting a movement of private capital investment. Was related to the recovery of damaged buildings architecture as well as supply of new services and usually occurs in the CBD (the city "core"). With this conversion, lower classes are displaced. In some cases, improvement it do not appropriate, on the contrary, it creates peculiar types of spatial segregation, often with increased income concentration (Smith, Williams, 1986; Zukin 1987).

Meanwhile, as well as the degradation of the built environment causes economic and social waste, building renewal has the potential to improve the quality of life of families affected and of the cities as a whole. It is possible to reduce poverty and crime improving built environment. Of course, projects requirements includes sustainability, looking at environmental (preference for low-impact materials), economic (economic viability) and social aspects (low impact on users).

This paper presents some results of research on sustainable solutions for building renovation. The work begins listing some elements to build a methodology and exposes a simulation study in a social housing complex in Porto Alegre, a Southern Brazilian city. Results indicate a good potential to consider rehabilitation as an alternative to contribute to the social housing issue.

SOME ELEMENTS TO BUILD A METHODOLOGY

The basic premise adopted is that to expand, improve and prolong the useful life of buildings is a form of recycling, avoiding new constructions, and then reducing the generation of waste, saving natural and financial resources, energy and urban land. It is assumed that there are economic benefits and better resource use with the renovation of buildings.

The rehabilitation project must be based on certain assumptions, including: (i) technical and economic feasibility, with proposing solutions to renew the appearance of buildings, promoting economic increasing, (ii) use of materials available in the region, low cost, that generate less waste and are recyclable, (iii) propose solutions that allow flexibility of use. These three points establish economic, environmental, and social sustainability. These premises are detailed to follow.

Viable and valued projects

Construction costs are a very important element in the social housing sector. In general there are too few resources and projects should attempt too many needs. So it is important to examine carefully the costs of rehabilitation projects to be economically viable. And further on, solutions must be technically feasible.

The costs were calculated by conventional budgets, measuring materials, labour, additional works, and administrative and legal costs. This part follows the traditional methods of budgeting. The feasibility analysis also requires estimates of increase on property values. We propose a basic way to measure the value using hedonic pricing models (Appraisal Journal, 2001; Rosen, 1974; Pagourtzi et al., 2003).

The models relating the price of a property with their characteristics are known as hedonic pricing models, which are econometric models, with a long application in economic studies and research (Rosen, 1974; Sheppard, 1999). Thus, value increasing may be measurable by comparing the current situation with the potential situation, which is based on the proposed rehabilitation.

For this, it was developed a pricing model for the correspondent property sector, according to traditional procedures for hedonic pricing models. This procedure is not detailed here for space limitations of this work. The information about sales data of the units was obtained from Sales Tax files in the Porto Alegre Tax Department, and statistical analysis was developed with 41,975 condo sales data in the period from 1998 to 2010. The resultant equation is as follows (Equation 1):

$$\begin{aligned}\text{Price} = (&73.59658 + 0.98101*\text{Building_Area} + 0.01836*\text{Land_Area}^{0.5} - 0.83540*\text{Building_Age} \\ &+ 1.02090*\text{Sale_Month} - 4.21273*\text{Sale_Month}^{0.5} + 6.22984*\text{Building_Standard} + 0.48867* \\ &\text{Settlement_Quality} - 3.75147*\text{Distance_to_Parks} - 1.23628*\text{Distance_to_Shoppings})^2 \end{aligned} \quad (1)$$

Where: Price is the selling price in US dollars; Building_Area is the total surface of the property (in m^2); Land_Area is the ground surface (m^2); Building_Age is the age of the building (years); Sale_Month is the time of sale (Month = 1 is October'98); Building_Standard is the quality of construction; Settlement_Quality is the quality of neighborhood; Distance_to_Parks and Distance_to_Shopping are distances to these points (kilometers). The model in Equation 1 was adopted before proven by the conventional tests, such as ANOVA, significance of the variables, and behavior of the errors; and it has a R^2 of 0.906.

Data sample is large in size and time period, allowing a reasonable confidence about market behaviour covering. In future applications, one may add new market data and to recalculate the model. Market do not change a lot in small time periods (e.g. some months), then it can expected small changes in the coefficients (the "shadow prices" of each building characteristic present on the Equation 1).

Sustainable projects

It's very clear the influence of buildings on the environment. The buildings require significant resources for its construction, as well as for operation and maintenance. The built

environment accounts for almost 50% of emissions of greenhouse gases, and a similar fraction of energy consumption and water (Gauzin-Müller, 2002; Yeang, 2001).

The issue of sustainability in construction have a link to sustainability in general, including problems of degradation of the natural environment, climate change and greenhouse effect, for example, and has three basic aspects: economic, environmental and social. These aspects should be pursued consistently (Gauzin-Müller, 2002).

There are several available criteria and principles for sustainability in construction, based on life cycle analysis, recycling of materials, components or construction and calculation of the energy involved (Kibert, 2005). Rehabilitation is a form of recycling the building, which attempts to use the existing structure of the building and infrastructure in the region, with less waste generation and lower energy consumption in the life cycle of the building. For the specification of new materials are adopted the choice based on the energy involved in each option, considering also the costs and the need for resources in the life cycle (Boussabaine and Kirkham, 2004).

Flexible projects

The repetition of the project can be considered as a cause of devaluation of social housing. In general, the mass housing market is seen as low quality housing, monotonous and intended for low-income population (Brattbakk and Hansen, 2004, Hastings, 2004; Verhage, 2005).

Kleinhans (2004) recommended the diversification of housing types and encouraging various economic activities (shops, offices, services), in order to attract a population with different socio-economic conditions. These are important actions to reduce crime and pollution, to expand and qualify the transport and urban infrastructure. Verhage (2005) also maintains that the building and urban renewal should encourage diversity of typologies, to attract different people and thus reduce the possibility of segregation.
Another premise is that the building should accommodate users along its life cycle and not vice-versa. For this, the design must incorporate some degree of flexibility. The research line "Open Buildings" continues studies of Habraken (1972, 1998) and represents a strategy of design, construction and operation of the built environment looking for flexibility (increasing the ability to adapt to the changes that occur throughout the life cycle of a building).

From this point of view, the building has basically two parts: shell (constructive form with durable characteristics) and infill (internal parts that can be performed with lightweight materials and should provide flexibility to adapt). This concept applies to new projects, where one can specify the structures, fences and building systems in a simple, yet also adaptation or renovation projects of buildings can (or must) take into account the flexibility (Habraken, 1998 , Kendall, 2005). There are some rehabilitation studies in Brazil for the social housing sector, such as (Folz, 2008; Marroquim and Barbirato, 2007; Szücs, 1998).

SIMULATION STUDY IN PORTO ALEGRE

This part of the work presents a study about on the possibility of renewal of an housing complex in Porto Alegre, Brazil. The investigation was conducted following the principles presented through simulation of alternative projects with actual costs and market values.

These projects usually have a repeating pattern and follow a common pattern (BNH, 1979). There is hundreds of this kind in Brazil, and in many cases they are in not too good conditions, or they have no requirements that families need today. It is still important to think about collective solutions to the joint through a strategy that will allow differentiation of the properties without losing the characteristic of the housing estate.

For build the proposals, were also considered good examples of social housing built in Brazil and other countries (French, 2008). It is important to note that we do not discuss the architectural quality of the project alternatives itself, which were generated to allow analysis and discussion of some issues. In addition, a more precise analysis of a building renovation project must involve the users (Giussani, 2007; Suschek-Berger and Ornetzeder, 2005).

Description of condominium blocks

The case study is about Rubem Berta settlement, considered the largest housing settlement of the state of Rio Grande do Sul and one of the largest districts in the country. It is an 8.7 km² built area and about 80 thousand inhabitants. The occupation in this region began in the 50's, to be formally established by a municipal law of Porto Alegre in 1968. It is a neighborhood occupied almost entirely by vertical buildings (Rigatti, 1999, Severo, 2006). Figure 1 show an aerial image, where one can see the density of occupation in the neighborhood, and a set of blocks in detail, with some façades. This set is located on the 22' Street (Rua Vinte e Dois). It was completed in March 1980 with the financing of BNH, consists of four blocks, with 4 levels and 8 apartments per floor, with a total of 5,872 m^2 and 128 units. The region has dozens of blocks of similar size and standard.



Figure 1 *– Aerial image and façade – 22' Street - Rubem Berta settlement*

Figure 2 shows the original floor design. It has three types of apartments, with one (R1=35m^2), two (R2=46m^2) and three bedrooms (R3=56m^2). Each level has 367m^2, with 5 double bedroom units, 2 units of 3 bedrooms and a single bedroom unit. Construction is on conventional reinforced concrete structure and masonry bricks walls covered with mortar joint; the windows are built on steel tubes, the roof has asbestos-cement shingles, and the rooms have parquet on the social areas, and ceramics at the service fields. There is no lift on the building.

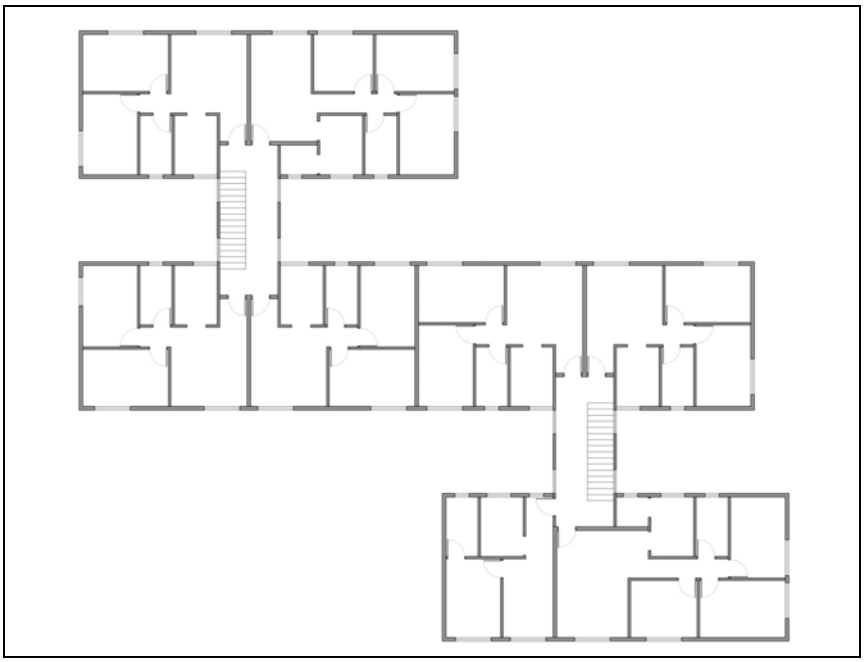


Figure 2 *– Original floor design – with 1, 2 and 3 rooms*

Internal rehabilitation design

This proposal seeks to use the existing structure, still generating internal differentiation in the building. They were proposed alterations from the original floor plant. The internal diversification of the apartments was explored, recombining existing units to form lofts, horizontal and vertical duplexes; with a greater variety of floor plans in the building (Figure 3). The project includes the expansion of the blocks including a new level. The flexible plan allows residents of the building to change property type without change your address along time. Thus, neighbourly ties are not lost and the community remains united.

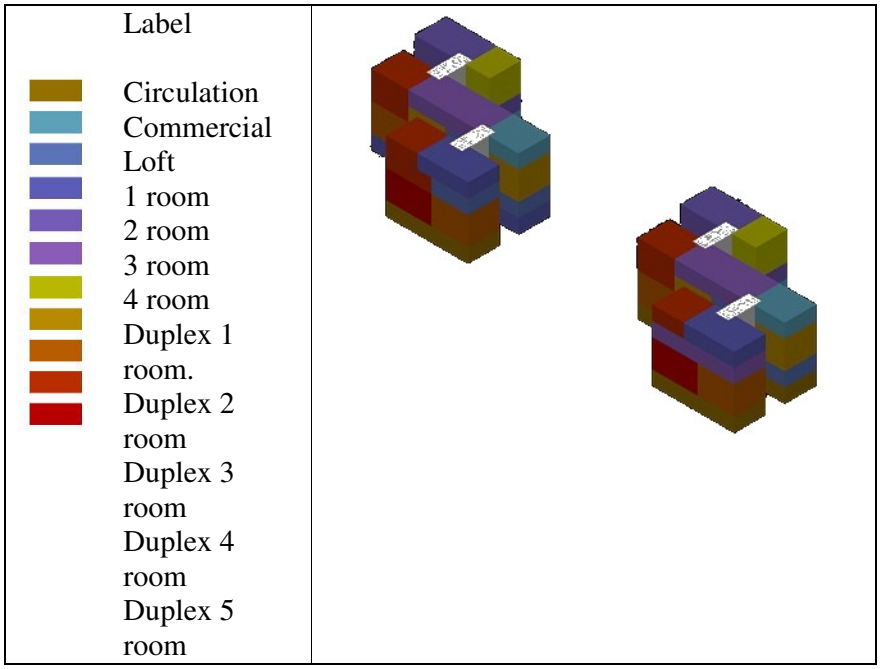


***Figure 3** – Different building types – Two block examples*

The project includes the expansion of the blocks including a new level in some blocks. The reinforced concrete structure is conventional. It has 30 years old and was calculated according to odd customs and rules, perhaps more demanding than today. We checked the quality and status of this structure through detailed field inspections. Can be seen that the structure is to extra-dimensioned in relation to existing concrete structures. Under these considerations, we can add a further layer in the block without loss of structural performance. The income from the sale of new units may finance the work. One can make the differentiation of units without undoing the basic features of the condominium, which maintains a regular appearance (Figure 4).



***Figure 4** – Buildings with different levels – 4 and 5 stories*

Façade rehabilitation design

The proposal adopts metal structural elements connected to the building's facade, including open or closed balconies. All the balconies incorporate barbecue equipment (grill), which is a very important element on local culture. The part of balcony positioned side by side on living room is open while the part at side of bedroom it's closed by a mobile brise (Figure 5). It was designed to obtain major environmental comfort on bedroom, which reduce sunlight and at the same time, allow free air circulation. The location of the wind may vary according to the needs of residents, keeping the same building pattern (Figures 5 and 6).



Figure 5 *– Façade options – building with and without balconies; open and closed balconies*

Roof housing rehabilitation

The structure is relatively old and we can say it's extra-sized in relation to existing concrete structures. In addiction, the new plant allows the use of a green roof. This green roof collects rainwater for reuse (Figure 5). The roof also contributes to the upgrade of the facade. We propose two different roof styles. In the first, the cover remained as originally, and on another was covered with a green protection, with thermal effect about the last level apartments (Figure 6). They have similar costs.



Figure 6 *– Roofs – Option A (conventional) and B (green roof)*

Economic viability of the rehabilitation project

The costs were calculated per apartment (average per unit). After that, we did the calculation of value adding using Equation 1. There are many different configurations of building renewal, but we presented one option, to examine the feasibility and to demonstrate the methodology of analysis. It is the simplest (assumed to be the most likely option in a real case): the inclusion of balconies with barbecue equipment, a very important element in local culture. Budget was considered for the buildings with one, two, or three bedrooms. Costs are different by building type (Table 1).

Table 1 – Budgeting details of façade renovation – average by unit – on USD

Rooms	Simple (R1)		Double (R2) or Triple (R3)	
Element	Dimension	Cost	Dimension	Cost
Foundation – radier on concrete	3.5 m^3	900.00	4.0 m^3	1,000.00
Steel balconies: 5.6m^2 – structure, floors and laterals	490 kg	3,950.00	650 kg	5,250.00
Aluminum brises	6.0m^2	1,350.00	8.0m^2	1,800.00
Inner changes (masonry, carpentry) – changes on windows, changes on the external walls		810.00		820.00
General painting	47.0m^2	910.00	49.0m^2	970.00

Project, tax, management	12.5%	880.00	12.5%	1,120.00
Unit costs		8,800.00		10,945.00

The market values for each apartment were calculated using the actual data of each type of building, for the month of December 2010. These values were obtained for the current state of the building. In a second stage it was proposed lowering the age for 15 years and increases the standard of level 2 for 3, for the purpose of updating and renovation of the façade (compare Figures 1 and 5, 6). It is a use of the concept of "apparent age" as used in commercial appraisals (Appraisal Journal, 2001; Pagourtzi et al., 2003). The change of standard is justified by the addition of the balcony with a barbecue equipment. In addition, we calculated the effect of increasing the area by the addition of the balcony. The calculated values for each unit are shown in Table 2. As the valuing is greater than the costs, we demonstrated economic viability. There is an advantage of about $ 300 to $ 1,100 per unit with the renovation. This small difference may decrease the risk of gentrification, why not bring a significant enhancement to the property. Properties maintain affordability, as well as, target group is not removed of your dwellings after refurbishment project.

Table 2 –Economic analysis of façade renovation

Apartment	Area (m^2)	Original value – USD	Area (m^2)	Value with renovation – USD	Valorization – USD	Profit – USD
Simple room – R1	35.00	36,800	40.6	46,700	9,900	1,100
Double room– R2	46.00	41,060	53.5	52,330	11,270	325
Triple room – R3	56.00	45,133	63.5	56,910	11,777	832

Economic viability has been demonstrated. Design strategy allows the differentiation of the blocks without mischaracterize the condominium. The quality of life for residents is extended with the addition of balconies and brises, and improving thermal comfort of the units. Sustainability is achieved through the use of steel, which is cheaper and has less energy incorporated than reinforced concrete.

FINAL CONSIDERATIONS

The Brazilian condominiums developed under BNH' period were built since the late 60's to the beginning of the 80's, with thousands of similar estates. Actually there are opportunities for renewal. This study used simulation proposing building renovation with maximum use of existing infrastructure. We develop design alternatives with budgets based on real costs. Final cost of refurbishment was compared with predicted value calculated by hedonic price models. HPM was based on a large data sample (in terms of size and time period), allowing confidence about market behaviour covering.

The renewal proposal adds differences in the condominium. The overall appearance of a monotonous, repetitive complex, with all the equal blocks, shown in Figure 1, is changed to a set that has common design features, but it has different characters in each block, with different heights (Figure 4), with balconies (Figure 5), conventional or green roof (Figure 6), and so on. In addition, there are buildings with different number of rooms, allowing that families with different configurations can share the same urban space (Figure 3).

The design process incorporated sustainability features, with the analysis of energy involved - preference for materials of lower total energy and greater potential of recycling - and economic viability analysis, which confronted the costs of implementing the building renewal. To partially fund the renovation of the building by selling units, or replacement of the residents of each block was designed adding a new level. This research has already shown it is possible to rehabilitate old buildings and blocks design with flexible design units, with this flexibility vertical or horizontal.

The small differences verified on property prices reduce the risk of gentrification. Properties maintain affordability and people are not removed of your dwellings after refurbishment project. To refinement of this method, we recommend to test different design options, to verify the best one, in economic and environmental terms.

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DRIVING SUSTAINABLE INNOVATION IN CONSTRUCTION COMPANIES

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Abstract
By adopting a theoretical framework from strategic niche management research (SNM) this paper presents an analysis of the innovation system of the Danish Construction industry. Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained. The analysis shows a multifaceted landscape of innovation around an existing regime, built in the existing ways of working and developed over generations. The regime is challenged from various niches and the socio-technical landscape through trends as globalization. Three niches (Lean Construction, BIM and System Deliveries) are subject to a detailed analysis showing partly incompatible rationales and various degrees of innovation potential. Based on the analysis, the paper further explores how companies can be introduced as drivers for innovation in the construction industry. By bridging SNM with business development activities through an adapted version of Ansoffs growth matrix, companies continuously and consciously can develop a competitive advantage by targeting new and existing markets with new or existing competencies/niches. The paper concludes with a discussion of how this approach can help to solve the challenge of retrofitting the existing building stock and thereby enabling the development a low energy consuming society.

Keywords: Innovation, Niche, SNM, Companies, Business development.

INTRODUCTION

The construction industry is often characterised as a tradition bound low innovation sector which struggles with low productivity. The constant comparison of the construction industry with other industries e.g. in relation to innovation is however problematic. The construction industry could be viewed as fundamentally different from many other industries by being project-oriented with a significant proportion of unique production. Construction is linked to a specific location and the design and production team is organized uniquely for each project. This dynamic frames the innovation process in contexts where continuous development is more or less impossible. Consequently many of the innovations are confined within the single project (Thuesen 2006).

The consequence is that numerous companies fail to evolve independently, but are subject to an industry development and regulation that fixates businesses in their existing working practices and institutional role.

Nevertheless, innovation processes *are* going on at all levels of the construction industry - from the builders at the construction site to the major development programs. Consequently a small but significant strand of Danish research has been conducted around innovation e.g. Clausen (2002), Simonsen (2007) and Vind and Thomassen (2009).

Despite the strong interest in stimulating innovation in Danish industry, the innovation programs are facing striking difficulties. Clausen (2002) concludes in his analysis of sectorial development programs that a mapping of innovation activity in construction industry is needed, focusing the interplay between strategically oriented and formalized activities and informal innovation processes on construction projects. (ibid: p. 13)

In this way it relevant to investigate how the construction industry capacity for innovation can be accelerated so that and how the industry can respond to new societal challenges such as the move towards CO2-neutral societies.

AMBITION

The ambition of the paper is to analyse the innovation system in the Danish construction industry (Thuesen et al 2011), and discuss by the use of innovation maps how companies can be introduced as vehicle for innovation driving towards a low energy consuming society.

THEORETICAL FRAMEWORK

The research of the innovation system of the Danish Construction industry draws upon a theoretical framework from strategic niche management research (SNM) (Schot and Geels 2008).

Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained (Schot and Geels 2008, p. 545). Illustrated in the following figure.

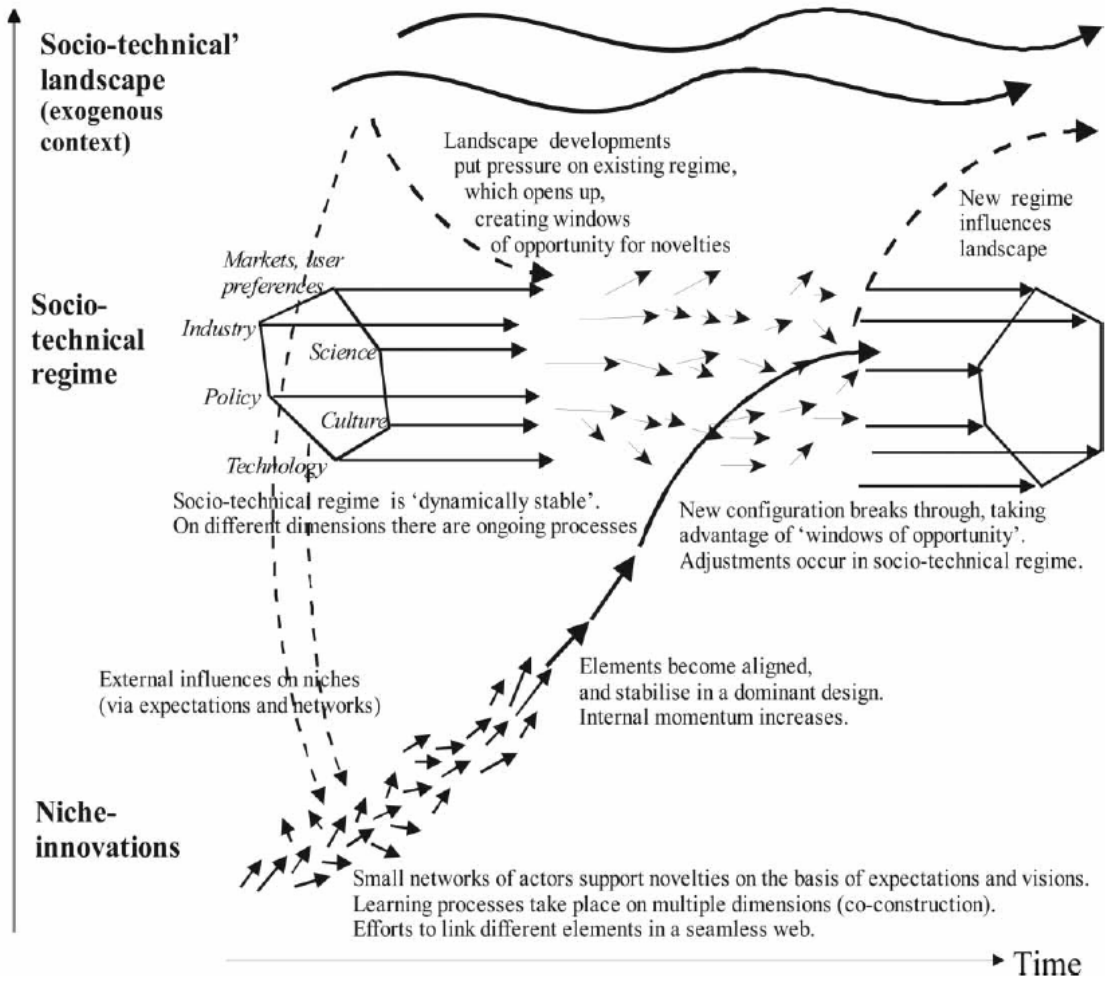


Figure 1: *Innovation in a sector explained in three levels (e.g. Schot & Geels 2008, s. 546)*

Niches form the micro-level where radical novelties emerge. The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical pattern of interaction which is reproduced by institutionalised learning processes. The macro-level is formed by the socio-technical landscape, an exogenous environment beyond the direct influence of niche and regime actors (e.g. macro-economics, deep cultural patterns, macro-political developments).

According to Geels and Kemp (2007) researchers within sociology of technology and evolutionary economics have stressed the importance of niches as driver of innovations, from where new socio-technical regimes can be developed (Schot 1998, Levinthal 1998). Niches work as incubations environments for new ideas by being protected from the traditional selection mechanisms of the marketplace.

By distinguishing between market and technological niches Schot & Geels (2008) explains how innovation can be achieved through institutional learning processes linking technological niches to niche markets. These changes could potentially lead to regime shift as outlined in the following figure.

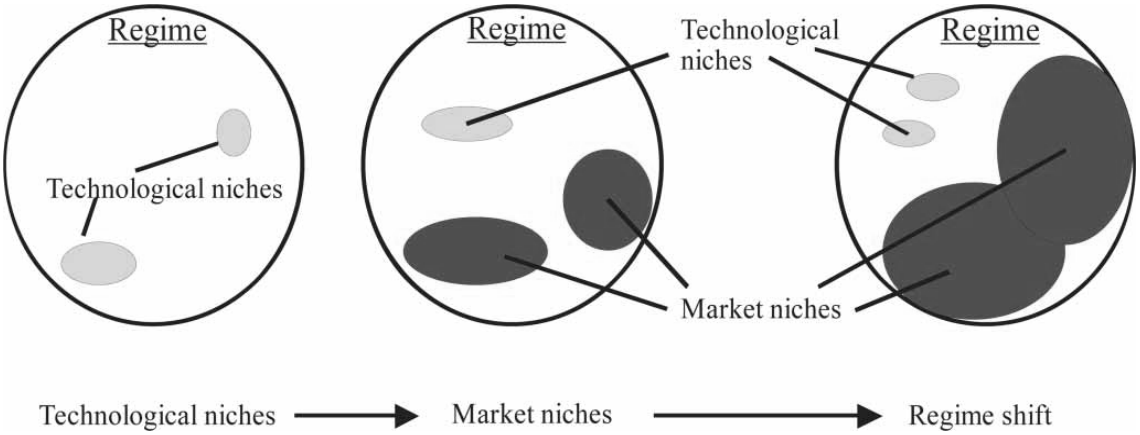


Figure 2: *Regime shifts from niche development (Schot & Geels 2008, 540)*

The regime is challenged as (1) technology matures in some closed technological niches (2) these technical solutions addresses a limited market need (3) and through the growth of the markets the technologies further matures and win wider acceptance in the entire regime.
An important premise for the development and maturation of ideas in the form of niches are learning processes and the building of social networks that support new innovations and investments (Schot et al 1994, Kemp et al 1998 & 2001 and Hoogma et al 2002). The development of niches through these activities is achieved through ongoing project-based learning processes which over time provides a certain direction / rationality as outlined in the following figure.

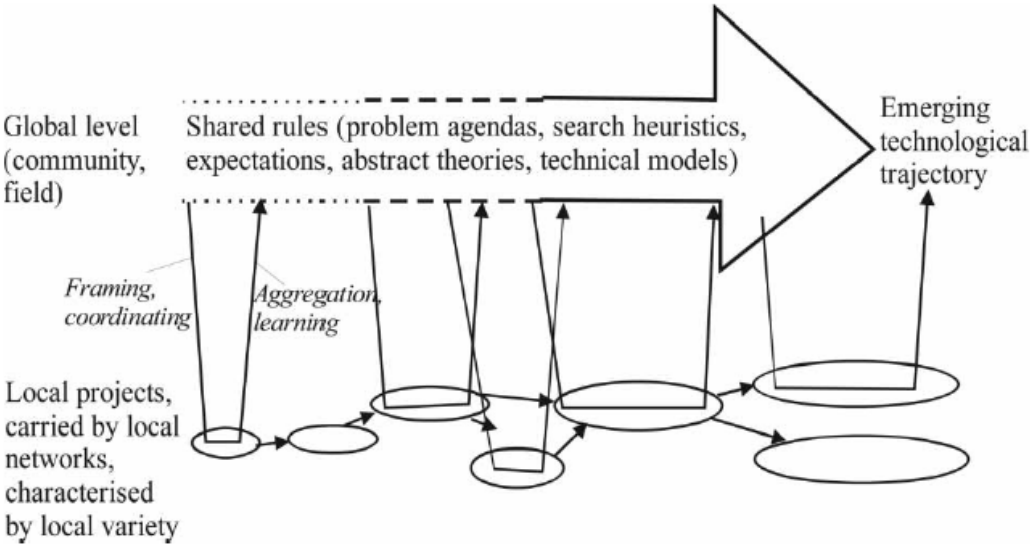


Figure 1: *Niche learning processes (Schot & Geels 2008, p. 544)*

It is precisely this common sense making which integrates the niches and develop its own sense of identity - a rationality that legitimizes the stakeholders' actions even though they may be in opposition to the dominant regime. Jensen et al (forthcoming) explain the rationality based on three mutually constitutive concepts an interpretive resource, a sector representation and a strategic orientation. Thus, they want to explain how a "tool" (the interpretive resource), forms a certain image of the existing regime (sector representation) and develops corresponding practices (strategic orientation). Rationality in the niche can thus

be explained by using a key metaphor in which a set of problems (the sectorial representation) can be unlocked with a corresponding solution (strategic orientation) by the key (the interpretive resource).

METHOD

Based on the theoretical concept, the collection of empirical material for analysing the innovation system draws on multiple sources like qualitative workshops, semistructured interviews, existing analysis and analysis of central texts.

The analysis of the existing regime draws upon a Foucauldian analysis of the development of the Danish construction industry (Gottlieb 2010) combined with an analysis of the past 25 years of development of construction based on the driving myths of construction (Thuesen et al 2009). This is supplemented by the IT element, based on Berard (2006) and Jensen (2011).

The three analysed niches in Thuesen et al (2011) have been selected from an initial larger sample of 'candidates' according to their innovation potential and the main drivers of the development being either the governmental or sectorial driven. The niches are the concepts around Lean Construction (Last Planner System LPS), BIM (Building Information Modelling) as a part of a general digitalization of the Danish construction industry and an emerging niche around new industrialization termed "system deliverances". The empirical material for analysing the niches consists of two qualitative workshops, eight qualitative interviews combined the central texts and theories of the niches. The material was collected in the period from the autumn of 2009 to the spring of 2010 starting with execution of the two workshops in communities around the niches followed by semi-structured interviews (Kvale, 1996) of persons in playing different roles the niche development. By asking the persons similar and different question based on their role it was subsequently possible to identify coherency and differences in their understanding of the niche and its relation to other niches and the existing regime. The material from Thuesen et al (2011) is supplemented by material on BIM from Berard (2006) and Jensen (2011).

ANALYSIS

The analysis of the innovation system is structured in three sections, firstly focusing on establishing an understanding of the predominant regime, secondly juxtaposes the three niches and finally analyzing the niches up against the existing regime.

The construction regime - developed through generations

The existing regime is developed through generations in a process characterised by periods of more and less stability and moments of radical changes in the construction practices. Although the moments of change encapsulates periods of fundamental different construction practices as between the premodern (-1945), modern (1960-70) and postmodern (1980-) construction the historical practices are to some extent sedimented in the present postmodern construction practices. Based on a historical analysis (Gottlieb 2010) the postmodern construction regime is identified as having the following characteristics according to the theoretical dimensions Technology, Industry, Market /customers, Policy, Culture, Education and research.

Dimension	Characteristics
Technology	Building materials: many different materials are in play all though there has been a preference around concrete elements since the introduction in the 60'ties. Processes: Phase models, in-situ production, planning tools based on Critical Path Method (CPM) wide spread, but "islanded" use of information technology, project management as the predominant management philosophy.
Industry	The organization of the industry is characterized by strong interest organizations representing many different professions like crafts, engineers, architects, contractors, and material producers. The value-chain is fragmented with a strong separation of design and production.
Market and customers	The market is heterogeneous and characterized by fluctuation. The customers are addressed by the architects, who tailor unique projects specifically to the customers' individual needs.
Policy	The sector is regulated around competitive bidding, tendering systems, shared standards and general conditions for work and supply. The development of the regulation happens in close collaboration between the interests organizations and the governmental anchoring (Danish Enterprise and Construction Authority, EBST), but also increasing EU.
Culture	The cultural organization of the industry is based on professions which are sustaining craft differentiated education institutions with a strong element of apprenticeship learning processes. The building organization has over time developed a strong separation between design and production favouring the development of cultures around problem solving. The institutional learning processes have the past 30 years, been centred on the myth about the unique building, make the actors perceive the nature of the build process as complex or even chaotic. Final there is a strong focus on collaboration rethorics among actors in the future development of the industry.
R&D	The organization and division of labour is mirrored and reproduced by the educational system. This system spans a wide way of cultural knowledge's from tacit and embodied situated in crafts to explicit and scientific in the academic professions. The central management practice is Project management, which is inscribed in the educational system and is influencing the research agendas.

Table 1: *overview of the building regime*

The regime is situated within a broader societal context which challenges it and creates new possibilities of innovation. Trends like globalization, climate change, an aging population, new technological breakthroughs partly destabilize the regime making it vulnerable to niche innovations and other dynamics. When this happens it can be understood as windows of opportunities for change of the existing regime.

Niches represent different sources of innovation

This window of opportunity might be addressed by different niches. We will here look closer to the niches around the Lean Construction, BIM and System deliveries illustrated in the following figures.

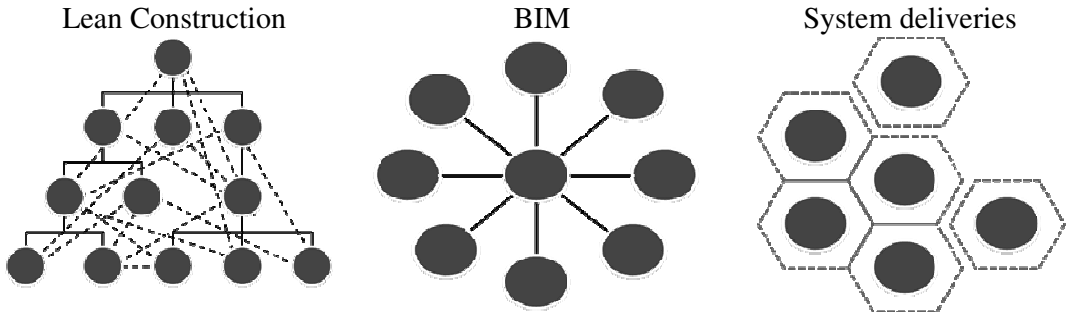


Figure 4: *Illustration of niches*

While the niches all try to address the regime, they represent different logics for building developments that are more or less compatible. The table below summarizes some of the key differences in rationality between the three niches.

	Lean Construction	**BIM**	**System deliveries**
Key (Logic)	Process planning tools around LPS	The object oriented 3D model / BIM	Mass-customization
Understanding of the existing regime (Sectorial representation)	The complex and chaotic building process makes long-term planning impossible.	The construction industry as a series of inconsistent and uncoordinated information flows	The construction industry as an under-modularized mode of production characterized by project-specific problem solving and short term collaboration, which hinders innovation and specialization
Solution (Strategic orientation)	Development of tools and processes for optimizing value and flow based on short term planning and involvement of crafts	The development of a shared object-oriented classification and information infrastructure able to ensure unequivocal information capable to coordinate the complexity of the construction process	Project independent design and production of modular and customizable products and services through product platforms, strategy partnerships and value-chain integration

Table 2: *Different rationalities of the niches*

The three niches perceive the existing regime from various perspectives and are consequently formulating different problems and solutions. In LC is the building process considered as complex and even chaotic, which prevents long-term planning. As a result is LC developing tools and processes for optimizing value and flow based on short term planning and involvement of crafts symbolised in the Last Planner ´System LPS. The perspectives offered by the BIM and System deliveries niche is different as they claim that the building process can be tamed and standardized so that information flows and processes can be coordinated. System deliveries also notes that the short-term collaborative constellations often prevents the development of the industry, and thus seeks to create a better process understanding across the actors enabling value-chain integration. As the different niches don't have identical

understandings of the regime their diagnosis of the regimes problems are different. Their different diagnoses and keys (logics) also allow different strategic development directions. While LC is trying to handle the complexity of the building process through short-term planning, the BIM concept is trying to manage complexity through common systems and standards for information exchange (interoperability) and final are System Deliveries strategy to reduce complexity through modularization.

While the niches have different rationalities, they are also major differences in terms of radicalism. While Lean Construction tries to change the regime from within reproducing the existing building practices (*reproduction*) system deliverances fundamentally tries to reorganize the regime from outside (*transition*). In between these BIM is trying to digitalize the existing regime while not fundamentally changing the organisation of the industry (*transformation*). The niches are thus having different innovation potential as summarized in the following table

	Lean Construction	**BIM**	**System deliveries**
Potential	Can strengthen the effectiveness and value-creation within the existing regime Short ROI – can be implemented at project level	Enables a more efficient exchange of information between building partners. Enables a greater complexity in construction	Addresses productivity challenge Delivers product of high quality, faster and cheaper
Barriers	Can't facilitate cross-project optimization – pursuing economy of scale. Requires change a in cultures	Hard to get all parties to agree => implementation is difficult. Can't optimize across the value chain – pursuing economy of scale. Long ROI	Long ROI Can't be realized at the project level, but requires a market of a certain size and extensive knowledge of customer needs Requires reorganization of the division of labour in regime.

Table 3: *Barriers and potentials of the niches*

The conflicting rationalities among the niches internally and towards the regime put emphasis on strategy development in the companies. Thus is it important to develop strategies which will be able to handle these differences and navigating in the innovation system.

DISCUSSION: COMPANIES A INNOVATION DRIVERS

Companies present innovation practices

Thuesen, Koch and Nielsen (2010) show how SME's is navigating in the innovation system today. They identify that companies have a reactive practice towards development, where companies try to follow the development in the market rather than shaping their own market in strategy processes which are characterized by being unstructured, undocumented and non-reflexive.

The table below compares the results from Thuesen, Koch and Nielsen (2010) with a similar study of SME in the general industry (DI 2011), showing that strategy processes among construction firms are not nearly as formalized and deliberate as in the industry.

Companies with …	Industry companies	Construction companies
no strategy	19%	39%
a strategy	81%	61%
a strategy which is implemented	27%	17%

Table 4: *Differences between industrial and construction companies' business development processes*

The non-reflexive strategy combined with the fact that the input to the strategy direction does not differ significantly from competitors' input makes the companies move in the same direction as the competitors. Consequently will they reproduce the existing division of labour in the industry.

This development has resulted in that most businesses operate from a Cost+ model, making the companies compete on their overhead rather than their core processes (Nicolini et al 2001). In this sense the market place is characterised as a typical red ocean environment, where the companies in the absence of core competencies compete on their overhead rather than their ability to reduce production cost and create value – as described by Kim and Mauborgne (2004, 81):

Red ocean strategy	Blue ocean strategy
Compete in existing market space	Create uncontested market space
Beat the competition	Make the competition irrelevant
Exploit existing demand	Create and capture new demand
Make the value/cost trade-off	Break the value/cost trade-off
Align the whole system of a company's activities with its strategic choice of differentiation or low cost	Align the whole system of a company's activities in pursuit of differentiation and low cost

Table 5: *Characteristic of red and blue oceans*

Companies as innovation drivers – combining markets and competences

Thuesen, Koch and Nielsen (2010) stress that although the red ocean market puts pressure on margins in each company making them struggle for survival it also represents an opportunity for creating an uncontested market space pursuing a blue ocean strategy.

A premise for the development of a blue sea strategy, however, requires a conscious approach for business development. This is supported by the DI study which identifies that 48% of companies that have a formulated strategy expect growth in the coming years, while only 12% of those who do not have a strategy expect growth (DI 2011, p 3). So there is a connection between conscious business development and growth.

By upgrading business development skills of managers of construction companies, while at the same time providing them with an overview of the socitial challenges which should be addressed and what potential tools and competences they can apply, we could potential realize an untapped potential for innovation in the industry's.

One of the classical approaches to strategy development is how company can combine competences and markets. The following figure, which is inspired by Ansoff growth matrix (Ansoff 1957), formulate strategy choices as a matter of combining new and existing competences and new / existing markets. In this way it can help to translate the concepts around niches and markets to the classic strategic tools.

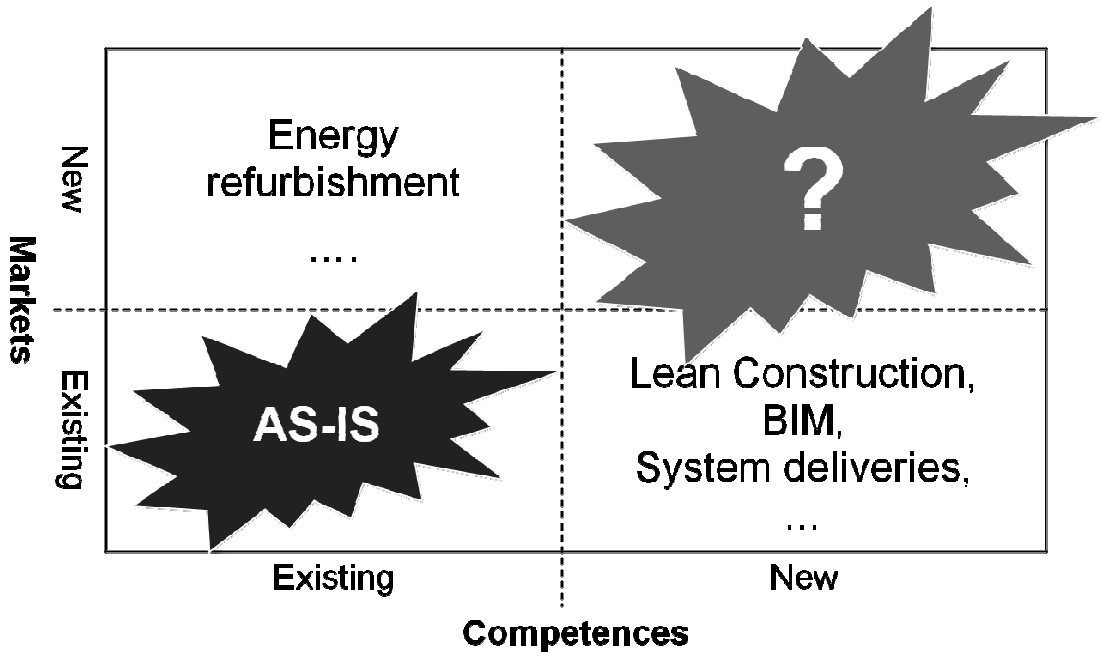


Figure 5: *Strategy as a combination of market and competences*

The companies which have to drive the innovation forward is neither large nor small, but a combination of different types and sizes, across sectors and roles. This means that companies do not have the same setup and hence not be able to make the same strategic choices. As an example it will be difficult for a small company to implement System deliveries because of the requirement to invested capital.

While the local strategic position of the company influences the possible strategic choices so do the internal compatibility of niches and markets. Not all the technologies/competences and markets that are well-matched. E.g. can the general market for energy renovations be addressed by System deliveries, LC and BIM, but if one have to build a one-of-a-.kind opera houses, system deliveries would not be as relevant as LC and BIM. Conversely, will a project of energy refurbishment of an opera house not be suitable for system deliveries. It may therefore be beneficial to help businesses to assess which technologies can be applied to which markets as outlined in the following table.

Market	**Energy refurbishment**								
Submarket/-complexity	**Dwellings**		**Apartment blocks**		**Offices**	**Simple**		**Complex**	
Size	Small	Large	Small	Large		Small	Large	Small	Large
Niches / competence									
Lean Construction	-	-	+	+	+	-	-	+	+
System deliveries (component)	-	+	-	+	+	-	+	-	+
System deliveries (concept)	+	+	+	+	-	+	+	-	-
BIM	-	+	+	+	+	-	+	+	+

Table 6: *Possible combinations of markets and competences*

The table shows the possible good and bad matches between technological niches and market niches exemplified by markets around the energy refurbishment. As an example will it not be very wise to renovate single-family homes based on LC, as these type of projects typically are small are therefore not sufficient large to bear the costs of implementing the LC on each project. Conversely, will it be obvious to address a big market around the renovation of single family houses with System deliveries (e.g. the ones build in the 60-70'ies) since the size of the market easily could cover the development costs across projects.

This analysis is of course a gross simplification, but is nevertheless trying to describe what constitutes good combinations. Therefore it may be appropriate to subdivide "niches" like it have been done around System deliveries since the applicability of these is very different if they focus on building components or concepts for entire buildings.

The flexibility in which companies can experiment with linking various technical competences with potential markets will ensure the testing of various combinations of markets and competencies. By the different strategic choices the companies will drive the innovation and since some combinations will be more successful than others the level of innovation in the industry can be strengthened.

Innovation map

In order to make the companies capable of navigating in the innovation system – their strategic direction can be supported by a map.

A central premise for the facilitation of innovation through in this perspective is the development of a "language" through which the industry can understand and articulate innovation and strategies. Here it is appropriate to draw on the theories presented in this paper. Through concepts as niches, regimes, etc. these theories offers a typology which can be ordered in a map. Such a map could provide an overview and orientation points for navigating in the innovation system. Moreover, the map could clarify the interfaces of key players such as the different interest organizations and governmental institutions. Consistency and transparency in the innovation activities can be developed internally among government agencies and between public and private players including construction companies.

By combining the past, present and possible futures in an innovation map, companies can orient and position themselves strategically and thus be the basis for the launching development initiatives in the individual company. By creating an overview of innovation in

the industry, companies can reflect on where they want to go. Will/can we focus on the short or long term? Will we take the risks needed to invest in System Deliveries or should we just choose to deploy LC ... or should not do anything. In this way, the map will be a tool for a more focused and deliberate business development where leaders do not just subscribe to every existing development agenda, but work with a limited, compatible and consistent number of elements ... in relation to the company's existing competencies, the industry's current regimen, technological niches and potential markets.

From a company perspective two elements are necessary in such a map – information about niches and markets.

The analysis of the niches can be inspired by the methodology one presented in this paper focusing on rationality and the potential and barriers with the niche. Furthermore can information about the niche relation to the existing regime, involved actors, possible networks and funding possibilities.
The analysis of the market can build on existing market analysis. These analyses which traditionally include quantification of existing markets could be expanded to include future niche markets. Furthermore could the analysis be added extra dimensions such as; sustainability impact, addressability, return on investment, market homogeneity. The figure below illustrates such a market analysis of the market for energy refurbishment of the existing building stock in Denmark (Thuesen 2011).

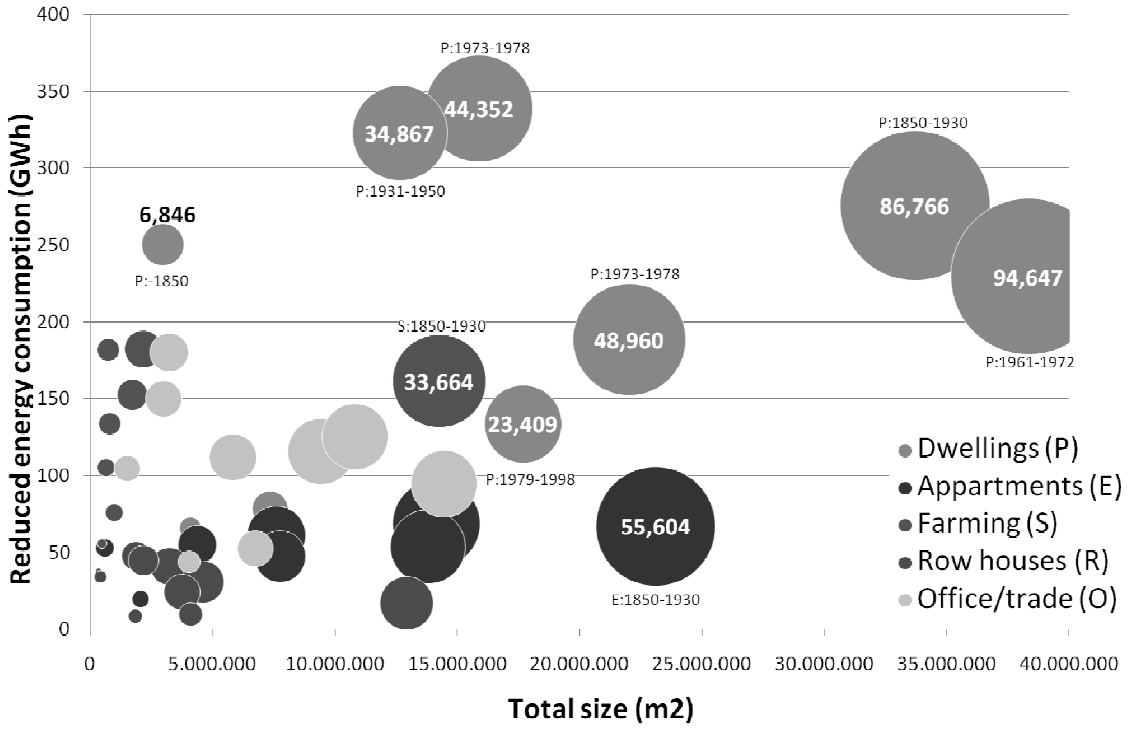


Figure 6: *Quantification of market for energy refurbishment of the existing building stock (the size of the circles represents the market size in Billion DKK)*

By adding different dimensions to the market analysis certain innovation agendas such as sustainability can be facilitated as it informs the company's strategic choices. In this way can the innovation map combined with aligned policy initiatives help to solve the challenge of

retrofitting the existing building stock and thereby enabling the development a low energy consuming society.

CONCLUSION

Based on the theoretical framework from strategic niche management research (SNM) the paper presents an analysis of three niches and a strategy for understanding and facilitating innovation activities in the sector by mapping the predominant regime, overall societal trends and different niches.

The analysis shows a multifaceted landscape of innovations around an existing regime, built in the existing ways of working and developed through generations. This regime is challenged from various niches and the socio-technical landscape through micro and macro trends. The detailed analysis of the three niches Lean Construction/Last Planner System, BIM, and System Deliveries, and their compatibility with the existing regime, show how they represent partly incompatible rationales and various degrees of innovation potential.

The conflicting rationalities among the niches internally and towards the regime put emphasis on reflexive strategy development in the companies. Thus is it important to develop strategies which will enable handling these differences in order to navigate in the innovation system.

By mapping some of the most influential trends and promising niche innovations and relate these to the existing paradigm, an innovation map can act as a medium in which policymakers, interest organization and companies can develop and coordinate future innovation activities.

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INNOVATION IN THE CONTEXT OF A DEVELOPING COUNTRY: A CASE OF GROUP HOUSING PROJECT

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Abstract

This paper presents a case of group housing project that was new of its kind implemented in the underdeveloped economy of Nepal. The concept of the project as a whole has been taken as a contextual innovation because of its newness and uniqueness in the context of the country at the time of implementation. This study presents a detail account of the project implementation emphasizing the challenges faced by the involved key parties. It provides important insight into the project which eventually proved to be a significant and successful initiating push in triggering a promising new real estate sector in the national economy. Qualitative approach was used for the research in which the main instrument for collecting primary data was face-to-face semi-structured interviews with the key people involved in the project. The findings have been presented in terms of the categories of challenges as the initial perceived constraints, management level challenges, and project level challenges.

Keywords: Innovation, group housing project, project implementation challenges, underdeveloped economy, Nepal.

BACKGROUND OF THE NEPALESE HOUSING SECTOR

General features of Nepalese housing sector in urban area can be explained on the basis of its specific socio-cultural, economic, regulatory and physical aspects. Nepalese society is a multi-racial, multi-lingual and class-wise stratified society (Nepal, 2006). It is traditionalistic and relatively collectivistic, tilted towards high masculinity, high power distance and short-term orientation, and it prefers uncertainty avoidance (Agrawal, 2001; Gautam et al., 2005). Descended from the traditional feudal or semi-feudal values, the land and housing is taken as a major asset and as the symbol of economic well-being, prestige and the power of a family (Mathema, 1999). Almost all of the Nepalese families are paternalistic joint families characterized by the eldest male member as the head of a family (Pant, 2004).

Besides direct purchasing, the ownership of the land and housing in Nepal is inherited from generation to generation in a family. In the Nepalese tradition of family succession, all the male offspring are entitled to the parental property including land and housing (Chapagain, 2001). As the family tree expands and as the joint family gets divided into several other related joint families, the family owned land and housing also gets divided and distributed as per the number of male members in the family.

Probably because of the traditional value system, Nepalese people have a deep rooted preference on building their own independent house in their own land with their own resources (Bhattarai, 2002; SAMN, 2005; Sherchan and Lamsal, 2005). Procuring a house is therefore a long process with the owner's self involvement in purchasing land, building house by own resources in various phases and then in providing infrastructure and utilities services later. Such housing system is termed as the Owner Builder System (NSP, 1996), in which self-financing mechanism is the predominant form of housing finance (Hada, 2001). As such, about 92% of Nepalese households own their housing units, 5% are renters (pay rent) and 2% live on rent-free housing units (CBS, 2004, Vol. 1, pp. 27).

As in other developing countries, there is high attraction differential – in terms of infrastructure facilities, job opportunities and securities – between the urban areas, especially the Nepalese capital Kathmandu, and the other parts of the country. Such differentials have created high immigrant pressure in the capital. About 40% of the population in Kathmandu is migrants from outside (Shrestha, 2004), and it has highly increased the demand and value of land and housing in Kathmandu. As such there is a high deficit in the supply of housing in the capital – for instance there was shortage of about 300,000 units of houses in 2000, and it was increasing at the rate of about 7% per year (Hada, 2001; Bhattarai, 2002).

On the regulatory front, there are separate Nepalese land and property laws that guide the regulatory policies pertaining to the land and housing. However, the government policy in the zoning and distribution of land is not strong and clear. Furthermore, the state administration of land and housing standards are relatively relaxed, and till now there is no public sector housing programs or comprehensive/consolidated land development schemes – except some recent and limited land pooling and development attempts in Kathmandu (Oli, 2003; Spotlight, 2003) – that have facilitated access to housing or land to any class of people, rich or poor (Mathema, 1999).

The socio-cultural, economic and regulatory aspects have significantly influenced the physical development pattern of land and housing in Kathmandu. The "sub-divide and inherit" practice in Nepalese family, the preference of own separate housing, the owner builder system, the high demand, value and consequent shortage of land and housing, and the weak regulatory system are some of the main reasons behind the typical fragmented land distribution and haphazard housing development pattern in Kathmandu. The tendency of haphazard housing pattern is remarkably severe in the high value urban center such as Kathmandu (Spotlight, 2003). Consequently the government has been unable to provide adequate infrastructural facilities to the haphazardly developed housings. Infrastructural facilities such as access roads, drinking water, electricity, sewerage and waste water drainage, arrangement for solid waste disposal, and open spaces have been increasingly becoming deficient for dwelling units (NSP, 1996; Spotlight, 2003). At the same time the quality of housing itself is also not satisfactory – only about 41% of housing in urban area are of permanent type, whereas the remaining housings are semi-permanent, temporary, traditional, and squatter types (NSP, 1996).

THE INNOVATION

The fragmented, haphazard, and low quality land and housing development pattern ingrained in the socio-cultural, economic and regulatory fabrics of Nepalese urban area has been a glaring example of the tragedy of the commons. There was an urgent need to reform the basic

concept of housing. However, changing the age old housing concept in the complex setting of urban area is a highly challenging task. In 1999, a Nepalese private business house came forward with a new idea of an organized group housing project in Kathmandu. The group housing project was a very important innovation in the whole concept of housing in Kathmandu (Humagain, 2001; SD, 2000). This significant housing concept innovation has been chosen for a detail case study in this research.

THE GROUP HOUSING PROJECT

The organized group housing project which is the first of its kind in Nepal was named as "Kathmandu Residency". It is basically an apartment-based housing project which is located at a suburb of Lalitpur District in Kathmandu valley. The project occupies about 1.76 acres (7125 square meters) of land in which a total of 145 apartment units were built. It is an integrated and self-contained residential complex which consists of a range of apartment types from studio apartment to one-bedroom, two-bedroom, and three-bedroom apartments with all the required amenities such as abundant water supply, sufficient electricity and power back-up, an efficient drainage system, private parking, 24-hour security, in-house club, crèche, convenient shopping and enough open spaces and greeneries. The total cost of the project was NRs. 300 million.

The Kathmandu Residency project was initiated by Chaudhary Group of Nepal in joint venture (JV) with Ansal Group Ltd. of India. Chaudhary Group is one of the big business houses of Nepal. The group is a conglomerate organization that accommodates more than 40 companies under its umbrella. Ansal Group Ltd. is one of the major Indian real estate and construction companies. The established JV Company was registered as Ansal Chaudhary Developers Pvt. Ltd. (ACDPL) in Nepal.

The ACDPL appointed a Nepalese local contractor company as the main contractor of the project. The local contractor company was a joint venture of three local contractors – M. B. Construction (an A-class contractor), Safal Builders (a B-class contractor), and R. M. Builders (a C-class contractor) – led by a Director of Safal Builders. The JV main contractor was selected by local tendering process and appointed on the basis of the cost plus fee contract. The ACDPL sought the function of construction from the market and appointed the main contractor. Another important function of architectural and engineering consultant was however internally arranged within the Ansal Group. The architectural and engineering consulting tasks of planning, designing, detailing and quantity survey of all the buildings and ancillaries of the apartment system were undertaken by the Ansal Group itself. All the designs, drawings and bill of quantities were supplied from the Ansal's office in New Delhi. Supervision of the construction works were jointly done by ACDPL.

The client JV together with a set of terms and conditions of the alliance. The Ansal Group and Chaudhary Group had 51% and 49% of shares in the JV respectively. On the other hand the main contractor JV was formed with the alliance of Safal Builders, M. B. Construction and R. M. Builders. These three local contractors formed their JV with a formal set of terms and conditions, and agreed to work together with their informal agreement.

The Chaudhary Group which initiated the project was the Origin Organization (OO) (Dulaimi et al., 2003) of the innovation. The other parties – the Ansal Group, M. B. Construction, Safal Builders, and R. M. Builders – were the main Supporting Organizations (SOs) (Figure 1).

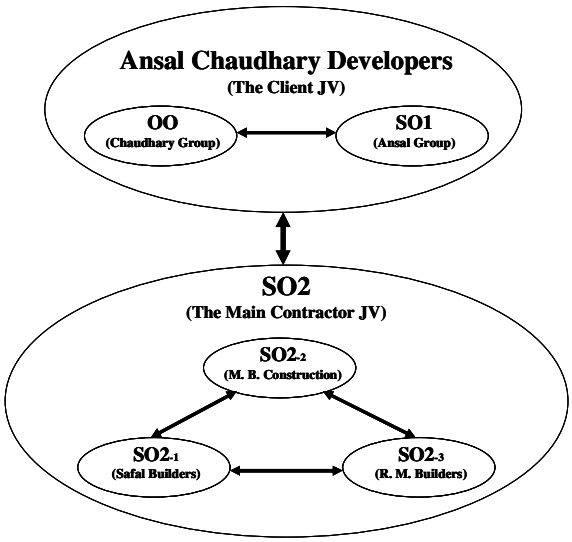


Figure 1. *The Key Parties in the Project*

IMPLEMENTATION OF THE PROJECT

Regulatory Backdrop

Before 1998 the Nepalese land and housing act was traditional one and it was primarily based on the individual or family ownership system. There was no national act that accommodates the concept of group housing. There was the law in vertical division system of land and houses, but there was no law that describes the horizontal division of land and houses. In 1994 a group of three local business houses came up with the idea of group housing in Kathmandu. The group was influential in the national politics and they were successful in raising the issue of group housing act in the parliament. However the process of formulating and enacting the new housing law took a long time, and it receded in the political turmoil of the country. Therefore the group had to abandon the group housing project they had conceptualized. They had even procured the land for the project, but they had to sell-off the land instead. The absence of the law and regulatory mechanisms led their innovative move into a failure.

Even though the first attempt was failed, it contributed in pushing and eventually producing the first laws and by-laws pertaining to group housing in Nepal. In 1997, Nepal Building By-Laws and Apartment Act were promulgated (NBBLAA, 1998).

Formation of the ACDPL

After the law was enacted, the Chaudhary Group moved its step towards the concept of group housing project in Nepal. The President of the Group set up a separate task group under him including the experts in group housing from India. The task group started its work with the feasibility study of the project. The local market study and economic analysis of the project was conducted. The group housing practices in other countries were also observed by visiting

some of the successful projects in India, Thailand, Malaysia and Singapore. At the same time the task group sought an experienced business partner to undertake the project. It contacted several Indian real estate companies, and eventually it was successful to form a partnership with the Ansal Group. The partnership was formed on both the financial and technical parts of the project, and it launched the ACDPL JV.

Initial Marketing

The initial concept and building designs were prepared at the design cell of the Ansal Group's Delhi office. Then the project was formally launched and publicized in the local media in 1998 as a new kind of housing system named Kathmandu Residency. As a part of the publicity, wooden show-piece mock-up apartment blocks were displayed for the marketing purpose. The initial marketing effort was successful in attracting the customers and they were willing to pay the booking advance which was 30% of the total cost of the proposed apartment unit. The ACDPL was successful in tapping a substantial amount of cash inflow from the booking advance.

Searching and Appointing a Main Contractor for Construction

After formally launching and publicizing the project, detail designs, drawings and bill of quantities (BOQ) were prepared in Delhi. As per the design and BOQ, a tender was called in Kathmandu to select a main contractor who would undertake the whole project package. The tender form was distributed only to selected 11 local contractors including a Chinese one. The tender amount was about NRs. 90.8 million. The tender was eventually awarded to a Nepalese local contractor joint venture team on the basis of negotiated lowest bid. It took about six month, since the first lot of customers made advance booking, to appoint the Nepalese local contractor joint venture team as the main contractor of the project.

Receiving the Construction Permit from the Lalitpur Municipality

After appointing the main contractor, the process of receiving the construction permit from the local Laltipur Municipality was initiated. The ACDPL involved the main contractor with its project personnel in dealing with the Municipality. As it was a new kind of project for the Municipality, it took about a year to study and grant the construction permission.

Construction and Handover of the Project

The construction of the project was started after the main contractor was assigned the job. As the Municipality took a long time to grant the construction permission, the construction was actually started before the permission was granted. The main contractor completed Block 1 to 8 within 18 months, Block 9 to 24 within 26 months, and the Block 29 to 32 within 29 months. The original schedule of the construction of the project was 24 month; however it was delayed for about 20 months. The remaining Blocks 25 to 28 and 33 to 36 were departmentally constructed by ACDPL specifically for the Chaudhary Group employees.

As the apartment units were completed with finishing, they were handed over to the customers who booked them. The occupying process of the booked and completed apartment units, and the construction of the remaining blocks went side by side. All the apartment units were fully occupied after six month of completion of the whole apartment system.

CHALLENGES FACED BY THE KEY PARTIES IN THE PROJECT

Initial Perceived Constraints

Chaudhary Group: As the OO of the innovation, the Group had to face several constraints before initiating the group housing concept. The constraints can broadly be explained in terms of the socio-cultural, economic, regulatory and physical aspects of urban housing in the Nepalese context.

The deep rooted preference of Nepalese people in building their own independent house in their own land with their own resources was a major perceived socio-cultural constraint in initiating the group housing concept in which people had to appreciate a different type of housing ownership system. The ownership of a space rather than a distinct piece of land and house, overlap in the private and common property, and the occupants' mandatory responsibilities on the common facilities management in the apartment system were some of the challenging aspects to be introduced in the traditional Nepalese society. Moreover, the psychological preference on the "self-built quality" may not readily appreciate the "quality built by others". Therefore the lack of trust of general Nepalese on the quality and reliability of a ready-made house was a potential constraint.

One of the underlying reasons of the preference on the Owner Builder System is the economic constraints in affording the cost of the whole house within one stretch of construction time. Building a house phase by phase as per the availability of money is a very common practice among general Nepalese. Because of such practice, owner has to directly get involved in building a house. In such economic setting, the low affordability of the Nepalese family was also an important perceived constraint in selling the ready-made apartment units at a full cost.

On the regulatory front, although the government had enacted the new housing act, it might not be complete and reliable as it was the first such act in the country. The government has a poor track record of drafting and implementing laws to cover new and potentially growing industries. Therefore the reliability and completeness of the government regulatory mechanism was also a potential constraint.

Physical infrastructure facilities – particularly water supply, sewerage and waste water drainage, and solid waste disposal – to be provided by the government might not be sufficient and reliable for the mass housing system. Moreover the narrow access road and the surroundings of haphazardly developed lands and housings around the project land might undermine the very concept of organized settings of the project.

Besides the above constraints, the unstable national political situation was a concern for all including the Chaudhary Group. The fluid political situation could disturb the project execution process and the confidence in the private sector investment.

Despite the constraints, there were some opportunities for the group housing project particularly in Kathmandu. At the socio-cultural front, there were certain segments of the society which prefer living in organized houses rather than the unplanned settlement in the city. Especially the modern and working families who do not have time to get involved in

building their own houses would prefer the ready-made ones instead. Economically such families can afford the apartment housing, or otherwise there was a high possibility that the local banks would come up with the provision of housing loans. As there was a high deficit in the supply of housing in Kathmandu valley, the housing and real estate market and thus its financing arrangement would shoot up once the organized development is triggered.

For the Chaudhary Group the prospect of housing market in Kathmandu was attractive amidst the inherent risks in the constraints. As the Group has a very strong corporate set-up in the country, it could manage the regulatory and physical constraints for the project.

Besides the above external constraints, the Chaudhary Group also had an internal constraint in the lack of core competency in the new business area of housing and real estate. In order to overcome this internal constraint, there was a way for the Group in seeking a partnership with a foreign JV partner who would be competent in the housing and real estate business.

Therefore with the market prospect and the possibility in acquiring the core business competency from a foreign JV partner, the Chaudhary Group considered that a medium size hosing project would help fulfill their expected goals amidst the inherent risks in the constraints.

Ansal Group: In the proposed housing project, the Ansal Group had to share the same socio-cultural, economic, regulatory and physical constraints as the Chaudhary Group. Moreover the Ansal Group also needed to bear the risks in a foreign country such as local political, regulatory and social risks. However, the Ansal Group trusted the Chaudhary Group as a "reliable and resourceful" partner to share the risks in a foreign country's new market. Therefore, with the perception of manageable constraints, the Ansal Group expected that its goal/s would be fulfilled with the project.

M. B. Construction, Safal Builders, and R. M. Builders: These three local contractors had the constraints of lack of technical and managerial capabilities in carrying out the relatively large size local project individually. Even though it was an A-class contractor, M. B. Construction could not bid for the project individually because during the tendering time its resources were diverted in one of its other projects for a long time. The contractor could not manage necessary resources to participate in the project individually. Safal Builders and R. M. Builders as B and C class contractors could not participate in the project individually. It is because according to the Nepalese Construction Enterprises Act 1998, the permissible range of bidding amount for class D construction firms was up to NRs. 3 million, for class C from NRs. 2 to 10 million, for class B from 6 to 30 million, and for class A any amount exceeding NRs. 20 million (CEA, 1998). However, when they together formed a JV company, they could bid for the project and eventually they were successful in winning the tender of the project.

Management Level Challenges

Receiving the Construction Permission from the Lalitpur Municipality : The management of the ACDPL had to deal with the hurdles in receiving the construction permit from the Lalitpur Municipality, and it was a significant management level challenge for both the Ansal and Chaudhary Groups as well as for the main contractor JV.

As the project was the first of its kind for the Municipality, it had to study and work in detail on the project before granting the permit. The Municipality officials were adept in dealing with small scale individual houses, whereas it was a considerable task for them to scrutinize the larger project. The project had the built-up area of about 17,150 square meters with a larger requirement of infrastructure facilities. The project land was surrounded by about 285 numbers of neighbors. The Municipality had to inform and receive the "no objection" papers from all the surrounding neighbors. The public around the project site generally become sensitive when there is news of a large project at their place. It took time to convince the general public and it was quite a clumsy task to do so in the local context in Kathmandu.

Another site specific issue in the project was the high tension 64KVA electrical transmission line across the project land. The apartment blocks were designed with 6 feet clearance from the transmission line whereas it should be at least 27 feet by rule. This critical issue also delayed the Municipality process.

In order to avoid the delay in the project due to the Municipality hurdles, the ACDPL along with the leader of the JV main contractor lobbied directly to the Mayor. After much deliberation they were successful in creating a special understanding with the Mayor, with which the project team started the construction work before receiving the formal permission. The Mayor had to put a special effort in convincing its Municipality staff, Local Town Development office, and the surrounding neighbours for starting the construction at the project site. After a year of starting the construction, the ACDPL was eventually successful in receiving the permission from the Municipality.

Project Level Challenges

After the construction was started, a series of challenges cropped-up in the project. All the parties in the ACDPL JV and in the main contractor JV had to face the project level challenges, some of which were critical for them.

The Main Contractor's Cash-Flow Crunch: One of the critical challenges for the main contractor was the management of cash flow for the project. The local Nepalese contractors have very limited financial capability to participate in a large project. A reason behind the formation of the JV between the three contractors was to formally show that they were financially, technically, and experientially capable to undertake the project. However, among the three parties, there was an informal understanding that the Safal Builders would bear the major financial obligations for the project and the remaining two would provide other necessary input when-and-where they could. The team leader of the JV from the Safal Builders provided the 3% (NRs. 2.7 million) of the total contract amount (NRs. 90.8 million) performance bond bank guarantee from his side.

The construction was started with NRs. 2 million mobilization advance from the ACDPL. However, the main contractor team leader claimed that because of the ACDPL's process of running bills payment, it was very difficult to manage the cash flow in the project. The total payment in each monthly running bill would be divided into two parts in the proportion of 75% and 25%. The Kathmandu ACDPL office would release the payment that amount to 75% of the running bill within 21 days of submission. For the remaining 25%, approval had to be granted by the Ansal Group's Delhi office and it would again be cleared only after 21 days of submission. The main contractor team leader claimed that according to the agreement, the 75% amount should have been released within 7 days – but it was never done

so. The remaining 25% was also delayed for 3 to 4 months. Each running bill would amount to NRs. 2.5 to 4.0 million, and because of the payment delays, it was extremely difficult to manage the cash flow.

The main contractor's shortage of the cash flow created ripples effects in terms of the delay in payments for the labor gangs and the material suppliers. It also dissatisfied the M. B. Construction and the R. M. Builders as they could not get timely return on their resources and efforts in the project.

Exacerbating Political Turmoil in the Country : The cash flow delay with the main contractor was further exacerbated by the political unrest in the country. The infamous Royal Palace massacre took place within the first fourteen months of the construction period. The transportation of materials and labor from one part of the country to the other part used to remain frequently blocked for days because of the political turmoil during the construction period of the project. The shortage of labor and materials delayed the work of the main contractor. It generated stress in the project schedule and lessened the amount of the running bill. It also generated confusion and disappointment at the ACDPL side, and subsequently it further delayed the main contractor's payments.

Error in Quantity Estimate: While the infighting for the cash flow started between the main contractor and the ACDPL, the former party found a serious error in the quantity estimate of the Rebar (Reinforcement Steel Bar). The error was made by the quantity surveyors (QS) at the Ansal Group's consulting cell in Delhi office. The total quantity of Rebar in the contract package was 327 MT (Metric Tonne) whereas the actual requirement was 612 MT. The error in the BOQ (bill of quantity) of Rebar was suspected at the eighth month of construction time because the consumption at that time was 150 MT, much more than expected. The main contractor raised this issue to the ACDPL, and it conveyed the information to Delhi office. It took time to convince the Kathmandu ACDPL team, to convey the information to Delhi, to be checked and confirmed the error in the BOQ by the QS in Delhi, and to get approval in the revised BOQ. The Ansal Group's QS approved for 572 MT whereas the main contractor calculated 612 MT. The deficit of 40 MT was later compensated by the ACDPL. The error and delay in the amendment of the significant Rebar quantity estimate generated confusion and dispute between the ACDPL and the main contractor.

Price Escalation and Adjustment in the Contract Amount: The uneasy situation created by the major amendment in the Rebar quantity was worsened by the price escalation in Rebar itself. During the verification and approval process on the Rebar quantity in the Delhi office, the price of the Rebar increased from NRs. 21 to NRs. 27 per Kg. The price escalation in Rebar and other materials along with some variations in the building designs were expected to increase NRs. 20 million (nearly 22%) in the cost of the project. Due to the probable project cost increment, the ACDPL wanted to save money in terms of the contract tax and the VAT (value-added tax) by curtailing the total contract amount up to NRs. 60 million. The ongoing disputes with the main contractor also supported the case for the curtailment in the contract amount. Therefore the ACDPL decided to limit the taxable formal contract amount up to NRs. 60 million and for the remaining works it decided to execute them under departmental works which was not taxable. With this arrangement the ACDPL could save 1.5% of contract tax and 10% of VAT for any works beyond the formal NRs. 60 million works.

The Main Contractor's Grievances: Under the curtailed contractual arrangement, the main contractor could only complete up to the structural works of the Blocks 1 to 8, 9 to 24 and 29

to 32. All the other Blocks and the finishing works were undertaken departmentally by ACDPL. The curtailed contractual arrangement was not only a major set back for the main contractor in getting expected return out of the project, it was also a basis for the ACDPL to hold the performance bond along with the latest running bill payments. Because of the adverse situation, the JV team of the main contractor got separated well before the new contractual arrangement was enforced. The ACDPL however retained the team leader from Safal Builders to manage the labor and material supply as an internal employee for the work beyond NRs. 60 million. The team leader agreed to work because he had to recover his investment on the project.

Turmoil in the ACDPL's Project Team: The ACDPL's project implementation team was assigned the task of coordinating and monitoring all the activities of the project so that they could be executed within the stipulated time and cost with the specified quality level. It was quite challenging for the project team to coordinate and monitor the activities amidst the main contractor's cash flow problem, the political disturbances, the error in quantity estimate and the material price escalation. There were frequent schedule slippages and the project team could not directly blame the main contractor and impose penalty to keep him in track. There were factors that were beyond the control of the main contractor, and he would direct his frustration towards the ACDPL management. On the other hand the ACDPL management team would pressurize the project team to keep the work in order. The management team would want to control the main contractor blaming on its ineffectiveness. In such situation, the project team was sandwiched between the main contractor and the ACDPL management. Because of the intense pressure, the key project leaders had to quit the project – they could not be committed with the unfavorable results. There were changes of at least three technical vice-presidents (project team leaders) and three senior managers in the project team. The main contractor therefore had to deal with the new and learning project leaders, and it created considerable impact in the schedule of the project. Moreover, at the end of the project, there was no project team leader to settle the final bill of the contractor. It was settled only after one and half years of completion of the project.

SUCCESS OR FAILURE OF THE INNOVATIVE PROJECT?

The first group housing project in Nepal was in general completed successfully and eventually satisfactorily handed over to the customers. The construction period, however was highly turbulent with about 85% time delay and some cost overruns. Despite the delay, as the finishing works of the completed apartment structure was carried out in parallel with the construction of remaining blocks, ACDPL could hand over the successively finished apartment units to the customers. The whole apartment system was fully occupied within the six month of completion of all the works. The success, however, has to be interpreted from the view points of the involved parties.

M. B. Construction, Safal Builders, and R. M. Builders: For the three local contractors, the project was not a successful undertaking as they could not satisfactorily achieve their expected goals out of the project. They could not complete the project as they were assigned in the initial contract. Even on the part of their work, that is under the "with material" contract sub-package, there was about five month delay. Moreover because of their interaction, especially at the implementation stage, they were not successful in establishing a good business relationship with the client. Financially they were unsuccessful in making profit out of the project. All of the three contractors had to bear a considerable financial loss

in the project. After the project experience, all the three parties were not willing to work together again in the future. However, in terms of track record, all the three parties were successful in adding the project in their respective company profiles. Because of their experience in the first group housing project, they were able to secure jobs in other housing projects which were launched by other parties after the success of the Kathmandu Residency project.

Chaudhary Group and Ansal Group: With the completion of the project, the Chaudhary and Ansal Groups were successful in establishing the ACDPL as their pioneering housing and real estate company in the country. Although the client JV had to bear a total of two year delay in the project and consequently they had to face some unsatisfied customers, the eventual success was well publicized in the media. The client JV was successful in imparting the impression on the general public that the project was a breakthrough in the Nepalese housing sector. The project was actually successful in crossing all the perceived socio-cultural, economic, regulatory and physical constraints in the housing sector of the country. After the completion of the project there was a phenomenal growth in the private sector housing in Kathmandu and beyond. There were about twenty major registered private housing companies as of June 2005 that were supported by about 14 banks and financial institutions in Kathmandu (SAMN, 2005). It was estimated that there were about 1820 housing units completed or under construction by June 2005 (Sherchan and Lamsal, 2005). It was further developed and got established as a well organised and growing real estate sector contributing significantly to the national economy (Rajbhandary, 2011).

The Chaudhary Group was therefore highly successful in establishing a promising new housing and real estate portfolio in its corporate house. At the social front the Group showed that the organized group housing concept is possible to be implemented in the traditional Nepalese society, which could be taken as a starting point to show that the haphazard urbanization process in Kathmandu can be controlled to some extent with such housing concept.

The Ansal Group was also successful in starting its business expansion in Nepal. Both the Chaudhary and Ansal Groups were successful in making good profit out of the project. They were successful in harnessing good cash flow from the booking advance. After a couple of month of launching the Kathmandu Residency project, the ACDPL procured another plot of land for their second housing project using the cash collected from their former project. They were again successful in collecting booking advance from the proposed second phase project. Virtually they did not need to make any substantial separate financial investment from their sides. As soon as the construction of Kathmandu Residency project was completed, construction of the second phase was started on the basis of labor contract. ACDPL did not hire any external contractor but undertook the second phase under their own management. At that stage the Ansal Group wanted to further move with a third phase immediately. However, the Chaudhary Group opted not to move so aggressively. As there were risks such as the construction delay that was experienced in the first project, accumulation of new projects would add on more risks. If ACDPL could not manage the risks it would directly impart negative impression in the market. As the Chaudhary Group had to operate in Nepal with its other businesses, it was sensitive in its reputation in the country. Therefore the Chaudhary Group wanted to move bit slowly. The Ansal Group on the other hand was working in the huge Indian real estate market and it wanted to increase its scale of operation in Nepal also. Probably the company wanted to get benefit of the economies of scale with the rapid expansion of the business. The two groups however could not agree with each other in this

issue of slow or rapid business move. The common expected goal of both the parties was to expand their real estate business. However, they could not agree on the way to achieve the goal. With this basic difference in the respective expected goals, the two parties went through a conflictive situation. As no significant concession was offered from both the sides, the result of the dealing was finally perceived unfavorable. Therefore they decided to terminate the JV and the Ansal Group left the on-going second phase project. Then the on-going project was fully undertaken by the Chaudhary Group under its company's name. As per its policy, it started the third phase only after completing the second phase.

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A CRITIQUE OF INTEGRATED WORKING AND PARTNERING

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Abstract

Many authorities have supported the concept of integrated working or partnering. They claim a number of advantages of partnering such as greater co-operation, cost savings, timely completion of projects and improved quality but there remain a number of difficulties both at a theoretical and practical level. These difficulties manifest themselves in the views expressed by some specialist contractors, whose voice is all too often overlooked.

A number of issues can be seen in the responses of specialist contractors to questions put to them in the quarterly survey of the National Specialist Contractors Council. These include measures of interim payment periods, tender prices, suppliers' prices, profit margins, contractual behaviour, methods of appointing specialist contractors and the time allowed to price a proposal. These measures can be compared to the state of specialist contractors' markets to reveal the underlying causes of main contractor behaviour and treatment of their subcontractors. For example, market constraints in times of economic difficulties may indeed directly affect such behaviour. If the gains and benefits of partnering were truly shared between all parties, then it is significant to note the views of specialist contractors and the fact that the difficulties they face in dealing with main contractors have not diminished over time.

Key words: Specialist contractors, supply chain management, integrated project teams and partnering

INTRODUCTION

Following the serious construction recession of the early nineties and before the subsequent period of sustained growth until 2008 a period of introspection within the industry brought about many changes to practice in both procurement and delivery of construction projects. Many construction partners and indeed the associated education and training sector largely embraced the concept of integrated working and project partnering as one technique with the potential to improve the behaviour and hence the performance of an industry hitherto subject to accusations of an adversarial culture and under performance.

However, rather than a deliberate attempt by firms in the construction industry to improve their behaviour, Smyth (2002) posited that the adoption of partnering was essentially a

procurement issue driven by client demand in an attempt to avoid what in relationship marketing is called switching costs – that is, the costs involved in replacing one supplier with another.

Switching costs and client loyalty levels are discussed by Smyth, who nonetheless identifies the advantage of partnering as providing market stability. Even where switching costs are low advantages are identified for partnering. For example, partnering is seen as meeting client needs more directly, helping to build up construction business and continuous client relationships. However, low switching costs may also encourage clients to take advantage of the lowest cost bid and limit the adoption of partnering.

SUPPLY CHAIN MANAGEMENT AND INTEGRATED PROJECT TEAMS

A number of papers have looked at the relationship between main contractors and specialist contractors, including, for example, Winter and Preece (2002) and Van der Vaart and Van Donk (2004). While Van der Vaart and Van Donk looked at the main factors that shaped the level of integration of different supply chains or networks, Winter and Preece examined, main and specialist firms in both Germany and the UK, in an attempt to determine the nature of their relationship and the extent to which relationship marketing had extended down through the supply chain. They found that where main contractors considered that a partnering approach directly with clients was seen as improving overall business, it was never seen from the point of view of the supply chain. This relationship with suppliers was characterised by a traditional approach without any reference to the potential benefits of partnering.

Winter and Preece identified pressure on prices, lack of trust, poor communications, inadequate information and perceived poor service as impacting on the relationship between main contractors and their suppliers. Nevertheless, some main contractors had identified the advantages of dealing with the issue of main and sub contractor relations in order to improve the 'internal market' within the construction process.

Van der Vaart and Van Donk (2004) also considered supply chains, where cost was the main order-winner and make-to-stock production, where shared resources might be necessary to achieve a high utilization of the processes involved. They concluded that in construction a high level of integration is difficult to achieve and is not always necessary given the fact that cost is important and setting up a genuinely integrated process can be a costly exercise. In any case sufficient time may not always be available to achieve the desired ends.

Vrijhoef and Koskela (2000) also point to the shortcomings of the construction supply chain. They examined the management of the construction supply chain. Reviewing modes of project integration, they cited studies showing partial and superficial integration, (e.g. Bennett et al., 1996; Konchar and Sanvido, 1998), concluding that the benefits of design-build, for example, are minor. They found the presumption to have been that improvement of the organisational structure alone would suffice.

Instead they found the construction supply chain consisted of the following elements: a temporary, converging supply chain, producing one-off construction projects through repeated reconfiguration of project organisations. They defined the construction supply chain as one typified by instability, fragmentation, and especially by the separation between the design and construction, a typical make-to-order supply chain. However, for projects of a

particular kind, the process can be similar. The majority of the causes of waste and problems, according to Vrijhoef and Koskela, can be attributed to traditional management of the supply chain. They go on to propose a number of their own principles and methods in order to provide a solution.

A VIEW FROM THE SPECIALIST SECTOR

Setting aside the findings discussed above, the National Specialist Contractors Council (NSCC), being a federation of trade associations, publishes guidelines for its members, extolling the benefits of integrated working, a form of partnering, which is claimed to include better financial performance, a specialist input to design and planning, better problem solving, a fairer share of risk, the opportunity for repeat business and better payment terms. Further, the NSCC recommends the setting up of integrated project teams (IPT) as an organisation or a single team with common goals.

In turn, the NSCC is a member of the Strategic Forum for Construction, which also publishes its own toolkit guide (see Strategic Forum for Construction, 2011) to both integrated supply chains and IPTs with the aim of improving project delivery, profitability, reduced operating costs, more sustainable outcomes, predictability of programme, price and quality.

The Strategic Forum also offers guidance on IPTs with the aim of streamlining transactions and in particular developing closer relationships with subcontractors. The case is made for an holistic approach to projects and thereby establishing the organisational desirability of collaborative working from identifying the need for the project to ensuring all the value criteria are met with due acknowledgement of the process, culture, methods and tools required.

This supply side engagement with the concepts of integration has been matched by the demand side principally through the involvement of government, which is still the largest sponsor of construction activity. Thus, the Office of Government Commerce (2007), now part of the Efficiency and Reform Group, set out a suite of procurement guides reflecting developments in construction procurement over recent years, not least building on government clients' experience of implementing the Achieving Excellence in Construction initiative.

The 2012 Construction Commitments, (Strategic Forum, 2012) recommend procurement to require ethical sourcing, best value and the early involvement of the supply chain. It also recommends an integrated project team to work together in terms of design, buildability, environmental performance and sustainable development.

Specifically, it recommends all members of the construction team should be identified and involved at an early stage, particularly during the design process, and encouraged to work collaboratively. Supply chain partners are required to demonstrate their competency, commitment to integrated working, innovation, sustainability and to a culture of trust and transparency. To ensure effective and equitable cash flow for all those involved, all contracts should also incorporate fair payment practices, such as payment periods of 30 days, no unfair withholding of retentions, project bank accounts and mechanisms to encourage defects free construction.

In the private sector changes in practice have taken place more rapidly. For example, the adoption of integrated projects was most notably addressed by the British Airports Authority (BAA), who were reported in an article in Building (2006) to be launching a procurement strategy for the following 10 years, a policy however quickly reversed in 2008. According to Building (2008), by 2008 the approach had changed to one of finding deficiencies in the supply chain and cutting them out. A reference to the successful completion of Terminal 5 Heathrow was tempered by the view that it was one of the most expensive terminals ever built, delivered on budget, but the key point to note was how high that budget was.

Major influences on the further development of integration must include the impact of debt, both public and private, downward pressure on pricing, client behaviour and of course politics. Clearly, the practice of integrated working and partnering has some way to go to match the rhetoric of its proponents.

Evidence for the implementation of supply chain management and integrated project teams can be seen in the responses of the survey of specialist contractors over time. This survey is taken from the point of view of specialist contractors. If the culture of the construction industry had been changed by the introduction of the concepts of supply chain management and integrated project teams, then it could be expected to be reflected in changes in the NSCC survey.

METHOD

An important player during this period of industry review was the National Specialist Contractors Council (NSCC), which established a quarterly survey of its member firms in order to provide evidence for the Latham Report (Latham 1994) on the state of the industry. Conducted and written by an academic, the NSCC State of Trade Report has developed along with the shifting interests of member firms through the changes in the construction industry and the economic climate.

The NSCC mission is to represent the interests of trade organisations within the specialist and trade sector of the construction industry and it currently brings together the common aims of 32 specialist trade organisations, amounting to some 7,000 firms, within the construction industry. NSCC member organisations cover a wide spectrum of the sector and include for example:

- Association of Interior Specialists (AIS)
- Contract Flooring Association (CFA)
- Council for Aluminium in Building (CAB)
- Federation of Piling Specialists (FPS)
- Glass & Glazing Federation (GGF)
- Mastic Asphalt Council (MAC)
- National Access and Scaffolding Confederation (NASC)
- National Federation of Roofing Contractors (NFRC)
- Painting and Decorating Association (PDA)
- The Tile Association (TTA)

The NSCC is an authoritative voice of specialist contractors in the UK and is therefore used by a number of leading organisations including:

- Construction Skills Certification Scheme (CSCS)
- ConstructionSkills
- Cross-Industry Construction Apprenticeship Task Force (CCATF)
- Health and Safety Executive (HSE)
- The Joint Contracts Tribunal (JCT)
- Safety Schemes in Procurement (SSIP) Forum
- Strategic Forum for Construction.

Since the first quarter of 2010, NSCC has contributed its survey findings to the industry wide quarterly State of Trade report compiled by the Construction Products Association (CPA) thus ensuring that the specialist sector viewpoint is represented, not least at the government hosted Consultative Committee of Construction Industry Statistics (CCCIS).
The information gathered by the survey has been used extensively, for Ministerial briefings and to assist in campaigns to promote the interests of members. The most recent campaigns have involved briefings to government on retentions, the Better Payments Campaign and Supply Chain Integration for Specialists. Supply Chain Integration is the subject of this paper.

The survey is conducted on-line and respondents are invited to complete a questionnaire covering the following main areas of activity: enquiries, orders, labour availability and change, labour, capacity and workload, planning, price and margin analysis, procurement, payment periods, retentions, contract abuse, and adjudication. Members are also invited to comment freely on the issues most affecting their businesses.

The questionnaires are sent to approximately 700 firms, all member firms of NSCC affiliated trade associations, covering the whole range of specialist activities. The average response rate is approximately15%. This is a higher response rate than was achieved using the original postal survey, which had been conducted quarterly until 2007.

In line with similar surveys the responses indicate, where appropriate, the actual percentage of respondents reporting increases or decreases in particular variables. A 'balance' indicator gives the best single measure of trend. The balance is the difference between the percentage of respondents answering 'more' or 'increase' of a variable less the percentage answering 'less' or 'decrease'. For example, if 30% of respondents report 'increased orders', 20% 'no change' and 50% 'reduced orders', the balance is –20%. Generally, a positive balance implies that a variable has increased and a negative balance implies a decrease. Balances close to zero imply no significant change has occurred.

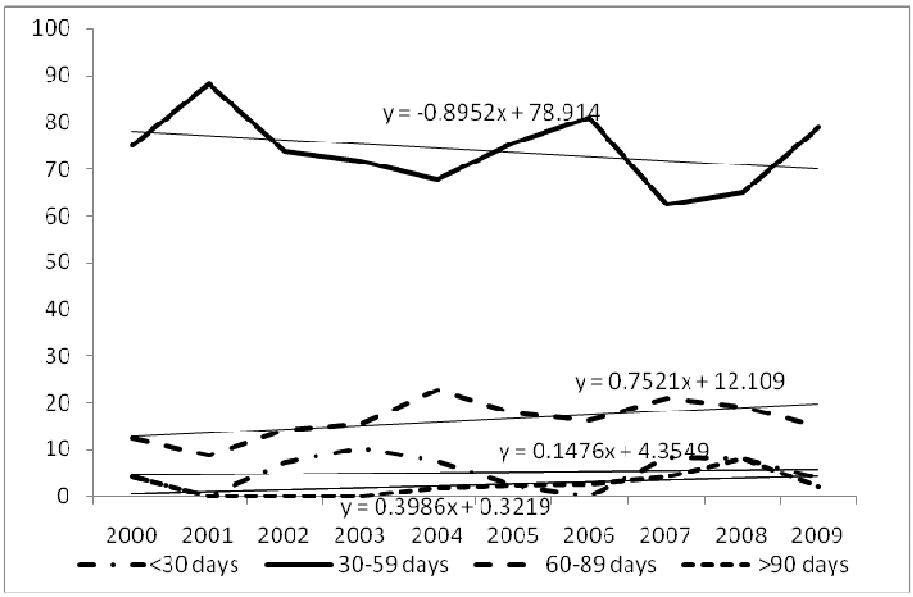
The findings below are largely taken from the quarterly survey of the NSCC State of Trade Report 2009 Quarter 4, but they are also derived from all the surveys conducted over the previous 10 complete years from the first quarter of 2000. Using the third quarter data of the NSCC survey, a trend analysis based on a linear regression was applied to the data.

FINDINGS

Firstly, one of the key drivers in establishing the NSCC trade survey concerned payment regimes between main contractors and specialists. This refers to excessive delays in paying specialist suppliers by main contractors, even when there are no reasonable causes for the delay. It continues to remain a major issue and has been responsible for the Fair Payments Campaign run by NSCC, which resulted in fair payments being adopted government

procurement policy. As recently as 2009Q4 fewer than 5% of specialists reported being paid within 30 days. Little noticeable change has taken place since 2000, with the rate of increase in the percentage of firms reporting prompt payment between 2000 and 2009 at 0.148 per cent per annum, according to the trend analysis shown in Figure 1, which shows the period of time specialist contractors reported they waited for interim payments. In contrast the percentage of firms reporting payments of between 30 and 59 days declined at approximately 0.895 per cent per annum. Although the percentage of specialist firms reporting payments from main contractors were taking longer than 90 days to pay appears to have declined in 2008 and 2009, if anything the time taken by main contractors to pay invoices increased in 2007 and 2008 during the worst of the financial crisis.

Both those firms waiting 60 to 89 days and those waiting more than 90 days to be paid grew at 0.752 and 0.399 per cent per annum respectively, although their actual numbers were small. These figures do not indicate the size of the outstanding payments but they do show that for the bulk of payments, firms were waiting longer than 30 days for payment, a period in breach of most specialist firms' terms and agreements. It is possible that the decline in the number of specialist contractors waiting 30 to 60 days in the decade was due to the need to re-engage with supplier firms during a period of steady employment. The reduction in the interest rates also reduced the incentive to delay payments.

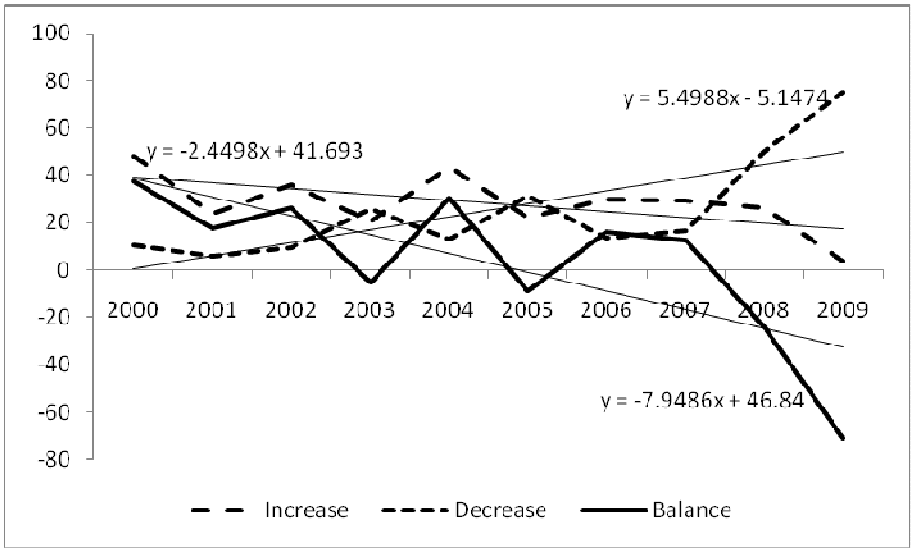


Source: NSCC State of Trade Survey: Q3 2001 – 2009
Note: Figures do not round to 100 as some respondents did not complete this question

Figure 1 *Interim Payments Period: average time for payment in 3rd Qtr 2000 - 2009*

The commercial pressures prevailing on this sector are emphasised by the percentage of specialist contractors reporting tender price increases. This data is given in Figure 2, which gives the percentage of firms reporting rising and falling tender prices. The balance shows the difference in the percentage reporting increases and decreases. By the 4th quarter of 2009, there was a large negative balance of 69%, signifying far more firms reporting downward pressure on tender prices, a characteristic of a buyers' market. As the buyers in this particular market are main contractors, this reveals their relatively strong bargaining position vis-à-vis their suppliers. The weak increases in tender prices had been offset in the deepest part of the

recession by reduced suppliers' prices, but there has now been a return to some supply side inflation. Increases in suppliers' prices placed pressure on margins, which continued to fall but respondents anticipated that the sharpest falls had passed.



Source: NSCC State of Trade Survey: Q3 2001 – 2009
Data is taken from the 3rd Qtr survey each year.
Note: Figures do not round to 100 as some respondents did not complete this question

Figure 2 *Specialist contractors' tender prices, 2000 - 2009*

Those reporting a decrease in tender prices grew by 5.5 per cent per annum between 2000 and 2009 but this downward pressure on specialist contractors was mainly due to the impact of the financial crisis of 2007. From 2000 to 2007 the number of firms reporting declining tender prices only grew by 1.6 per cent per annum. This implies that the pressure on specialist contractors to reduce their tender prices existed even before the financial downturn. The converse of this is given by the decline in the percentage of firms reporting increasing tender prices. The annual rate of decline of firms, given by the trend line in Figure 2 was 2.45 per cent per annum. By 2009 only 4 per cent of firms reported that they were still submitting higher tender prices than in the previous year. These figures are reflected in the balance, which shows the summary of the relationship between those firms reporting higher and lower tender prices. The balance shows a decline of almost 8 per cent per annum, leading to a prevailing pessimism in construction markets.

This pessimism is further shown by specialist contractors, who cite late payment, weak cash flows, valuation disputes and a strong disregard for retention. Late payment, bid peddling and Dutch auctions have the most significant effects on specialist contractors' businesses. Further evidence from the 2009Q4 survey indicated that 84% of respondents still had monies withheld against them in retentions with an average of £125,082 per respondent and of that amount an average of £38,522 per respondent (27% of retention monies withheld) was overdue for release.

Although the UK Government's announcement that it had made fair payment a contractual requirement on public sector works from 1 April 2010, this measure has yet to be seen as having an effect on contract behaviour.

A significant challenge to the notion of integrated working within the sector is evidenced by only 6% of specialists reporting that they were chosen by nomination. When selected to make a proposal 50% of specialists are given less than 10 days to submit a bid and 18% of specialists did not even receive their contract documentation until after they have started the work. Generally it would appear that most specialists have less than 10 days to prepare and price a proposal.

Finally, when asked to identify the major issues affecting their business, specialist contractors' comments included the following:-

- Start dates being moved (by months in some cases)
- Main contractors were taking longer to pay than agreed. As a consequence a cash flow problem emerged.
- Obtaining credit cover on main contractors through credit insurance.
- Poor credit rating of main contractors and onerous and complicated payment terms.
- Extended payment terms imposed even when the contract is government funded.
- Difficulty in getting retentions paid.

DISCUSSION

One would have expected clear changes to have emerged in the attitude of specialist contractors if changes in supply chain management and IPT's had been successfully adopted. Improvements in the attitudes and behaviour of main contractors towards specialist contractors would have been reflected in the quarterly survey. However, none of these are yet apparent by the time of the fourth quarterly survey.

This is therefore indicative of a failure to introduce supply chain management by gaining the collaborative working environment that might have been hoped for. As far as the NSCC survey is concerned there is little or no evidence to support the claim that supply chain management has improved the degree of collaborative working.

The difficulties facing specialist firms is caused by the fact that according to the terms of their contracts, much of their work is carried out prior to payment. It therefore follows that their bargaining power, vis-à-vis main contractors, is severely weakened as they are then not in a position to impose costs on the project or the main contractor. If they cannot delay completion of a project, there are few other practical sanctions that can be used by subcontractors other than seeking adjudication, arbitration or litigation.

A large question remains. To what extent does the data reported here reflect basic economic realities and conflicts embodied in the relationships between main contractors and their suppliers, the specialist subcontractors? If the data given here reflects basic conflicts found in markets, then they represent universal conditions and similar surveys in other countries would produce largely similar results. We hold that the findings here are probably generalisable and that they therefore have relevance and implications universally.

As long as construction relies on markets to provide specialist skills and services, there will be conflicts between main and subcontractors. Only when firms themselves become fully integrated would common corporate identity begin to provide opportunities for truly collaborative working practices. Even then interdepartmental conflicts and rivalries arise within the same organisation and there can never be a guarantee that construction projects or any kind of production process is necessarily carried out on a co-operative basis.

CONCLUDING REMARKS

At a project level it would appear from the findings that there is still a need to train managers on the implications of supply chain management to alter the culture of confrontation and mistrust that arises on construction sites. The message needs to be communicated down to those, who actually manage the interface between main contractors and specialist contractors. The evidence from the NSCC survey does not provide support for the argument that this is happening effectively. Only once the behaviour of main contractors begins to show understanding of the difficulties faced by their specialist suppliers will the promises of management theories designed to improve the work attitudes, productivity and outcomes on construction sites be achieved.

The findings of the NSCC survey begin to show the divergence of opinions about the performance of contractors as far as specialist contractors are concerned. This calls into question the gains to the supply chain in the construction sector claimed by some of the proponents of integrated working. Further, the practice of partnering has not extended its reach throughout the sector as much as might have been expected.

One conclusion that may be drawn is that the drive to partnering has been mainly marketing exercise by contractors, not matched by practice. Instead it has allowed the strongest players in the building team to continue to take advantage of the weakest members and that the time has come to call the concept of partnering as practiced in the UK a failure.

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COLLABORATIVE DESIGN OF PARAMETRIC SUSTAINABLE ARCHITECTURE

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Abstract
Sustainable architecture is complex. Many aspects, differently important to many stakeholders, are to be optimized. BIM should be used for this. Building Information Modelling is a collaborative process where all stakeholders integrate and optimize their information in a digital 3D model. Sometimes it is called Green BIM. But what exactly is that? Is the International Standard Organization IFC standard useful for this? And is it compatible with new developments in parametric design? Advantages and disadvantages of BIM are listed. Full parametric design is needed because it keeps the design flexible and open for changes until the end of the design process. However it is not compatible with IFC; only object parametric design is. A possible way out of this paradox could be the use of scripts that only create objects if they are not already in the BIM database and otherwise only adapt their properties. An example of parametric sustainable architectural design explains the mentioned issues.

Keywords: Sustainable architecture, BIM, collaborative design, parametric design, IFC

INTRODUCTION

Sustainable architecture is architecture that meets the needs of the present without compromising the ability of future generations to meet their own needs (adapted from WCED 1987). One of those needs is energy for heating, cooling, lighting and equipment of buildings. Estimations show that buildings use 20 - 40% of the energy in Europe (IEA 2008).

During the energy crises in the seventies of last century people became aware of the necessity to protect the environment and to find alternatives for fossil fuel. The book “Small is beautiful” had a big influence (Schumacher 1973). Function integration is still an important issue. Passive solar energy became popular, insulation of outer walls in buildings was improved and double glazed windows became the standard. There were small scale experiments to use rainwater and reuse grey water in households and compost toilets. Green roofs were re-introduced (they existed already in the stone age of course). PV panels appeared on buildings, high efficiency boilers were installed, heat pumps and heat exchange equipment were introduced and recently rest heat from industrial plants is used in buildings nearby.

The built environment is our habitat. This word is used in Ecology to address the circumstances that make species flourish or not. Our habitat should be built with all stakeholders in mind. Municipalities could play an active role in this. They should not only approve or ask for changes in the plans, but actively interfere from the start with the design of the habitat of its citizens. Municipalities could demand for design teams with delegates representing all stake holders (including the building professionals). Such multi-disciplinary design teams can develop designs that optimally fulfil the needs and demands of all concerned.

In 1984 the author designed a sustainable office building (Figure 1). It had a floating foundation, because of the risk of flooding and also to take profit both in summer and winter of the constant ground temperature of 10 ^{o}C. The roof construction would be made of round wood with Ethylene TetraFluoroEthylene (ETFE) cushions, and has been realized several times since then. It had collection and treatment of rainwater, heat storage in salt, fish culture and a vegetable garden. The feasibility study for this innovative office for the multidisciplinary centres of Delft University of Technology took 2 years. And finally it turned out that there was a negative return of investment, mainly caused by the expensive foundation. In order to speed up and to improve this kind of evaluations, multidisciplinary ICT projects were initiated.

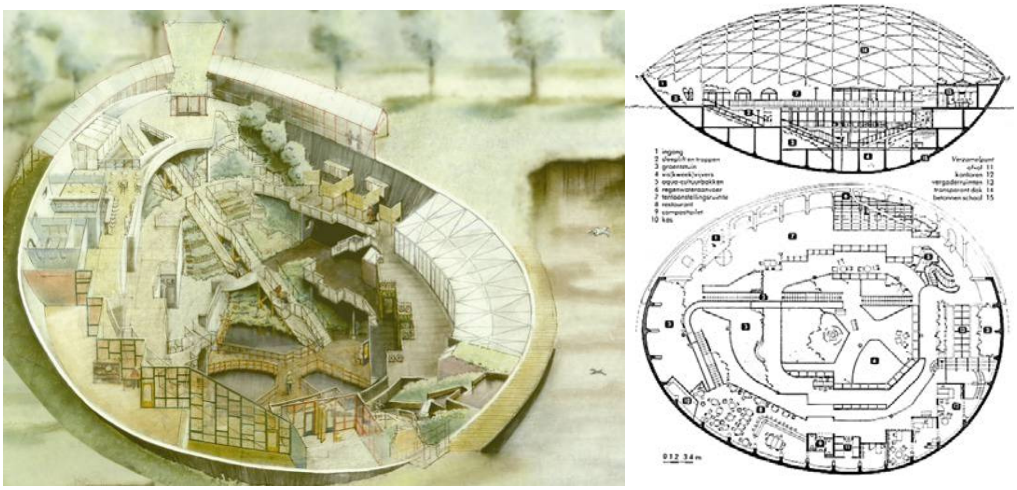


Figure 1. *Ecological office building "The Egg" (Hubers 1986).*

Also around 1985 the Biosphere 2 was realised in the U.S. as a closed ecological system. Fifteen years later the Eden project was realised in England. Governments started to fund research into sustainable architecture end of the last century. Demonstration projects were funded and alternatives were stimulated with grants. The report of MIT to the Club of Rome in 1972 about the limits to growth had a big impact. People became aware of the endlessness of fossil fuel and other resources (Meadows et al. 1972). The Brundtland report in 1987 introduced the concept of sustainability. Later the triple P was added: People, Planet and Profit. Prof. Duijvestein, one of the founding fathers of sustainability at Delft University of Technology listed in detail the criteria for buildings under every P (SenterNovem 2009).

Feminias (2004) gives a nice overview and analysis of demonstration projects in Sweden and The Netherlands. She concludes that though important real-world data as reference are very important, there is a lack of incentives and interest for learning; deficiencies in the production of reliable and useful information; and a lack of institutions for information dissemination.

Reuse of existing resources with as less degradation as possible (cradle to cradle) is important (McDonough and Braungart 2002).

But it was not until vice-president Al Gore went over the world in 2006 showing the spectacular movie: "An Inconvenient Truth", that people became aware of global warming, the ozone hole, widespread land degradation and declining biodiversity. Standards were developed to express how well buildings perform energetically. The United States Green Building Council (USGBC) was founded in 1993. The LEED standards begin in 2000. There

are many other standards like BREEAM (NL, UK), Itaca (IT) etc. Every country has its own regulations and standards. The work of Jón Kristinsson should be mentioned, especially his design for the Floriade 2012 (Kristinsson 2010). Of course the IPCC reports are important references.

SUSTAINABLE BUILDING DESIGN

The biggest challenge stays with existing buildings, because it represents 20-40% of the energy use and CO2 emission and because it is more difficult to reduce this in existing buildings than to avoid it in new ones. Special attention should be paid to lighting and air-conditioning. When buildings get insulated lighting becomes relatively more important. And because of airtightness the indoor air quality becomes an issue and buildings don't lose heat during nights that easily.

Recently the author developed together with greenhouse, sustainability and other specialists a proposal for synergetic greenhouses on existing flat roofs in the cities. It is called SynSerre.

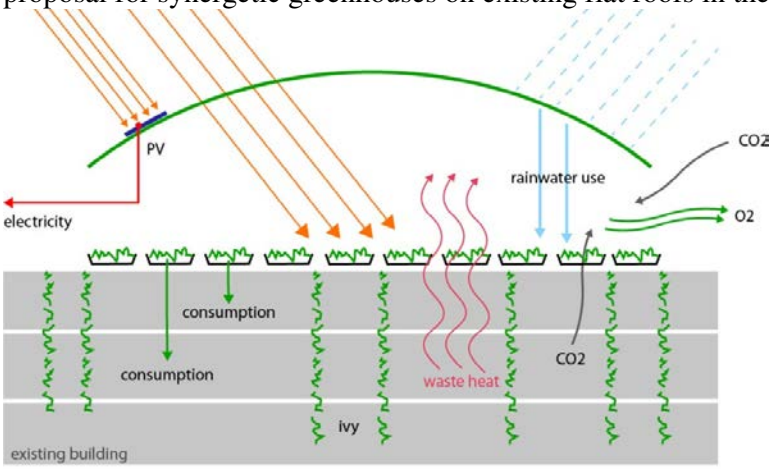


***Figure 2**. Schematic representation of the SynSerre project.*

One of the proposed eco-innovations in this project is the combination of multilayered ETFE cushions with reflecting patterns on the film that concentrate the spectrum of sun light which is not useful for plants (~50%) to PV disks mounted on space frames of round wood. Through in- and deflating the right chambers in the cushions the system becomes interactive.

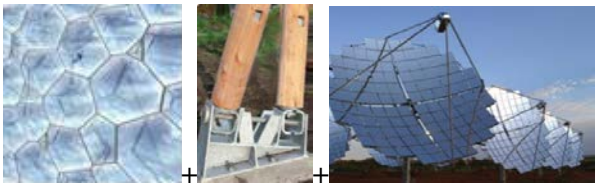


***Figure 3**. ETFE cushions + Tentech round wood connection + PV concentration*

But it could well turn out that SynSerres in Northern countries need a different solution than in Southern. Up to 77% of direct sunlight for PV reduces the cooling capacity by 4.

A SynSerre is not just a traditional greenhouse superposed on the roof of an existing building. That wouldn't be competitive with normal greenhouses. The innovation is the combination of all the points listed below. This project proposes solutions for the following problems.

1. Depletion of fossil fuel. SynSerres supply energy and insulate existing buildings.
2. Flooding in the world's delta areas due to climate change endanger the food supply of the growing cities. SynSerres bring food production into the cities on high and dry places.
3. Many existing buildings in European cities with flat roofs from the sixties and seventies need renovation. Well designed and styled SynSerres are beautiful and synergetic alternatives for traditional renovation.
4. Many of those buildings are in problematic neighbourhoods. SynSerres create jobs and offer social activities.
5. There is a lack of space for extending greenhouses in the green areas around cities (VROM 2010). The roofs and facades of existing buildings offer considerable space for SynSerres.
6. Cities run out of space and the value of buildings in the target areas is decreasing. There is added value through double land use.
7. Low quality of food in supermarkets. Neighbours profit from fresh herbs, vegetables, flowers, plants and control the quality.
8. Global warming due to CO2 and particulates. Plants convert CO2 in O2 and plant material. Particulates stick to ivy on the facades which are linked to the SynSerre.
9. High cost for maintenance of green areas in the cities and e.g. ivy on the facades. The greenhouse farmer maintains the green on and around the building.
10. Overflow of sewage system during rain fall. Rainwater is collected, stored and used to grow plants.
11. Little awareness of sustainability. SynSerre attracts attention and has an educational function.
12. Transport causes much pollution and accidents. Less transport because of local production and trade.

Because existing buildings vary enormously, the SynSerre concept is adaptable. Parametric design software will be used and dimensions expressed in variables. The number of modules and their dimensions are matched with the existing buildings. The SynSerre will be offered as a parametric product through websites as www.conceptueelbouwen.nl. as part of an innovative turn towards an offer based building market. Clients (i.e. greenhouse farmers) buy the product in about the same way as a customisable car. The local team receives the command, adapts the design in some days and prepares the building permit request. The consortium offers SynSerre in principle as a Design & Build contract and shares the profit.
The idea of SynSerre is obviously inspired by the design of Figure 1, but combined with other ideas. In 1992 ONL, one of the partners in the project, participated in a study where greenhouses were planned on top of housing (Bahlotra 1992).



Figure 4 *Elkas (WUR 2010)*

However not on existing buildings and more as an urban design. Grau (2009) proposed to integrate greenhouses on the roofs of Barcelona, however also not on existing buildings and not developed as a realistic product. SynSerre partners from the leading greenhouse research centre in Europe, the Wageningen University and Research centre in the Netherlands, showed the advances of energy producing greenhouses like the Elkas and the Fresnel greenhouse (WUR 2010). This together with the ideas of Urgenda (2010) and the initiative of Rotterdam (2010) to turn existing flat roofs into green roofs led to the idea of this project. The Elkas produces 18-15 KWh/m2 year at the curved side of the roof by reflecting and concentrating the Near Infrared Radiation of the sun to an adaptable line of PV cells.

The SynSerre project will develop innovative business models where energy production, plant production and sales, environmental maintenance, educational and social activities are integrated with innovative synergetic solutions like new photovoltaic technologies. Small scale SynSerres could be exploited by restaurants or shops, while larger ones by professional greenhouse farmers. The focus will be on the latter. Two greenhouse farmers are participant in the project.

Another eco-innovation will be the integration with climate control of the existing building; e.g. convert CO2 rich exhaust air into O2 and plant growth. The examples mentioned in 1.2. will be used as starting point. There is an urgent need for feasibility studies of this concept. Two real scale test models of 100 m2 will be built and monitored; one in Delft and one in Rome. For monitoring we will use wireless Arduino based systems as can be found at http://sense.almende.com.

Now is the time to develop synergetic greenhouses on existing buildings, because the above mentioned problems are getting quickly more important and most of the suitable buildings from the sixties and seventies in the European cities need refurbishing and renovation.

Besides fossil energy use, CO2 emission and the problems mentioned before, there are other criteria that a sustainable building should answer. The author made the list in Table 1and used it during a test case of collaborative design (Hubers 2008). The list was meant to be completed by the design team. It turned out that the multidisciplinary design team only focused on a few criteria and didn't take the time to add other criteria or to evaluate all of them. Also other research shows that weighted criteria evaluation is not reliable (Lawson 2006). But maybe it is better to have a badly used list of criteria, than no list at all. It at least helps efficiently focussing the discussion on the main subjects. Subjects team members don't agree about (standard deviation in Table 1).

A multidisciplinary design team needs more than a list of criteria. It needs to have good ideas! Developing ideas and evaluating them with criteria are the two main sub processes of design (Lawson 2006, Hubers 2008). Knowledge sharing and management is important. We plan to use Wikis for this. Wikis are websites that everybody that is authorized can easily edit. Well known is Wikipedia. Creativity is needed to turn experience and knowledge into ideas. Different techniques can be used. The use of different representations and different media is one of them (Stellingwerff 2005, Schön 1983). The work of Edward de Bono shows several methods like Random Word Stimulation, Analogy thinking, Brain storming etc. (Bono 1980). The Environmental Maximisation Method of Duijvestein is interesting though a bit laborious (Duijvestein 2002). It consists of drawing the design only from the point of view

of one function, e.g. water, green, sun or wind power, traffic, housing, parking etc. and later integrating the plans. Recent developments in ICT make it possible to share all this information in 3D digital models. We call this Green BIM.

			Evaluator 1	Evaluator 2	Standard deviation
			2 4 6 8 10	2 4 6 8 10	2 4 6 8 10
Relation with environment	1	wind hinder	6	3	2
	2	sun light	5	5	
	3	urban infrastructure	10	5	4
	4	waste	4	10	4
	5	view	8	3	4
Adaptability	6	flexibility	2	9	5
	7	expandability	2	9	5
	8	handicapped	5	5	
Spatial organization	9	routing	8	7	1
	10	viewing lines	9	9	
	11	functional relations	9	9	
	12	privacy	3	8	4
Safety	13	fire	8	8	
	14	burglary	8	8	
	15	flood	5	5	
	16	traffic	5	8	2
Experience	17	recognizablity	9	9	
	18	proportions	9	9	
	19	rhythm	9	9	
	20	acoustics	5	5	
	21	comfort	7	3	3
	22	contrast	9	9	
Materials	23	colour	9	3	4
	24	texture	9	3	4
	25	sustainability	5	5	
Construction	26	safety	5	5	
	27	comfort	5	5	
	28	speed	4	2	1
Energy use	29	insulation	5	5	
	30	outer surface	8	8	
	31	wind tightness	5	5	
	32	ventilation	5	5	
	33	sun light	3	3	
	34	lighting	8	8	
Cost	35	initial, maintenance, demolition	9	5	3

Table 1. *Criteria for sustainable buildings*

BIM

BIM is mainly used in the meaning of Building Information Modelling, the process of making a Building Information Model. Collaborative design is one of the main aspects of BIM (Eastman et al. 2008, Hardin 2009, Hubers 2008). We define it as follows. Collaborative architectural design is multidisciplinary simultaneous design from the very start of a project. It is also called co-design or concurrent engineering.

The pressure to use IFC based BIM is growing. IFC is an ISO standard. A good introduction to IFC-based BIM is to be found in Khemlani (2010). Autodesk adopted it a.o. in Autodesk Revit. Other major CAD developers in the AEC industry support it too. The Dutch part of the

buildingSMART association, which develops IFC, states in her newsletter that the directions of Governmental Services of U.S., Denmark, Finland, Norway and the Netherlands signed an agreement for adopting IFC based BIM for all major government projects (BS 2010). Contractors for a long time are working on this and recently the Dutch Conceptual Building network starts working in this direction too (CB 2010). The conceptual building approach converts the demand market into an offer market. Providers of concepts no longer wait for a client to define a demand, but develop complete adaptable solutions that clients can order. It is more or less like in the car business: lean production and mass customization.

The simulation of buildings is a vital benefit. VR systems like CAVEs and Head Mounted Displays are used for that. Delft University of Technology developed a lab called protoSPACE which uses these techniques (Hubers 2009). Eastman et al. report 10 case studies of realized buildings.

Feasibility study	
1	Support for project scoping and cost estimation (2)
Concept design	
2	Scenario planning (2)
3	Early and accurate visualizations (3)
4	Optimize energy efficiency and sustainability (1)
Integrated design/construction	
5	Automatic maintenance of consistency in design (8)
6	Enhanced building performance and quality (5)
7	Checks against design intent (3)
8	Accurate and consistent drawing sets (8)
Construction execution/coordination	
9	Earlier collaboration of multiple design disciplines (6)
10	Synchronize design and construction planning (5)
11	Discover errors before construction (clash detection) (5)
12	Drive fabrication and greater use of prefabricated components (5)
13	Support lean construction techniques (2)
14	Coordinate/synchronize procurement (4)
Facility operation	
15	Lifecycle benefits regarding operation costs (1)
16	Lifecycle benefits regarding maintenance (1).

Table 2. *Advantages of BIM (Adapted from Eastman et al. 2008, p. 321)*

The 16 reported benefits are summarised in Table 2 with the number of projects that had these benefits. Benefit 9 'Earlier collaboration of multiple design disciplines' is in the Construction execution/coordination phase and thus not collaborative design as we define it. Not one project had all those benefits. Besides benefits of BIM there are also drawbacks of course. It is obvious that BIM asks for much knowledge about 3D, 4D, 5D, nD CAD knowledge (4D is planning, 5D is cost, nD is management etc.). Then there are the difficulties of author/ownership and liability of the BIM. Contracts like Design Build and Guaranteed Maximum Price have enormous impact on the concerned professional practices (Hardin 2009).

Recently parametric design software is used. Two main groups of parametric design software can be distinguished: object parametric or process parametric. The problem is that only object parametric design software is compatible with IFC (Hubers 2010).

CONCLUSION

Sustainable architecture has many criteria to fulfil of many stakeholders. A promising idea is to develop synergetic greenhouses on flat roofs of existing buildings. Research is needed to find ways to use both IFC based BIM and full parametric design software. Only then multidisciplinary teams can work efficiently together on sustainable architectural designs. A solution might be the use of scripts that only create objects if they are not already in the BIM database and otherwise only adapt their properties.

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INTRA-FIRM, INTERDISCIPLINARY NETWORKS IN MULTI-NATIONAL ENGINEERING ORGANIZATIONS

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ABSTRACT

To gain a competitive advantage, project organizations are interested in sharing knowledge gained through their experiences across the organization. Despite the advantages, this can be particularly challenging for multi-national engineering organizations. These organizations not only encounter typical knowledge sharing constraints due to lack of resources, individual motivations, and a project-based focus; but also the additional challenges of geographical, cultural and disciplinary boundaries. However, gaining knowledge from the diverse environments in which multinational engineering organizations work is a large advantage for working globally. To better understand the networks that exist for sharing knowledge within these organizations, this research employed a case study of a sustainability network within a large multinational engineering organization. The organization selected individuals from offices that were dispersed across nineteen countries. These individuals responded to ego-centric social network surveys that contained questions about their background and the people with whom they share knowledge. The results found that geographic distance created large barriers in the knowledge-sharing network. There was a high prevalence for regional knowledge sharing, which resulted in regional and country level silos with weak ties to offices in other geographies, particularly for knowledge sharing that occurred on a more frequent basis. The research also found a significant focus on knowledge centered from and with the home region for the organization. The results also found that a person's disciplinary background influences the frequency of knowledge sharing within the network. Intra-disciplinary knowledge sharing connections increase with knowledge exchange that occurs on a more frequent basis. The results highlight the need for focused strategic efforts by the firm to encourage knowledge sharing ties between offices and countries separated by geography. In addition, to reap the advantages of working globally, firms must focus on creating low levels of centrality to encourage knowledge flow from offices in emerging countries.

Keywords: Knowledge Management, Organizations, Networks, Global

INTRODUCTION

To meet the trillions of dollars of needed infrastructure (Launch 2003) for a growing global population, multinational engineering and construction companies are expanding their operations to a diverse array of markets and regions (ENR 2010). A common goal of multinational organizations is to learn from each market that they enter to gain collective organizational knowledge across geographical regions (Miller and Chen 1996). In fact, this attribute is one of the key advantages of the multinational organization because the ability to

use the organization's collective knowledge acquired throughout the world is expected to achieve higher performance (Ghoshal 1987; Zahra 2000).

However, in order for an organization's collective knowledge to add value, the knowledge needs to be accessible when and where it is needed. Creating global knowledge sharing networks is fundamentally important for communities of practice (CoP) within multinational organizations because connections between people that span physical barriers can increase opportunities to access information and improve performance (DeSanctis & Monge 1999). Specifically, recent research has demonstrated that task-relevant knowledge sharing between people in different geographic regions can boost performance at the project level (Cummings 2004) and at an individual level (Cross and Cummings 2004).

Organizations that are successful at fostering inclusive knowledge sharing relationships have the potential to reap rewards of not only improved project and individual performance, but also innovative changes in the way they conduct business. Much of today's environment has diverged from the past. Rather than a traditional exploitative, cost-based relationship, a growing number of multinational organizations want to include employees within emerging markets within their knowledge networks to gain benefits. Specifically, emerging markets are believed to help an organization create disruptive innovations that can help the company adapt to operate in emerging markets, and they also have the potential to alter the way business is done throughout the world (Economist, 2010). However, this potential can only be realized if organizations can engage knowledge flows across the organization regardless of location.

Connecting people across geographical and cultural boundaries, in addition to the project and disciplinary boundaries inherent in construction and engineering, has its challenges; however, there is a clear need to integrate knowledge by fostering these connections and creating an inclusive global knowledge-sharing network. This paper seeks to increase our understanding of knowledge sharing connections in multinational organizations by analyzing individual attributes of employees engaged in knowledge sharing connections. Specifically, we analyze the influence of geographical location and discipline practice on the creation of knowledge sharing network connections.

ORGANIZATIONAL KNOWLEDGE

Many organizations are learning disabled: they "don't know what they know" they "know more than they can tell" (Polanyi, 1967). As a result, in recent decades, organizations have aimed to improve their knowledge sharing abilities, as this can help to encourage new collaborations, foster new ideas and share best practices while avoiding repeated mistakes and the "reinvention of the wheel". In fact, under the knowledge-based theory of the firm, organizational knowledge is a resource with at least the same level of importance as capital (Grant 1996, Spender 1996). If, however, knowledge is the most important resource of the firm and knowledge resides within individuals, then the most important organizational capability is the *integration of* individuals' knowledge (Grant 1996). Therefore, an organization must concentrate on connecting employees to encourage knowledge sharing within communities of practice (CoPs) to build competencies and achieve high performance.

Connecting people to enhance knowledge sharing across an organization is particularly difficult in the project-based engineering and construction industry. The autonomy of projects can cause the project team to become siloed, making knowledge sharing challenging across projects and regions (Sydow, Lindkvist and DeFillippi 2004). In addition, the incomplete transfer of knowledge can cause unnecessary rework and delay for projects and the engineering or construction organization (Paulson, 1976; Jin and Levitt, 1996). However,

due to the fragmented nature of tasks in the engineering and construction industry, coordination and sharing of knowledge is fundamental for projects (Jin and Levitt, 1996), innovations (Taylor and Levitt 2007), and organizational success. Therefore, the engineering and construction industry in particular must focus on breaking barriers inherent in the industry to share their knowledge across the organization.

GLOBAL KNOWLEDGE NETWORKS

Today's global environment creates additional hurdles due to distance and dispersion. Organizations no longer have the luxury of discussing projects and strategy in the corridor or around the water cooler in the same office. Instead, they must coordinate and share knowledge globally through virtual platforms. But these challenges do not end with physical distance. Organizations are no longer homogenous; they are now comprised of employees from multiple cultures and countries, creating an office with diverse socio-cultural backgrounds. These backgrounds condition how individuals perceive information and interact in various countries and locations (Hofstede 1991, House 2004) and can increase costs and schedule delays on projects due to misinterpretation and miscommunication (Orr and Scott 2008). In addition, engineering and construction organizations employ specialized actors with diverse disciplinary backgrounds to meet project requirements. The geographic distance, socio-cultural differences and interdisciplinary CoPs all increase the complexity and uncertainty of networks within the global organization and thus increase the challenges of coordination and knowledge sharing.

Despite these challenges, the global environment in which we operate can offer significant benefits. The long-known concept of "boundary spanning" influences how information enters organizations (Tushman, 1977). More recently, research has found that relationships that cross department or functional boundaries are important for effective knowledge transfer within organizations (Tsai, 2001) and that relationships spanning geographic locations can boost performance at the project level (Cummings, 2004) and at the individual level (Cross and Cummings, 2004). Thus, a key competitive advantage for global organizations and teams is the ability to foster the exchange of diverse ideas from people of various backgrounds, helping to facilitate learning and innovations (Barkema and Vermeulen, 1998; Ghosal 1987). However, this only becomes an advantage if knowledge and ideas can be shared across members.

Recognizing the need for inclusive global knowledge sharing networks and addressing prior calls to explain network emergence (Monge & Contractor 2001, 2003), this research will fill an important gap, focusing on the unit of analysis of network connections to understand how and why these connections are formed and maintained.

To answer these questions, we will utilize and expand upon social network analysis applied to construction. Social network analysis is a tool that provides researchers an understanding of a group's social structure and relationships visually and mathematically. Therefore, the analysis is ideal for understanding how knowledge-sharing connections exist within an interdisciplinary community of practice. Chinowsky and colleagues developed the Social Network Model for Construction to expand the traditional focus on efficiency within the engineering and construction industry to focus on performance (Chinowsky, Diekmann and Gallotti 2008). The model incorporates a social network perspective to recognize the importance of collaboration and knowledge exchange to achieve this higher performance without abandoning the required dynamics of information exchange for task completion. This model has been applied to both construction project teams (Chinowsky, Taylor and DiMarco 2009) and management teams (Chinowsky, Diekman and O'Brien 2010) within construction and engineering organizations.

RESEARCH METHOD

To determine knowledge sharing connections and patterns, we employed social network surveys and analysis within a community of practice (CoP) in a multinational engineering organization. We worked with the organization to identify a CoP that was interdisciplinary and globally distributed across all operating locations and selected the sustainability CoP. The sustainability CoP is comprised of people from the majority of disciplines within the organization, including mechanical engineering, civil engineering, environmental engineering, environmental consulting, structural engineering, etc. The goal of the CoP is to develop and share sustainability knowledge, primarily environmental, but also social, and sustainability tools across the global organization. Selecting this global, interdisciplinary CoP was important to encourage boundary-spanning ties across disciplines and geographic distance. Because the sustainability CoP included 1,333 employees, the organization selected employees that represented the major regions and countries in which the organization has a permanent office to participate in the research. This allowed us to examine regional and disciplinary representation in the knowledge-sharing network.

Ultimately, thirty-seven of the CoP employees responded to the questionnaire. These employees represented thirty-two different offices within nineteen different countries. These individuals answered the questionnaire, which was developed from the Social Network Model for Construction (Chinowsky, Diekmann, and Galotti 2008). The questionnaire asked three categories of questions, including mechanics, dynamics and attributes. On the mechanics side, the survey included questions on information and knowledge exchange. For example, on the mechanics side, respondents were asked: "What individuals have you exchange job related sustainability issues with?" and included various questions regarding frequency of communication from annual up to daily communications. On the dynamics side, the questionnaire elicited responses to questions that asked respondents to rate the amount of dependence, reliance and trust they have that the other individual will complete their job related sustainability tasks. In addition to the prior questions developed from the Social Network Model for Construction, we asked additional questions related to individual attributes that may influence the mechanics and dynamics of the network. These questions included the respondent's professional discipline, location of birth, business practice, generation, level within the organization, number of years employed by the organization and prior physical locations worked. We used Network Genie, an on-line survey system designed specifically for managing social network analysis surveys (Hansen et al 2008), to deliver the survey.

"Egos", or the respondents to the survey, reported 407 knowledge sharing connections across a network of 320 individuals, which included both the "egos" and "alters", or people that did not respond directly to the questionnaire but whom "egos" reported knowledge sharing connections with. Attribute data on the alters was obtained through the organization. Data collected from the survey was used to identify and analyze the global knowledge-sharing network and connections within each organization using the UCINET Social Network Analysis software (Borgatti, Everett, and Freeman 2002). The UCINET software provides the mathematical measurements (Wausermann and Faust 1994) as well as the graphical representations required to conduct a Social Network Analysis. Additionally, we analyzed survey responses using traditional spreadsheet analysis to report connections and test the influence of attributes.

RESULTS

For the purpose of this paper, we analyzed the global sustainability network for frequency of job-related knowledge sharing based upon geographical location and discipline.

Influence of geographical location on knowledge sharing

To understand the global distribution of knowledge sharing, we first analyzed the existence and frequency of communications according to geographical location. When respondents were asked who they exchanged job-related sustainability knowledge within in the last 12 months, 407 knowledge sharing connections were reported. The graphical representation of these annual knowledge-sharing connections is shown in Figure 1. Within the network figures depicted, a shape or node represents each individual, while the knowledge sharing connections are displayed as lines between the nodes. We attempted to display these graphically according to region (Asia, Australia, Africa, Middle East, UK, Eastern Europe, Europe–Other and North America). The black nodes represent individuals whose information is not known, either because they left the company or could not be identified from the survey.

Within the annual communications, we witness a propensity towards regional knowledge sharing. Specifically, 62% of the knowledge-sharing connections are between individuals from the same office (e.g. an employee from the San Francisco office sharing knowledge with another employee from the San Francisco office), same region (e.g. an employee from the Cape Town office sharing sustainability related knowledge with a person from the Johannesburg office) or similar region (e.g. a person from the Milan office sharing knowledge with a person from the London office). 29% of the knowledge-sharing connections occur between employees located in different regions (e.g. a person from the San Francisco office sharing knowledge with a person from the Bangkok office) and 9% of the connections are tied to individuals with whom no geographical information is known.

The analysis of these knowledge sharing connections reveals that knowledge sharing patterns based upon geographical location (either the same office, same region, or similar region) or sharing knowledge with the "home office region", in this case, the UK. Table 1 lists the percentage of knowledge sharing connections originating from a region (e.g. Australia has 27 knowledge sharing connections reported from the region) along with the percentage of ties to other regions (e.g. 89% of Australian employee's sustainability knowledge sharing connections are with other employees located in Australia). All regions exhibit the same knowledge sharing patterns, with the majority of knowledge sharing connections existing amongst employees within the same region and the second highest percentage of knowledge sharing connections with employees from the home office region of the UK.

From these results, we build the following propositions:

Proposition 1: Of the knowledge sharing connections that exist between employees in a globally distributed community of practice, the majority of connections will exist between employees located in the same geographical region.

Proposition 2: Of the knowledge sharing connections that exist between employees in a globally distributed community of practice, the majority of connections external to a region will exist with employees from the home office region.

We analyzed these connections further to determine if geographical location impacted the frequency of knowledge exchange. Figure 2 depicts the knowledge sharing ties within the CoP based upon quarterly knowledge exchange. Analyzing the quantity of connections by region for quarterly communication, we discover that 80% of the knowledge sharing connections occur within a region, 14% occur between a region, and 6% of the connections

are with an alter whose location is unidentified. Table 2 lists the percentage of knowledge sharing ties according to region for quarterly communications.

When we analyzed the knowledge sharing connections at increasingly higher frequencies of exchange, we witness increased regional knowledge sharing with decreased global knowledge exchange. For example, 88% of the 139 connections that exchange knowledge at least monthly (depicted in Figure 3) are located within the same region. For the sixty-nine connections that exchange knowledge at least weekly (depicted in Figure 4), 93% of the exchanges occur within the same region. Table 3 lists the knowledge sharing connections according to frequency of knowledge exchange for intra-region, inter-region and unknown connections.

From these results, we build proposition 3:

Proposition 3: Geographical location impacts the frequency of knowledge exchange. Knowledge exchange that occurs on a more frequent basis will occur between employees located in the same region.

Influence of Discipline on Knowledge Sharing

Within the sustainability network, interesting results also emerged regarding the influence of discipline on knowledge sharing connections. Whereas we expected to see a bias of knowledge sharing within the same discipline, 58% of the connections were classified as interdisciplinary, 15% were unknown, and only 27% of the knowledge sharing connections occurred between individuals with the same disciplinary background.

Similar to the geographical location, we analyzed these knowledge sharing connections further to determine if the frequency of communication was impacted by disciplinary background. Table 4 displays the inter-disciplinary, intra-disciplinary and unknown knowledge sharing connections based upon frequency of knowledge exchange. As the frequency of communication increases from annual communications to weekly communications, we witness an increase in intra-disciplinary knowledge sharing connections and a decrease in inter-disciplinary knowledge sharing connections. Specifically, interdisciplinary knowledge sharing connections make up 58% of knowledge sharing connections on an annual basis, but gradually decrease to 38% of connections on a weekly basis. Conversely, intra-disciplinary knowledge sharing connections make up only 27% of the annual connections, but increase to 41% of the connections that share knowledge on a weekly basis.

From these results, we build proposition 4:

Proposition 4: Background discipline impacts the frequency of knowledge exchange in interdisciplinary communities of practice. Intra-disciplinary knowledge sharing connections increase with knowledge exchange that occurs on a more frequent basis, whereas inter-disciplinary knowledge sharing connections increase with knowledge exchange that occurs on a less frequent basis.

CONCLUSION

Prior findings have highlighted a need to share knowledge across departmental boundaries to increase knowledge flow (Tsai 2001) and across geographic locations to increase performance (Cummings 2004, Cross and Cummings 2004). However, little is known about how geographic locations and disciplinary backgrounds of participants in an interdisciplinary engineering CoP influences frequency of knowledge sharing.

This research found that the majority of knowledge sharing connections occurred within a region. When we analyzed knowledge exchange according to frequency, we found that knowledge exchange that occurs on a more frequent basis will occur between employees located in the same region. This becomes a large concern based on research in small group communication that emphasizes the need for frequent exchange to ensure the transfer of ideas between participants (Fisher 1974).

When knowledge-sharing connections were analyzed inter-regionally within the network, we found that the majority of knowledge sharing connections was with the home region, in this case the UK, for all regions in which the company operates. This may be indicative of a transfer bias towards centralized knowledge exchange patterns which limits the amount of flexibility firms have to create "boundary spanning" ties to increase innovations.

In addition to geographic location, we wanted to study the influence of disciplines on the creation of knowledge sharing connections within interdisciplinary CoPs in an engineering organization. In addition to the knowledge sharing barriers created in a project-based industry, the industry is also comprised of individuals with diverse disciplinary backgrounds. When we analyzed the knowledge sharing connections for the attribute of disciplinary background, a surprising result was that a majority of ties were interdisciplinary. However, when we analyzed the network for more frequent connections, we discovered that inter-disciplinary knowledge sharing connections decreased and intra-disciplinary knowledge sharing connections increased for more frequent knowledge sharing connections. If, in fact, knowledge sharing that occurs more frequently adds increasing value, this again highlights an area of concern for the organization. Because today's large challenges require an increasingly diverse combination of disciplines to solve, organizations will want to focus on creating connections that span traditional disciplinary and functional backgrounds.

Our future work plans include analyzing the additional attributes collected to determine their influence on both the dynamics and mechanics of the knowledge sharing network. In addition, we plan to expand the study to include additional CoPs from other multinational engineering organizations that include both interdisciplinary and discipline- specific CoPs.

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FIGURES

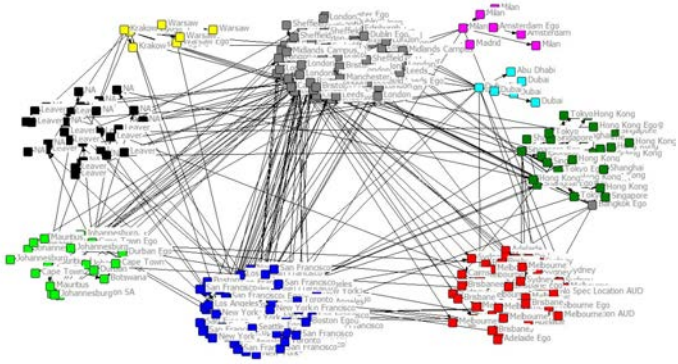


Figure 1: Annual Knowledge Sharing Connections

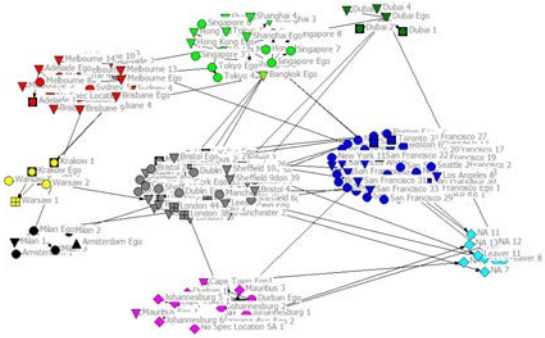


Figure 2: Quarterly Knowledge Sharing Connections

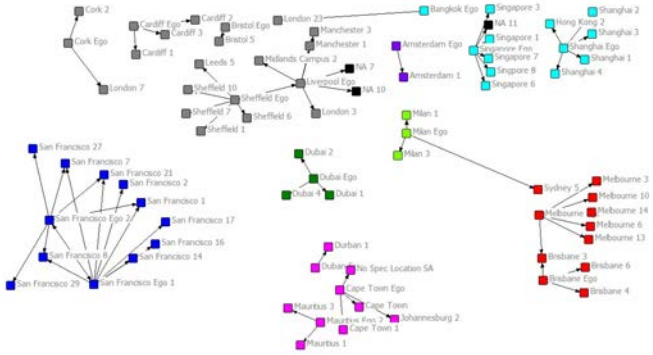


Figure 3: Weekly Knowledge Sharing Connections

TABLES

Table 1: Annual Knowledge Sharing Connections by Region

		EGO'S							
		Africa	Asia	Australia	Eastern Europe	Europe	Middle East	North America	UK
ALTERS	Africa	**58%**	-	-	-	-	-	-	5%
	Asia	-	**59%**	-	-	-	-	3%	3%
	Australia	8%	14%	**89%**	-	14%	18%	6%	10%
	Eastern Europe	-	-	-	**33%**	-	-	-	-
	Europe	-	-	-	-	**43%**	-	-	1%
	Middle East	-	-	-	-	-	**29%**	-	-
	North America	6%	7%	-	7%	-	12%	**71%**	13%
	UK	**28%**	**20%**	**7%**	**27%**	**29%**	**29%**	**15%**	**58%**
	NA	19%	7%	4%	33%	14%	12%	5%	10%
		n=43	*n=47*	*n=27*	*n=15*	*n=7*	*n=17*	*n=136*	*n=115*

Table 2: Quarterly Knowledge Sharing Ties by Region

		EGO'S							
		Africa	Asia	Australia	Eastern Europe	Europe	Middle East	North America	UK
ALTERS	Africa	83%	-	-	-	-	-	-	-
	Asia	-	67%	-	-	-	-	-	-
	Australia	-	10%	100%	-	17%	13%	2%	-
	Eastern Europe	-	-	-	100%	-	-	-	-
	Europe	-	-	-	-	67%	-	-	-
	Middle East	-	-	-	-	-	50%	-	-
	North America	-	5%	-	-	-	-	88%	20%
	UK	-	14%	-	-	17%	25%	7%	75%
	NA	17%	5%	-	-	-	13%	3%	6%
		n=18	*n=21*	*n=14*	*n=3*	*n=6*	*n=8*	*n=60*	*n=51*

Table 3: Knowledge Exchange Frequency based upon geographical location

	Frequency of Knowledge Exchange			
	Yearly	***Quarterly***	***Monthly***	***Weekly***
Intra-Region	62%	80%	86%	93%
Inter-Region	29%	14%	8%	2%
NA	9%	6%	6%	4%
	n=407	*n=181*	*n=139*	*n=69*

Table 4: Knowledge Exchange Frequency based upon discipline

	Annual	**Quarterly**	**Monthly**	**Weekly**
Inter-disciplinary	58%	50%	44%	38%
Intra-disciplinary	27%	33%	35%	41%

Unknown	15%	18%	21%	22%
	n=407	*n=181*	*n=139*	*n=69*

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THE AMSTERDAM GUIDE TO ENERGETIC URBAN PLANNING

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Abstract

The City of Amsterdam has ambitious goals as to become climate neutral. This will only be possible through a structured approach to both new and existing neighbourhoods.

Following steps from the New Stepped Strategy - as used in the Rotterdam Energy Approach and Planning (REAP) - and using the methodology of Energy Potential Mapping (EPM), the Amsterdam Guide to Energetic Urban Planning (in Dutch: Leidraad Energetische Stedenbouw, LES) must become the manual that will support urban area (re)development towards energy neutrality.

The Guide clarifies local Amsterdam energy potentials, both natural and anthropogenic, and gives an extensive overview of measures and data to be used for the sustainable provision of electricity, heat and cold. This is presented in a very tangible manner, practical to urban planners, architects, housing corporations, developers, public institutions and politician.

The Amsterdam Guide has been tested on two sites, one to be newly constructed and another to be redeveloped, and the incremental approach proved worthwhile, enabling energy neutrality in both cases. The Guide has incited discussions on both short-term actions and long-term visions needed to facilitate real climate neutrality in the city of Amsterdam.

Keywords: sustainable urban planning, New Stepped Strategy, Rotterdam Energy Approach and Planning, Energy Potential Mapping, energy neutrality

INTRODUCTION

Urgency

In spite of some discussion caused by inaccuracies in their 2007 reports, the general conclusions by the IPCC [2007] still stand and are widely supported. The climate is changing at an unprecedented rate and mankind is one of the major causes as acknowledged.

Although the earth receives almost 9000 times more energy from the sun than that mankind needs, energy is becoming a huge problem. Western societies heavily rely on energy, fossil fuels in particular. The Netherlands for instance produces less than 4% of its energy by means of sustainable sources [CBS, 2008]. The rest is fossils and a bit of imported nuclear energy. As Mackay [2009] demonstrated, it is very difficult to establish a society fully run on renewables. However, Cullen & Alwood [2010] showed that most of the energy we use is lost as non-functional waste energy. So the initial demand can be reduced by more effective usage, such as by low-exergy means [Stremke et al., 2011].

Although estimates of resources fluctuate, it is apparent to both energy experts and oil companies that the end is coming near. We have passed peak oil [ITPOES, 2010]: these days we consume more oil than can be produced. That this is a literally dangerous situation was demonstrated by the two gulf wars and recent turmoil around gas from Russia (first: Ukraine disconnected, second: Belarus threatening to halt the throughput of Russian gas). Apart from this international perspective and its influence on the price of energy, few people from the West understand how dependent they have become on energy, and that a collapse in the provision would have devastating effects to everyday life.

Last but certainly not least, the western appetite for energy is severely limiting the opportunities of developing and emerging regions to catch up in prosperity. As figure 01 indicates, western countries owe their prosperity to limited use of energy in other parts of the world. Needless to say this situation deviates strongly from the equity goals posed by the Brundtland Committee in 1987.

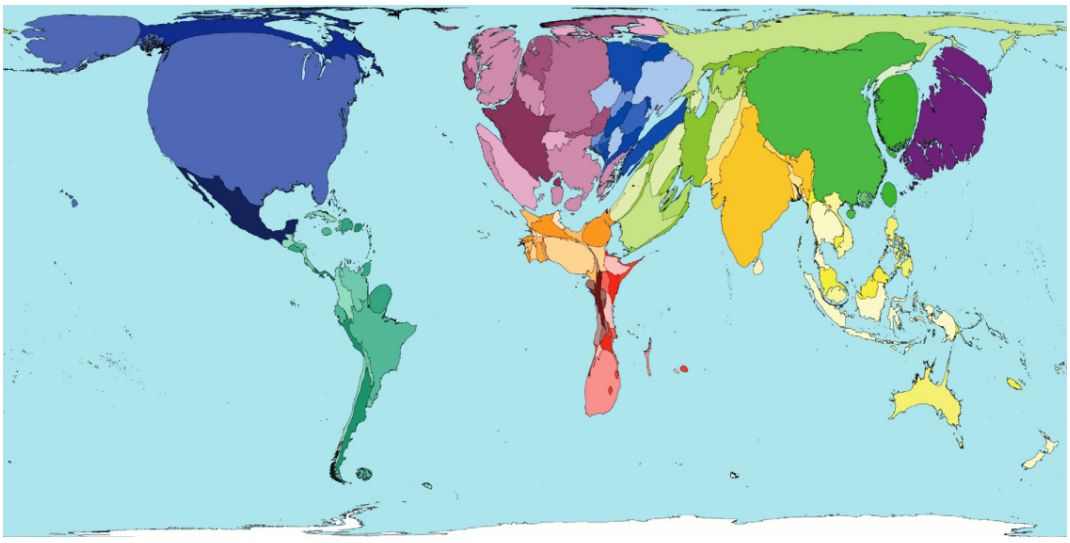


Figure 1: *Developed countries above the equator infest on other regions for energy… Countries and the area of land respective to the amount of fuel they consume [Dorling et al., 2009, downloadable from www.worldmapper.org]*

The abundance – until now – and relatively cheap and easy access to fossil energy has made the world lazy and inactive to search for local possibilities that would avoid demand from alien energy in the first place. We need to learn this again: planning and designing in such a way that local resources are optimally seized before any demand is posed upon other areas.

How can an urban area become energy neutral ? To accelerate this transition planning and design are crucial aspects to consider. Urban planners are in need of planning tools that bridge the gap between mapping, planning, zoning and designing on one hand and understanding of spatial implications of energy, technical energy data, energy solutions and energy scenarios on the other hand.

Climate-neutral ambitions

10 September 2008 the Amsterdam municipal council decided that as of 2015 new construction projects need to be climate-neutral. This means that projects need to comply with the definition of climate-neutral building (see section 1.3), with a 9.0 - 9.5 score of the Dutch EPL (energy performance on location. This council decision implies that energy will become an integral part of area development, a challenge and opportunity as cooperation between projects and connection with the surroundings offers added value at various scale levels.

The Amsterdam approach to climate-neutral building aims at project development and the contribution authorities can make therein. Agreements can be made, for instance, on the thermal insulation rate as well as energy consumption and generation. The ambitions can only be realised through a structured approach to both new and existing neighbourhoods.

Definitions

In Amsterdam, 'climate neutral' is defined as "building without use of fossil resources for the building-related energy demand" [Ontwikkelingsbedrijf Amsterdam, 2009]. This encompasses heating and cooling, hot tap water, ventilation and lighting, all ingredients of the energy performance of a building, however approximately half of all energy used in buildings. The other half is user-related (predominantly from user appliances).

In terms of the Amsterdam definition of climate neutral, critical connotations can be made, as the term actually implies a net zero effect on the climate, including all emissions with an influence on the climate, not just carbon dioxide (CO_2), yet also nitrous oxide (NO_x), water vapour, chlorine-fluorine-carbons (CFCs), methane (CH_4), ozone (O_3) etc. Through the avoidance of fossil fuels for building-related energy demands, emission of carbon dioxide, and a great deal of methane, nitrous oxide and water vapour is avoided, but not everything. Usage of biomass – provided it is replanted – may be considered as climate- or carbon-neutral, but the technical means to enable this may not be as such. The story is slightly different when using solar energy, wind and geothermal heat. These sources produce no CO_2 and their equipment for energy conversion will be energetically earned back within a certain time-frame, leaving no climate marks on the planet.

In this sense the Amsterdam definition rather equals energy neutral than climate neutral. Also carbon-neutral would describe the aim better than climate-neutral. Perhaps even better would be 'fossil energy free': avoiding any use of fossil fuels in building-related energy consumption.

This said, the official objective of the city is clear through its own definition of climate neutral, and we can proceed how to achieve it.

METHODOLOGICAL BASIS

The Amsterdam Guide to Energetic Urban planning is founded on methods previously developed: Energy Potential Mapping (EPM) and the Rotterdam Energy Approach & Planning (REAP), which in its turn is based on the New Stepped Strategy. All of them will be discussed in this chapter.

Energy Potential Mapping

The foundations for the method of Energy Potential Mapping (EPM) were laid during the Grounds for Change project [Noorman et al., 2006], where new perspectives were sought for a sustainable energy system in the Northern Netherlands (provinces of Frisia, Groningen and Drenthe). This region traditionally had provided the country with energy – peat in the 19th and early 20th century, mineral oil since the 1950s and natural gas since 1960. and is de methodiek van energiepotentiekaarten ontstaan. The design team of Grounds for Change [Roggema et al., 2006] introduced a cartoonesk way of charting potentials in the region for energy harvest.

The method of EPM was significantly improved and provided with a scientific approach through a study for the new environmental plan (POP) of the province of Groningen [Dobbelsteen et al., 2007]. Based on rudimentary information from topographic, climatic, geophysical and infrastructural maps, various new GIS-based maps were produced for potential production of renewable fuels, power generation, heat and cold potentials and even possibilities for carbon sequestration. Figure 2 clarifies the method developed.

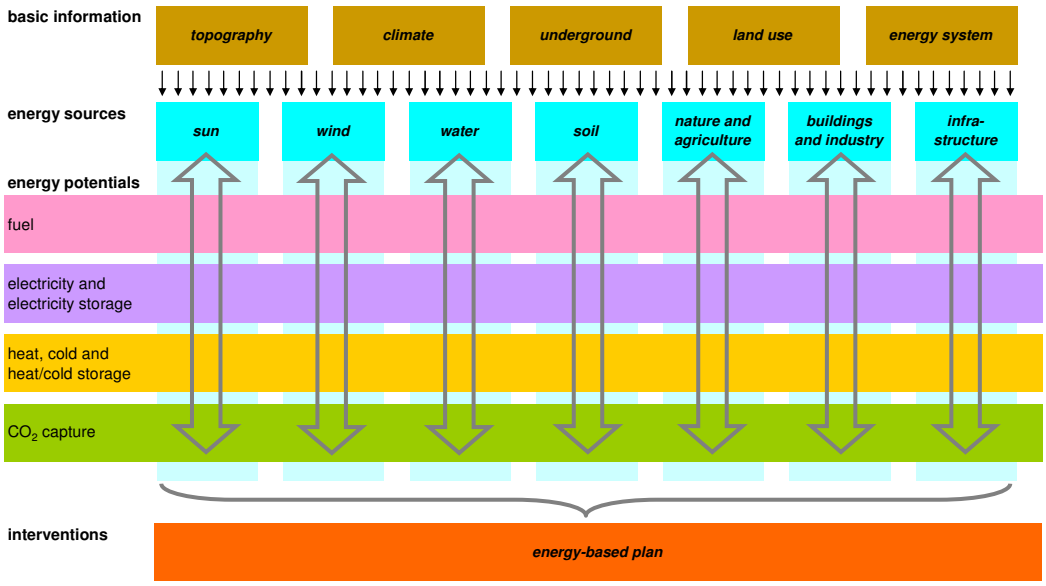


***Figure 2**: Method of Energy Potential Mapping, graphically clarified [Dobbelsteen et al., 2007]*

After the POP Groningen report, EPM was further enhanced and tested at other scales through the EPM studies for expansion plans of Almere, Schiphol Airport and Hoogezand-Sappemeer [discussed in Dobbelsteen & Broersma, 2010]. For Schiphol and Hoogezand-Sappemeer the outcome was newly presented in stacked maps, depicting energy potentials at

various heights and depths, as shown in figure 3, which enabled calculations of the maximum yield to be reapt. In the case of Hoogezand-Sappemeer, the energy produced would potentially exceed the demand, which is important as the new development then could also serve older parts in town.

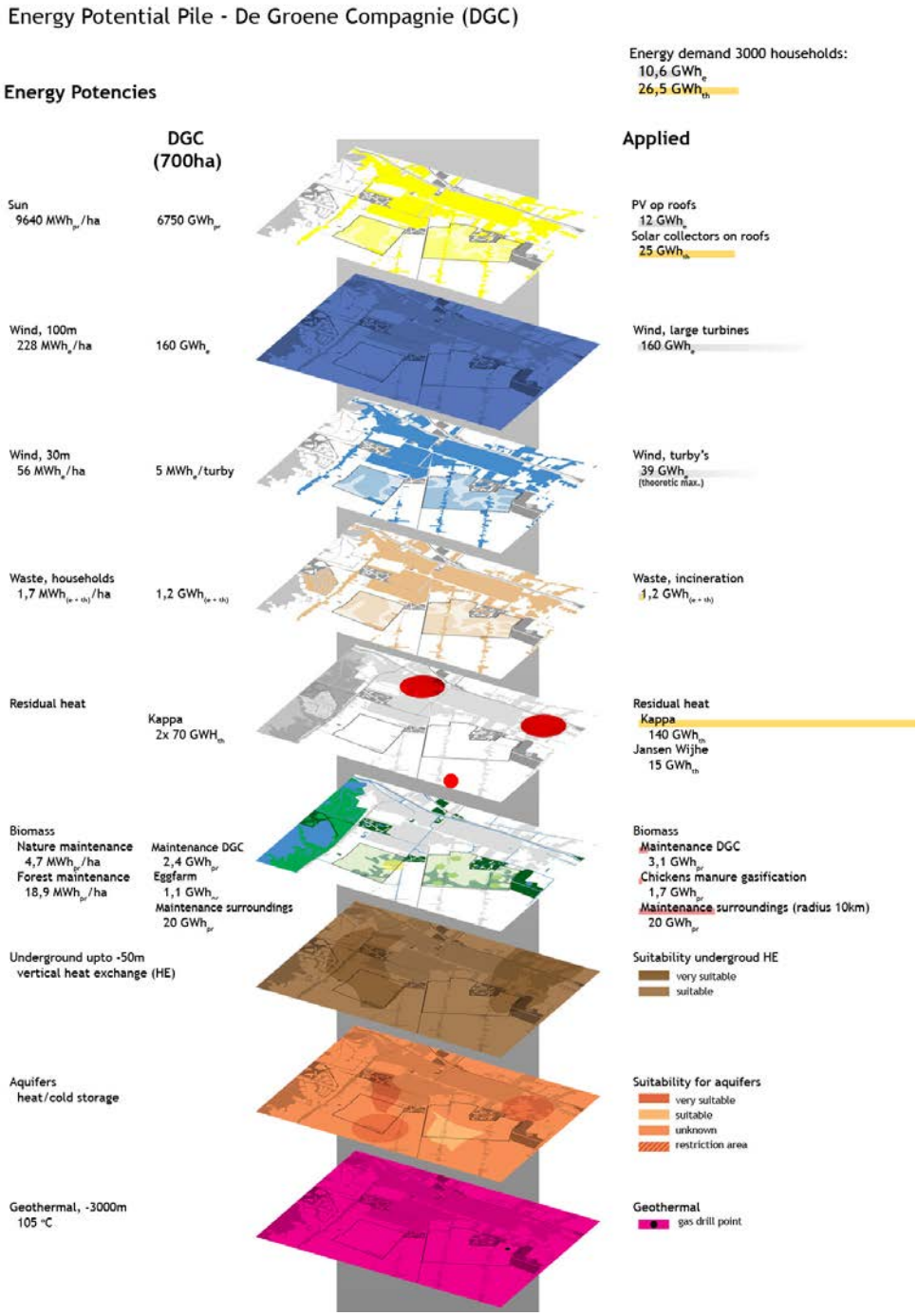


***Figure 3**: Energy potential map for the expansion plan of Hoogezand-Sappemeer, depicting energy potentials at various heights and depths, enabling calculations of the total energy yield possible [Broersma et al., 2010]*

A last development in the EPM range are the heat maps made for the Netherlands [Broersma et al., 2010], focusing solely on heat and cold demand and supply, and meant to feed a national website, which will serve the realization of better exchange of energy in the built environment, or even the spatial planning of new developments.

The New Stepped Strategy

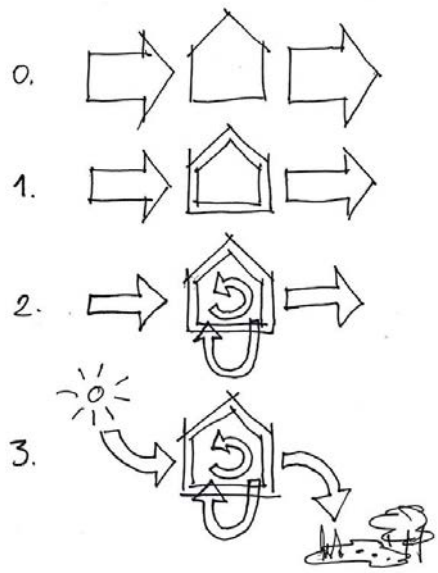
Since the end of the 1980s, approaches to sustainable building have often followed the 'Trias Energetica' [Lysen, 1996], or three stepped strategy:

1. Reduce the demand
2. Use renewable energy
3. Supply the remaining demand cleanly and efficiently

The Trias Energetica forms the guideline for a logical, environmentally conscious approach. However, in the period it has been in use it has not led to the progress required. In particular the extent of penetrated renewable energy technology, step two, is minimal. Mainly in the Netherlands one mainly concentrates on step 3, after limited efforts with step 1 and skipping step 2. No wonder the Dutch are still relying on non-sustainable energy for 96% of their demand.

That step 2 is often neglected and so little use is made of sun, wind and other renewable energy sources has a lot to do with the step abruptly following a sub-optimal reduction in energy demand and with the fact that an important intermediate step is not explicitly mentioned in the Trias.

This is the reason why, the New Stepped Strategy (NSS) [Dobbelsteen, 2008] was presented as a substitute for the Trias Energetica. This strategy adds an important intermediate step between the reduction in demand and the use of renewable sources, and it incorporates a waste stream strategy, inspired by the Cradle-to-Cradle philosophy [McDonough & Braungart, 2002]. The former last step, implying hence accepting the use of fossil fuels, is abolished. Thus, the New Stepped Strategy is as follows (depicted by figure 4):



1. Reduce the demand
2. Reuse waste streams
3. Use renewable energy sources (a) and ensure that waste can be used as food (b)

Figure 4: *Principle of the New Stepped Strategy [Dobbelsteen, 2008]*

The Rotterdam Energy Approach & Planning (REAP)

Based on the New Stepped Strategy, a team of people from the City of Rotterdam, architects and TU Delft [Tillie et al., 2009a] developed the Rotterdam Energy Approach & Planning (REAP) for a structural approach to urban areas. Therefore, the three steps of the NSS were not only connected to buildings yet also to clusters or neighbourhoods, districts and the entire city. Figure 5 graphically clarifies the principle of REAP method.

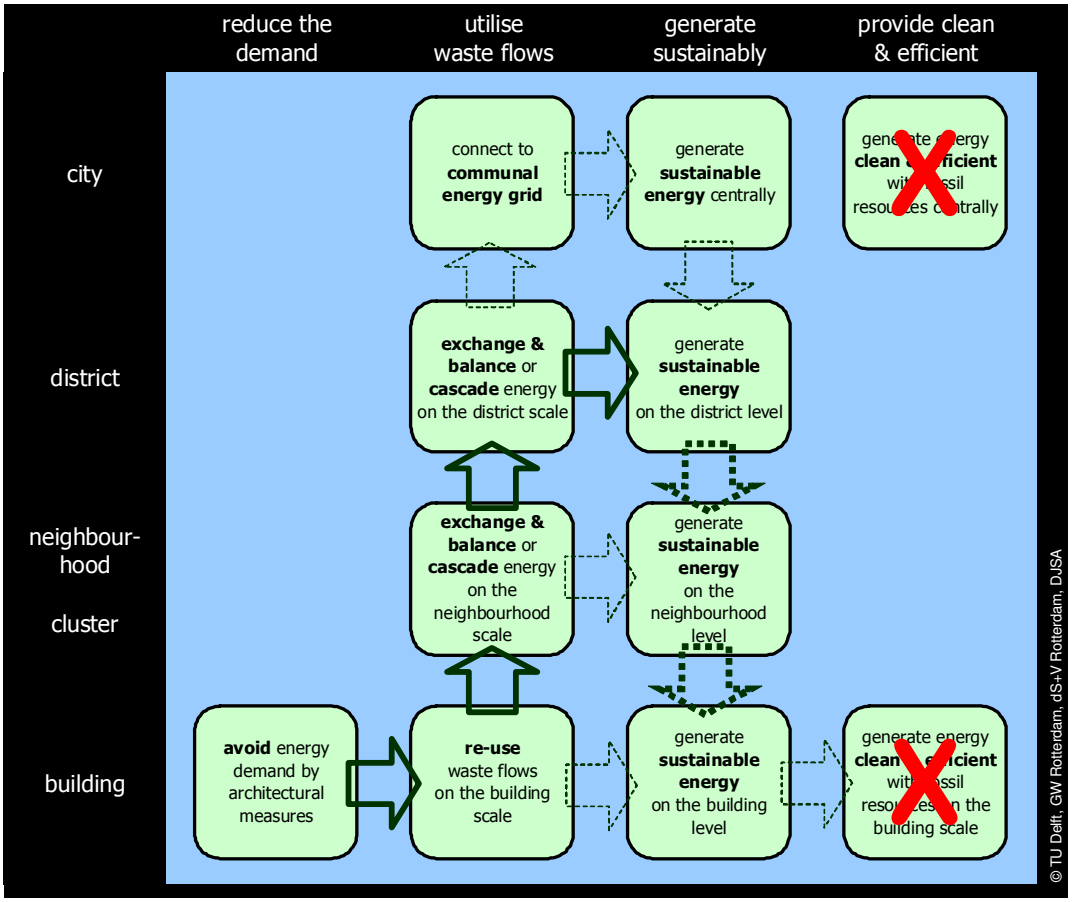


Figure 5: *Principle of REAP for urban areas: the New Stepped Strategy that starts with buildings but expand to neighbourhoods and district for optimal balancing of supply and demand before the question of sustainable generation is tackled [based on Tillie et al., 2009a]*

REAP was tested on, or actually evolved with a study of, the district of Hart van Zuid ('heart of south'), for which the City of Rotterdam wanted to explore the possibility to become carbon neutral. The largest harbour city of Western Europe has the ambition to become 50% carbon neutral by 2025, so interventions in the existing urban landscape will be necessary. REAP demonstrated that Hart van Zuid could become carbon neutral without devastating demolition of existing building, however with smart exchange of waste energy streams from different urban functions, as well as some additions of greenhouses, green facades and roofs.

The essential novelty in the REAP method is the explicit step of exchanging, balancing and cascading of waste energy in an urban context (figure 6). Earlier approaches had neglected this yet unreapt energy potential in cities.



Figure 6: *Urban functions have totally different energy patterns for heat (W), cold (K) and electricity (E). This image shows that a logical connection between specific functions can be made that require heat or cold, since the generation of cold produces waste heat, which can be used elsewhere but usually is emitted into the air [Tillie et al., 2009a]*

Since its presentation in a Dutch and English language book [Tillie et al, 2009a], it was handed to the Dutch minister of the environment, got coverage on national tv and radio, was published in a scientific journal [Tillie et al., 2009b] and inspired other cities to work accordingly. One of them was the city of Amsterdam.

THE AMSTERDAM GUIDE

Amsterdam Guide to energetic urban planning (in Dutch: Leidraad Energetische Stedenbouw, LES) must become the manual that will support urban area (re)development towards energy neutrality [Kürschner et al., 2011].

Outline of the Amsterdam Guide

The Guide clarifies the local Amsterdam energy potentials, both natural and anthropogenic, and gives an extensive overview of measures and data to be used for the sustainable provision of electricity, heat and cold. This is presented in a very tangible manner, practical to urban planners and architects, housing corporations and project developers, public institutions and politician. Figure 7 gives an overview of measures (in simplified icons) in the Amsterdam Guide, divided between heat and cold versus electricity, with the potential improvement of energy performance added.



Figure 7: *Overview of the Amsterdam Guide to energetic urban planning, according to the New Stepped Strategy and with a division between measures (simplified in icons) for heat and cold (thermisch) versus electricity (Elektra); big printed numbers and percentages below are the potential improvement in energy performance*

Amsterdam potentials

The Amsterdam Guide commences with an inventory of all energy potentials of the city, in accordance with the method of Energy Potential Mapping. Thus the booklet gives all potentials of natural energy sources and anthropogenic functions that produce waste streams. This latter is of course necessary for the second step of the New Stepped Strategy.

Factsheets

Where REAP was merely a method for an approach to energy-neutral or carbon-neutral cities, the Amsterdam Guide is presented as a handbook, guideline for urban planning within the objectives of the Amsterdam climate goals. The method is set within the municipal managerial system of PLABERUM (translated in English: 'planning and decision making of spatial measures') and gives practical data regarding financial and technical-spatial measures. Figure 8 gives apart of the overview of measures of thermal energy.

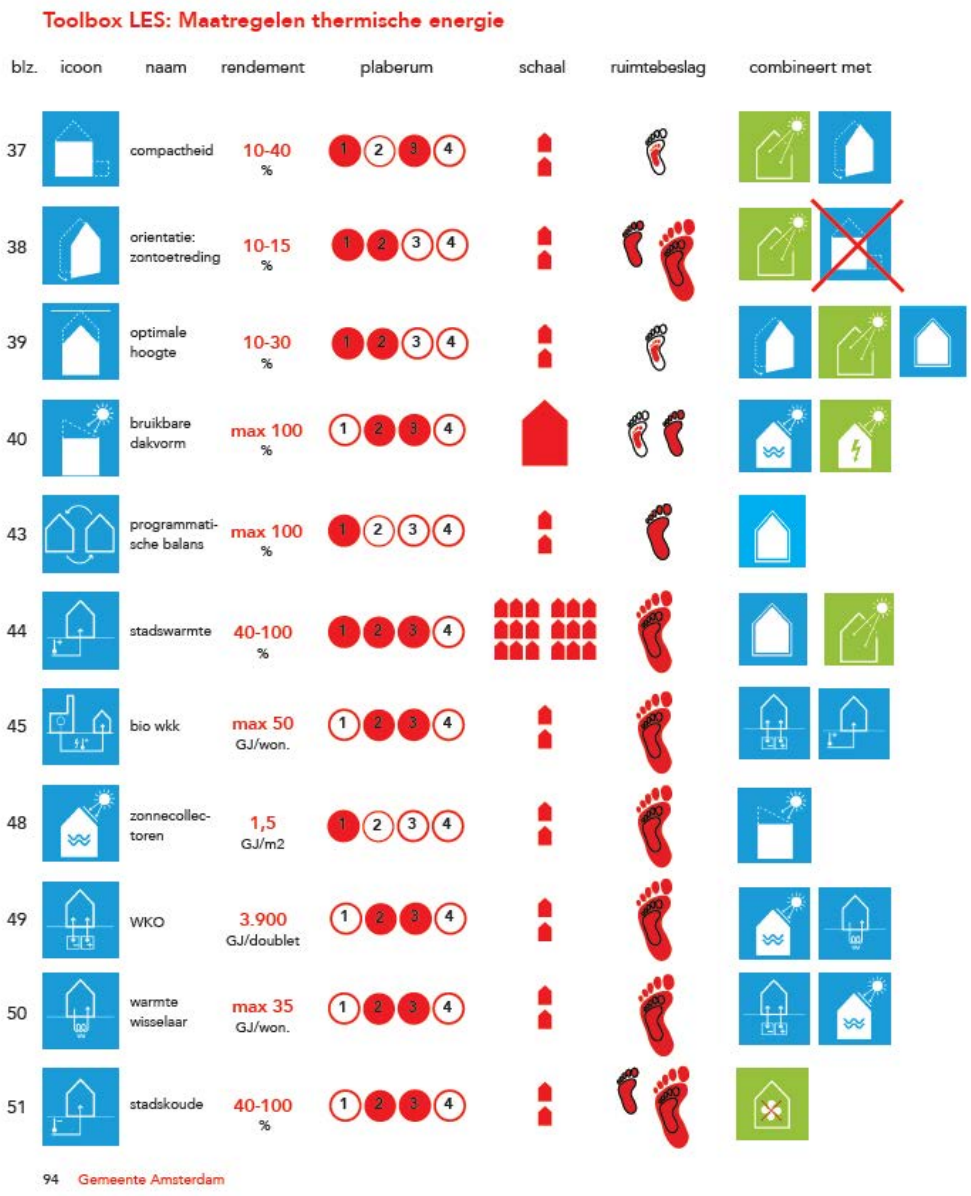


Figure 8: *Overview of the Amsterdam Guide to energetic urban planning, according to the New Stepped Strategy and with a division between measures (simplified in icons) for heat and cold versus electricity; figures in the column 'rendement' are the potential improvement in energy performance*

Measures are presented in factsheets, of which figure 9 gives two examples, one for heat and cold, one for electricity. These factsheets are meant to be practical and helpful for urban planners and other stakeholders involved in the process of making Amsterdam climate neutral.

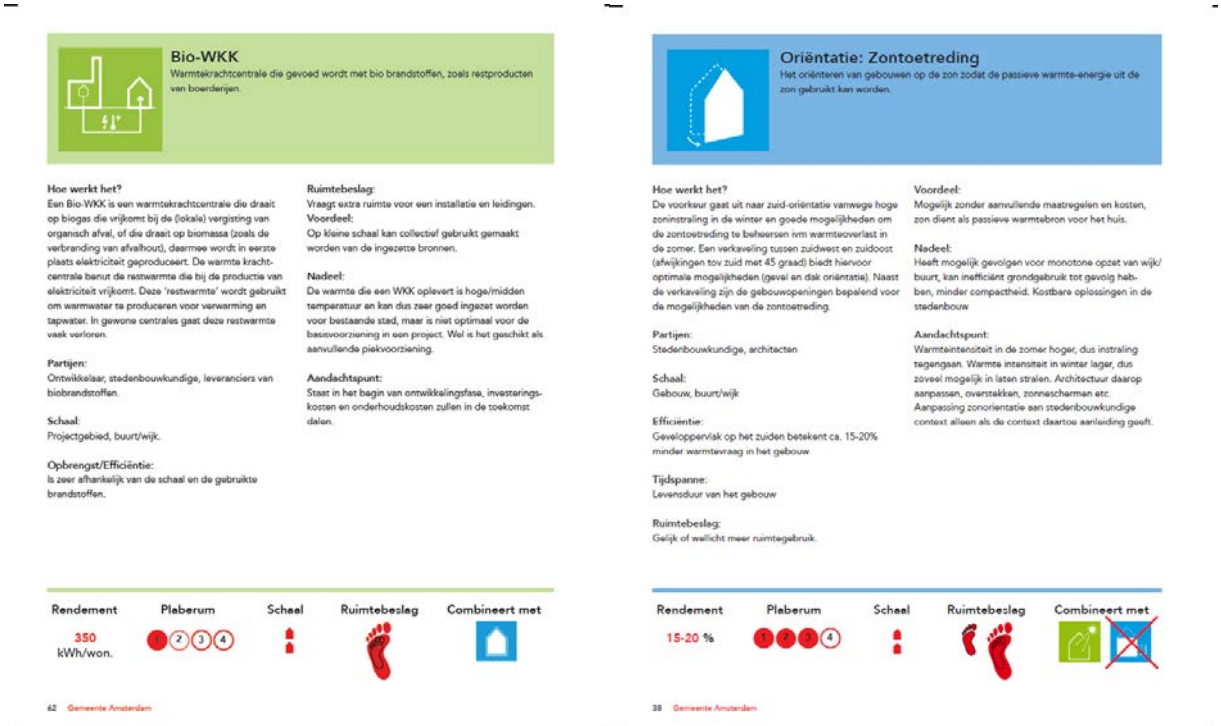


Figure 9: *Two examples of factsheets within the Amsterdam Guide, on the left hand side bio CHP for heat production and on the right hand side solar access for power generation*

Case studies

The Amsterdam Guide has been tested on two sites, one to be newly constructed (in northern Amsterdam) and another to be redeveloped (in western Amsterdam). With a mixed team of urban planners. energy experts from energy companies, housing corporations, project leaders and the authors presentations were given about the Amsterdam Guide about how to use it, showing what options planners have. After that each group worked on of the areas in an iterative design process planning and energy options were tested in the design and a reality check was performed directly with the stakeholders at the table. After this an energy performance was calculated via an excel sheet of the Amsterdam Guide. The outcome was direct feedback in the ongoing process. This incremental approach proved worthwhile, enabling energy neutrality in both cases. The Guide has incited discussions on both short-term actions and long-term visions needed to facilitate real climate neutrality in the city of Amsterdam. Both urban areas could be made energy-neutral according to the steps of the Amsterdam Guide.

Implementation

Before being finally presented, the Amsterdam Guide was discussed with a response group of

people who would have to work with it or who had profound knowledge of the matter. These meetings were used to improve the model. The concept version of the booklet was presented and discussed with the Amsterdam alderman for spatial planning, and finally it was presented early 2011 to colleagues of the departments of spatial planning and environmental & building regulations, hence the people who need to work with it in practice. The response to this was positive and everyone was asked to test the model in concurrent projects and get back with comments or suggestions for improvements.

DISCUSSION AND PERSPECTIVE

The Amsterdam Guide to energetic urban planning, just as REAP, so far have only been theoretic, though practical, methods that could help urban development towards energy, carbon or climate neutrality. Useful as they may seem, the proof is in tasting the pudding, so ongoing projects within the cities of Amsterdam and Rotterdam will have to show whether the models actually work.

In Rotterdam a REAP follow-up study recently started to investigate not just the technical consequences, yet also the legal, strategic, social and spatial consequences. The test-case this time will be a real project to be elaborated by the municipality, giving it a proper meaning and insight to: What energy scenarios are possible at this local level; what are the building blocks used, to make combinations between scenarios; what are the back up systems and what are the legal, spatial and social consequences.

In Amsterdam, several areas are under study, paving the way for a new approach according to the Amsterdam Guide. The year of 2011 will provide the first findings of working according to the method, inevitably leading to necessary improvements to version 2.0, expected late 2011.

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CLIMATE CHANGE EFFECTS ON LIVING QUALITY; AWARENESS OF HOUSING ASSOCIATIONS

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Abstract

A changing climate can have a large influence on the living quality of houses. A case study was carried out on the level of awareness of housing associations. This study forms the start of a research project on governance strategies for adaptation in residential buildings. A content analysis on climate change related topics was pursued on the policy plans and the most recent annual reports of the 25 largest Dutch housing associations. They were classified according to their level of awareness. Based on the results of the analysis it is concluded that the housing associations fall within the lowest category of awareness. In order to reach higher levels of awareness, governance strategies for adaptation have to be developed. The nature of possible strategies will depend on the level of awareness of the housing association. The definition of strategies will be studied in the future.
This research provides basic information on 'climate change awareness' that is valuable for governmental and non-governmental policymakers on the national, regional and local level, who are dealing with climate change issues.

Keywords: Awareness, Climate Change, Adaptation, Social Housing, Energy Efficiency

INTRODUCTION

There is clear scientific evidence of a changing climate on the global and the national level. The Intergovernmental Panel on Climate Change (IPCC) states that "Warming of the climate system is unequivocal". It reports that during a period of twelve years - between 1995 and 2006 - eleven rank among the warmest years since measurements started in 1850 (IPCC (2007a). The Royal Dutch Meteorological Institute (KNMI) found out that the long term mean temperature in the Netherlands has risen by 1.7˚C since 1900, while the global increase was 0.8˚C. In the time frame 2003-2008 three years were part of the top-10 warmest years since measurements started in 1706 (KNMI, 2008). These evidences determine that policy makers have to start facing the consequences of changing environmental circumstances. Scientists commonly agree that climate change is a fact, and they are now investigating the precise impact of it on the living quality in our cities, offices and houses, and how we can prepare for and adapt to these impacts.

In the international debate on climate change, opinions diverge. Internet forms a broad base for blogs and blog posts from adopters, who actually believe that the climate is changing (Gore, 2010) and skeptics, who don't believe that climate is changing [i, ii, iii]. The discussion even entered into the Dutch political system, when errors were discovered in the Fourth Assessment Report of the IPCC early 2010. This was a motive for the Dutch House of Representatives to ask the minister of Housing, Spatial Planning and the Environment for an evaluation of the report. This was carried out by the Netherlands Environmental Assessment Agency (PBL) which concluded that the report did not contain any significant error. It did confirm, however, that more transparency is required in the Fifth Assessment Report (due in 2013), concerning both the sustenance of the findings and the benefits of climate change (PBL, 2010). In this paper we follow the line of the PBL. We trust the work of the thousands of scientists, who have collaborated on composing the IPCC report, until there is scientific evidence that they drew the wrong conclusions. The skeptic voices have sharpened our critical attitude which will help us presenting the most realistic results and solutions for effective adaptation strategies. After all, we know that housing associations will not take all scientific evidence for granted.

With the intention to reduce the effects of climate change (mitigation), policies have been adopted on the international and the national scale. For example, the European Commission has approved Directive 2002/91/EC, known as the Energy Performance of Buildings Directive (EPBD) (EP, 2002). In the Netherlands, this EPBD is applicable on existing buildings. Moreover, for new buildings legislation on energy performance is operative. Because a building can only be built when it complies with the building code, property owners and the building industry are automatically aware of the legal mitigation measures. However, even if it is possible to stabilize greenhouse gas emission, the changing process and its corresponding effects will continue developing (IPCC, 2007). Consequently, measures have to be developed for adaptation, which is defined as "any action, either intentional or accidental taken to minimize the adverse effects of climate change or to take advantage of any beneficial effects" (Crown, 2006). Policy on this theme is being made on a regional and a national scale. The European Union has shown adaptation awareness by firstly launching a Green paper on Climate Change in 2007, which set out ideas on adaptation measures, (CEC, 2007), followed by a White Paper on climate change in 2009 (CEC, 2009), proposing legislation on the matter. On the level of national governments, adaptation strategies are ready or in progress in countries such as Denmark, Finland, France, Germany, Hungary, the Netherlands, Romania, Spain and the UK (Biesbroek et al., 2010). On a local scale, information is more diffuse, but adaptation strategies are implemented or under development in cities such as Cape Town, Durban, Quito, Tokyo, Walvis Bay and Windhoek (MIT, 2011). The conference '*Resilient Cities 2011, 2nd world congress on cities and adaptation to climate change*', will strongly contribute to awareness among all participating cities (ICLEI, 2011). The engagement of the 'Hotspots'/Stakeholder cities in the Climate Proof Cities project in the Netherlands (Knowledge for Climate, 2010) indicates that they are also aware of a changing climate. The sense of urgency for adaptation has emerged as plan development field in the new Millennium (Biesbroek, 2010). As a result, much effort is still put into the setting up of adaptation programs, which can eventually lead to legislation. As a consequence, the awareness of adaptation is not as widely spread as awareness of mitigation, especially on the level of the property owners and the building industry.

In order to find out if the awareness of adaptation has already reached the operational level of policy making, we carried out a case study among housing associations in the Netherlands. They own and manage 2.3 million dwellings, which is approximately 32% of the total Dutch housing stock (CFV, 2010). Their successful involvement in the adaptation of the built environment will not alone provide living quality for the social stock, but will certainly help

to reach a substantial part of the existing housing stock and provide tools for private owners to follow similar actions. Knowing the state of awareness of the housing associations, appropriate governance strategies for adaptation can be developed. This study on awareness is considered as a starting point for a larger research on the application of climate change adaptations in social housing.

DUTCH HOUSING ASSOCIATIONS

Housing associations have legal duties on six performance fields, being: the quality level of the dwellings, renting of the houses, tenant-participation in policy making and management, financial continuity, livability, and housing and care (BBSH, 2011). Focusing on the quality aspect, it is their task to be aware of the changes that might challenge the living quality of their tenants and to provide housing with future value, which includes climate change resilience.

Energy efficiency

Since January 1, 2008, it has been compulsory for housing associations to hand over an energy label at the transaction moment of a dwelling. This obligation follows from the implementation of the EPBD. In the Netherlands, the energy label is merely a communicative instrument because of a lack of law enforcement possibilities and/or sanctions, and because a required minimum energy performance level is missing. However, it does give an insight in the energy performance of the dwelling. As most housing associations have 'labeled' all units in their possession, they know the current energy performance status of their building stock (Tambach et al., 2010). This insight, complemented by the housing associations' statutory performance requirements on livability and its sense for Social Corporate Responsibility (SCR), has opened possibilities for the introduction of the 'energy efficiency'-theme in the strategic asset management. By implementing energy saving measures, the associations fulfill their task of providing affordable housing, as they slow down the influence of the rapidly increasing energy costs on the overall operating costs. They also improve the living quality of the building, as for example an insulated wall or window not only saves energy but usually also contributes to noise reduction; humidity decrease and cold air flow reduction (Smid and Nieboer, 2008).

However, it is not only the 'social incentive' (livability, SCR) that makes the housing associations more alert on energy saving. The Dutch government has set up energy saving goals as the consequence of the ratification of the Kyoto Protocol. In order to reach these goals they approach the housing associations as one of the key actors, since the social housing stock is considerably large, with a projected emission of 137 Mton CO2 in the period 2009-2020 (adapted from: Rooijers et al., 2009). The so called 'Covenant Energy Saving Housing Association Sector' was set up, where housing associations and government have agreed on mutual efforts to improve the energy efficiency in the period 2008-2020. During the course of the covenant, housing associations have to invest in energy saving measures, targeting for an energy reduction of 24 PètaJoules. The measures to reach this reduction are: pursue to reach energy label B or raise 2 label steps (for instance from F to D) when performing high level renovation interventions and reduction of energy use of newly built dwellings with 25% from 2011 and 50% from 2015 (reference year 2007). In turn, the government is committed to introduce the valorization of the energy performance in the 'dwelling evaluation system' (MinVROM, 2008). This is a system used in the Netherlands to rate the quality of the dwellings in the rental sector. The height of the evaluation score determines the maximum rent a housing association is allowed to ask for the dwelling. If the

association improves the energy label, the evaluation score and maximum rent will increase accordingly. In this way, applying energy saving measures provides extra income for the housing associations.

CLIMATE CHANGE IN THE NETHERLANDS

As exemplified in the foregoing, the current national and local governance strategies focus mainly on mitigation rather than adaptation. This can be seen in the ambitions of CO2 reduction and energy saving measures of the existing building stock. However, policies are to a large extent based on responsibilities of actors, building owners and contractors, and on market mechanisms. These last appear not to work well enough to reach the intended goals in the Netherlands (Daniels and Kruitwagen, 2010). Together with the unstoppable changing process of the climate (IPCC, 2007), adaptation measures are inevitable to withstand the upcoming effects of climate change.

Climate change adaptation

The temperature in the Netherlands has risen significantly in the last decade, as described in the introduction. Also the overall precipitation has increased with 18% over the past century and the multi-day precipitation amounts augmented, especially in winter (KNMI, 2006). Moreover, the summer rainfall values in the coastal zone (between 0 and 30 km's from sea) are higher than in any other part of the Netherlands, which is expected (but not scientifically proven) to be influenced by the rising water temperature of the North Sea (KNMI, 2008). The effects of climate change in the Netherlands are numerous. The sea level will rise (KNMI, 2006), threatening the lower parts of the Netherlands and the major rivers will have more run-off in winter (Bessembinder, 2008), threatening the areas close to this rivers. All together, the risk areas for sea and river flooding cover 55% of the surface of the Netherlands (PBL 2011). Another thread comes from intensified peak precipitation, which can cause local flooding (Bessembinder, 2008). The increase of temperature will affect the natural environment (PBL, 2009) and the climate in the cities (Salcedo Rahola et al., 2009).
In order to create a base for planning and policy making, four scenarios have been developed by the KNMI showing the prognosis of the state of the climate in 2050 (see table 1) and in 2100. Although there are some different trends in various scenarios, the average temperature is expected to rise in all scenarios, as well as sea level and peak precipitation (KNMI, 2006).

		G	G+	W	W+
Global temperature rise		+1°C	+1°C	+2°C	+2°C
Change in air circulation patterns		no	yes	no	yes
Winter [3]	average temperature	+0.9°C	+1.1°C	+1.8°C	+2.3°C
	coldest winter day per year	+1.0°C	+1.5°C	+2.1°C	+2.9°C
	average precipitation amount	+4%	+7%	+7%	+14%
	number of wet days (≥ 0.1 mm)	0%	+1%	0%	+2%
	10-day precipitation sum exceeded once in 10 years	+4%	+6%	+8%	+12%
	maximum average daily wind speed per year	0%	+2%	-1%	+4%
Summer [3]	average temperature	+0.9°C	+1.4°C	+1.7°C	+2.8°C
	warmest summer day per year	+1.0°C	+1.9°C	+2.1°C	+3.8°C
	average precipitation amount	+3%	-10%	+6%	-19%
	number of wet days (≥ 0.1 mm)	-2%	-10%	-3%	-19%
	daily precipitation sum exceeded once in 10 years	+13%	+5%	+27%	+10%
	potential evaporation	+3%	+8%	+7%	+15%
Sea level	absolute increase	15-25 cm	15-25 cm	20-35 cm	20-35 cm

Table 1: *KNMI'06 climate scenarios for 2050 (source: KNMI 2006).*

Risks affecting the social housing stock

As climate change shall inevitably threaten the well being of their clients, housing associations need to withhold climate change from decreasing the living quality of their building stock. With the current knowledge, key issues to focus on are discomfort caused by heat and consequences of flooding, as these have a direct influence on the living quality of the tenants.

Heat effects

The main heat effects are directly related to human health issues, rather than the financial damage on properties caused by natural catastrophes such as flooding. Expected effects are heat stress, summer smog, and allergies and viruses. A positive effect of a warmer climate is the reduced illness and mortality in winter (PBL, 2009).

As 62% of the social housing stock is located in urban areas (with a density > 1500 addresses per sqkm, VOIS, 2011), special attention is paid to the 'Urban Heat Island'-effect. This is the effect where the urban structure accumulates heat and consequently is warmer than the surrounding countryside. The highest temperature differences occur at the end of the day and can reach up to 10˚C (Salcedo Rahola et al., 2009). The 'Urban Heat Island'-effect is caused by several factors, being absorption of sun radiation, air pollution, 'street canyons', anthropogenic heat (cars, air conditioners, industrial processes etc.), heat storing materials, decreased evaporative surfaces, and reduced wind speeds (Kleerekoper et al., in press)

Water effects

The risk of flooding caused by sea and major rivers will be tackled to a large extent if the national government executes the measures proposed by the 'Delta Commission' (Deltacommissie, 2008). The focus for housing associations will be to contribute to the reduction of flood risk caused by precipitation.

Adaptation measures

None of the above named effects of climate change can be controlled by the housing associations alone. They are dependent on co-operation with other stakeholders as water boards and municipalities etc. However, housing associations do have the possibility to

contribute to the climate robustness of the living environment of their tenants by applying adaptation measures to the houses, preferably during maintenance and renovation activities. They could for example apply light colors on their building façades in order to reflect radiation and reduce the inner-temperatures. In the case of allergies, they could be more alert on which type of vegetation they plant in the common gardens of e.g. apartment blocks. The reduction of the harmful effects of flooding caused by extreme precipitation can be established by applying adaptation measures to retain water temporarily, such as 'green roofs' or to ensure effective drainage as open pavements so that the peak load on the sewage system is topped off. Another effective measure is to use the materials that are not negatively affected by water so that the consequences are less intrusive if, despite all protective measures, flooding happens in case of extreme circumstances (Pitt, 2007).

Whatever measures will be applied on the different scales, it has to be taken in to account that collaboration and a multi-scale approach can be beneficial. For the housing associations, the local authorities and the tenants are the first stakeholders to deal with when addressing climate change adaptations. Moreover, the type of measures will bring more benefits when they focus on climate resilience than on climate robustness. For example, in the first case, flooding in extreme situations would be accepted and the extra water would temporarily be buffered in a designated natural area, which would benefit the quality of the landscape in general when not flooded; while in the second case, measures could be to simply raise the height of the dikes (Pijnappels and Sedee, 2010).

However, before measures will be taken, the actors have to be aware of the task that lies ahead. This research determines to which extent housing associations are aware of this task. Only after their level of awareness is known, effective strategies can be developed for adaptation to climate change.

RESEARCH METHODOLOGY

In order to obtain a clear view of the awareness of Dutch housing associations towards climate change and its threads, a content analysis (Bryman, 2008) was carried out, searching for climate change related topics in their policy documents.

The research question for the content analysis was: How much do housing associations express their awareness to climate change in their policy documents? The sample consisted of the 25 largest housing associations in the Netherlands. Together they own 881.000 dwellings, which is 37% of the social rented housing stock (ABF, 2008). The housing associations are divided through the Netherlands (see figure 1), but mainly in the western part, where most people live. From the sample, 24 associations had their annual reports available for analysis and 18 associations their policy plan. The reference year for the awareness is 2010.

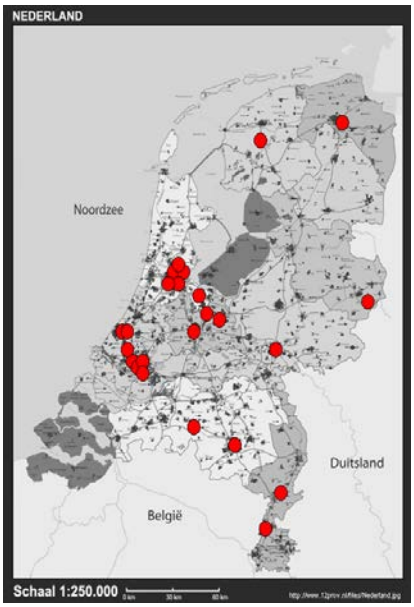


Figure 1: *Distribution of the 25 housing associations*

Two types of documents have been selected for this survey as they would evidence the associations' implemented projects and general strategies. The first type of documents analyzed was the annual report describing the associations' projects and activities executed during 2009. The second type was the corporate policy plan. In this document the housing associations have described their strategies for a time span of several (3-5) years. The oldest plan dates from 2006, looking forward to 2010. The newest plan dates from 2011 with a vision till 2015. Additionally, the policy plans especially addressing sustainability issues were searched. However, as many housing associations are drawing them up at the moment of writing, the number of available documents was only 6. They were, however, analyzed in order to discover if they would differ much from the general policy plans and annual reports.
The topics that were searched for were divided into three groups. The first is 'Adaptation', containing the topics *Climate*, *Climate change* and *Climate change adaptation*. The second group is 'Mitigation', containing *Energy*, *CO2* and *Operating costs* (in the sense of all costs related to live in a house, i.e., rent, energy costs, local taxes etc.). The topics that literally belong to one of the two groups, but do not refer to climate change, were left out of the results presented in this paper. For example, the topic *Climate* in the sense of "inner climate" or "social climate" was excluded.

Four stages of learning
In order to define effective approaches for governance of adaptation, four awareness categories have been created, in analogy with the four stages of learning model, which describes the process of learning. See table 2. The housing associations will be attributed to one of the awareness levels.

Level	Stages of learning (Hughes, 2002)	Awareness levels of housing associations
1.	*Unconscious incompetence* One is not even aware that he or she lacks knowledge or	*Unaware non-adapted* The housing association doesn't show awareness to climate change adaptations in

	skill (that is, one lacks an awareness that certain know-ledge or skill even exist)	its strategies and projects
2.	*Conscious incompetence* One is aware that he or she lacks a knowledge or skill	*Aware non-adapted* The housing association shows awareness to climate change adaptations in its strategies
3.	*Conscious competence* One acquires the missing knowledge or skill and applies it in articulated or codified ways	*Aware adapted* The housing association shows awareness to climate change adaptations in its strategies and projects
4.	*Unconscious competence* One's knowledge or skill becomes second nature, applied seemingly without thought or effort	*Unaware adapted* The housing association shows awareness to climate change adaptations in its projects

Table 2: *Four levels of awareness of housing associations*

RESEARCH FINDINGS

The annual reports of the 24 housing associations were analyzed, and the results are presented in Figure 2. In the reports, hardly any attention is given to the 'Adaptation'-related topics. Out of the 24 reports analyzed, 14 (58%) do not mention *Climate*, whereas only one association (4%) mentions the topic more than 10 times. Zooming in on the topic *Climate change,* this only appears twice, being mentioned only once by 2 associations. The topic *Climate change adaptations is* not mentioned at all. The 'Mitigation' topics, however, showed up far more frequently in the annual reports. *Energy* appears in all (100%) annual reports analyzed. The number of topics range from 4 to 88, with an average value of 31.0. The related topics *CO2* and *Operating costs* were also frequently mentioned, both by 19 (79%) housing associations.

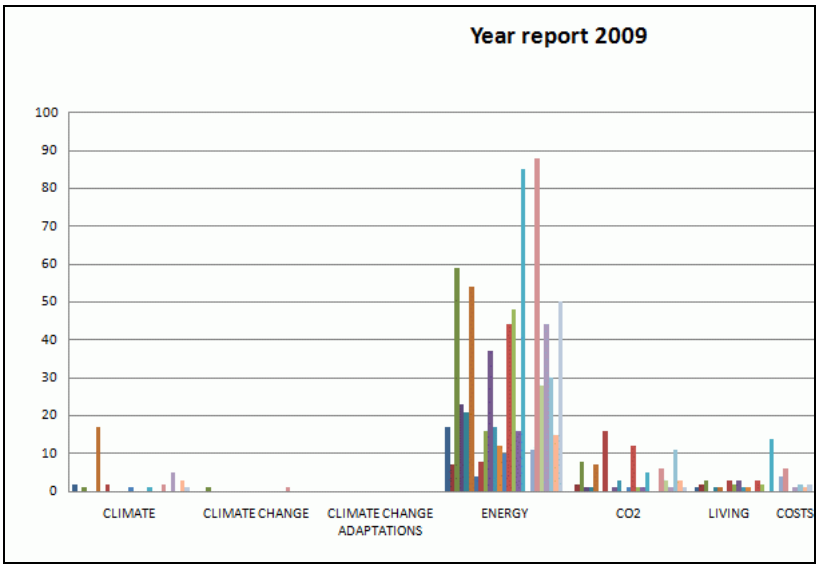


Figure 2: *Content analysis results for the annual reports of 2009.*

Figure 3 presents the results of the document analysis of the 18 policy plans. The 'Adaptation' topics appear on a very small scale. *Climate* is used in only 3 documents (17%). *Climate change* and *Climate change adaptations* appear in none (0%) of the policy documents. The 'Mitigation' topics appear more than the 'Adaptation' topics. *Energy* appears in 15 (83%) of the policy documents analyzed, whereas *CO2* and *Operating costs* appear in 8 (44%) and 13 (72%) documents, respectively

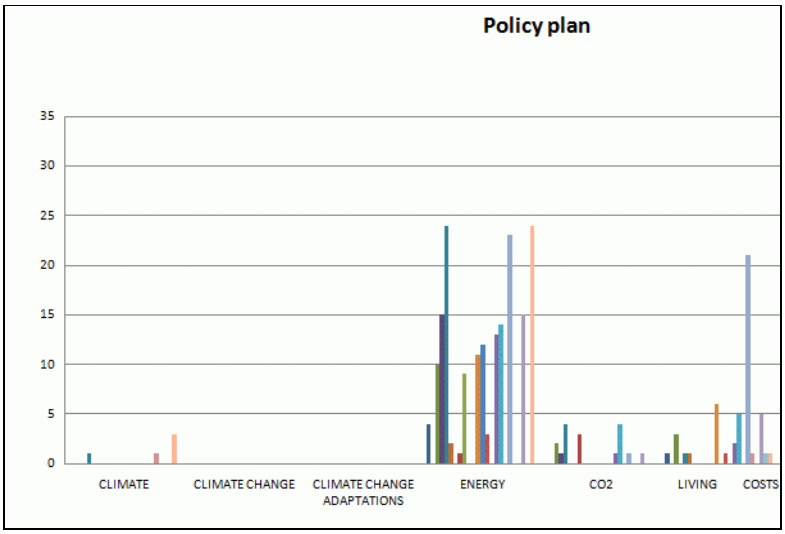


Figure 3: *Content analysis results for the policy plans.*

Energy

The Dutch housing associations reported on in this paper show little awareness for the threats posed by climate change. The governance on implementing mitigation measures, however, seems to have been effective judging from the fact that many housing associations show awareness of the *Energy* topic. Figure 4 demonstrates that this awareness has increased since 1 January 2008, when a new law came into force obliging the social housing sector to provide energy labels for their housing stock. The policy plans with a scope from 2009 onwards, which were drawn up in 2008, show an increase in energy attention. However, even though the action of taking energy saving measures not only serves the goal of compliance with the EPBD, but also improves living quality and provides cost savings for the tenants, it is the regulatory measure by the government that appears to have been the impetus for taking action.

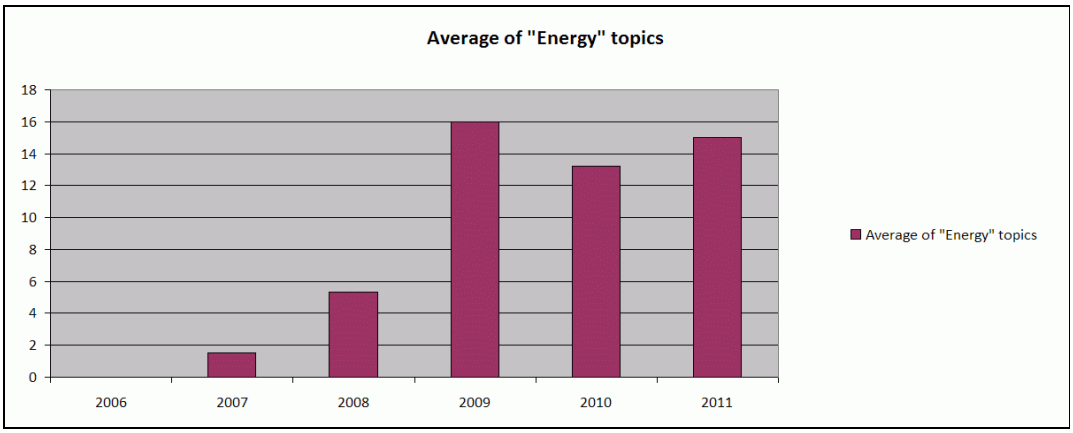


Figure 4: *Development of "Energy" topic.*

The attention for energy-related issues is also reflected in the energy policy documents available for analysis. The topic *Climate* is referenced in 83% of the documents, *Climate change* is referenced in one of the documents (17%), but *Climate change adaptation* is not referenced at all. The focus on energy topics becomes clear in the 'Mitigation' group, whose topics (*Energy, CO2 and Operating cost*) are all mentioned in all documents. The highest number of *Energy* topics is 174, in one document (see Figure 5).

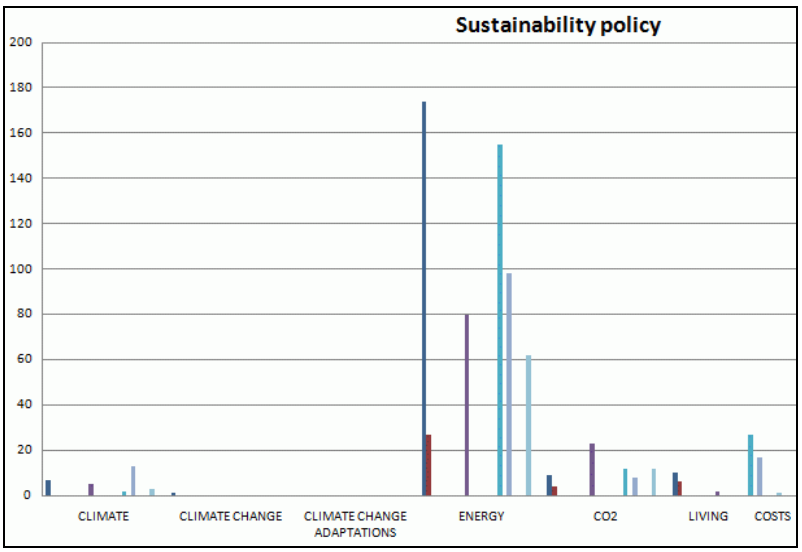


Figure 5: *Content analysis results for sustainability policy.*

Further proof of the attention given to energy can be found in the projects developed by the housing associations concerning energy efficiency or sustainable energy. Among the remarkable projects initiated in this area are: a geothermal heating system [iv], use of CO2-capturing materials (olivine) on roofs [v; vi] a tenant-oriented website for energy information [vii] and a 'Green Deal' between a housing association and an energy company [viii].

DISCUSSION AND CONCLUSION

Based on the content analysis of the two types of documents, it can be concluded that, to date, awareness of housing associations with regard to climate change adaptations is still very limited. All housing associations of the sample can be categorized into the lowest awareness level, "unaware non-adapted". The topic *Climate change adaptations* was not mentioned, neither in their strategies nor in the projects they executed. In order to validate the results presented in this paper, we would recommend analyzing other documents, such as the strategic asset management plans, using the same topics, or analyzing the same documents using a larger number of topics related to climate change adaptation measures.

The categorization of the housing associations according to their level of awareness allows for differentiated governance strategies for adaptation. As it is expected that not all housing associations will shift to higher levels of awareness at the same time, a differentiated framework with strategies focusing on each level would seem to be more effective than one general approach. What the results of this study have made clear is that the governance strategies for adaptation need to be further studied, taking into account the impact of the

governance strategies for mitigation. They appear to be effective for awareness raising on both the strategies and the projects level.

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BARRIERS TO IMPLEMENTING ENERGY PERFORMANCE CONTRACTING (EPC) MECHANISM INTO HOTEL BUILDINGS RETROFIT IN CHINA

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Abstract
Building sector contributes a large part of total energy consumption. Building Energy Efficiency Retrofit (BEER) is an effective approach to save energy & reduce emission of CO_2 and improve sustainability of existing buildings. Energy Performance Contracting (EPC), a market oriented mechanism provided by Energy Service Companies (ESCOs), has been widely used to improve energy efficiency in developed countries. EPC mechanism has been introduced in China since 1990s and implemented in different energy efficiency improvement projects. However, EPC mechanism is still unimplemented in some existing building retrofit projects. This research takes hotel buildings as example aims to identify the barriers to implementation of EPC mechanism into hotel buildings retrofit in China. Qualitative research methodology is employed in this research. In order to identify these barriers, a set of interviews are conducted. After that, a qualitative analysis of feedback information is discussed. Finally, a series of corresponding measures for remove identified barriers are proposed.

Keywords: Energy Performance Contracting, ESCOs, Building energy efficiency

INTRODUCTION

Existing buildings require over 40% of the world's total final energy consumption, and account for 24% of world CO_2 emissions (IEA, 2006). Buildings also represent an important and increasing component of China's energy consumption. For the past 20 years, Building energy consumption in China has been increasing at more than 10% each year. In 2004, building energy consumption alone constituted 20.7% national energy consumption (Jiang and Yang, 2006; Liang et al, 2007). Currently, there are nearly 40 billion m^2 buildings in China and the urban building area is up to 14 billion m^2. 95% existing buildings in China are "highly-energy-consuming". Building Energy Efficiency Retrofit (BEER), such as upgrading to newer, better-performing equipment and building's renovations, is a great way to save on energy bills over the long term. Building Energy Efficiency Retrofit (BEER) supports excellent opportunities to reduce energy consumption in buildings as well as encourages environment protection, rational resources use, and occupants' healthcare.

Although there are many benefits and large potential energy-saving of energy efficiency program in existing buildings, many energy efficiency projects are still unimplemented. The

reasons for delaying projects may vary, most energy efficiency projects stall due to one or a combination of the following perceived barriers (Zobler and Hatcber, 2003): (i) Lack of money, (ii) Lack of time or personnel to design and plan the projects because of other higher priorities, (iii) Lack of internal expertise to implement the projects, (iv) Lack of policy support within the decision making process. Besides above general barriers, there are other special barriers to building energy efficiency retrofit in China: there isn't the energy consumption baseline of different types of buildings in China, which should be established though lots of surveys; the ownership rights of many buildings are not clear; most people have low consciousness to energy efficiency project; new technologies for energy efficiency retrofit should also be further explored (Jia and Zhou, 2008; Yang et al., 2006; Lv and Wu, 2007).

Energy Performance Contracting (EPC) is a market mechanism to deliver energy efficiency projects. EPC mechanism is emerged in US in 1970s and was introduced into China in 1990s (Shen, 2007a). Energy Performance Contracting (EPC) is financing package provided by Energy Service Companies (ESCOs) that include energy savings guarantees and associated design and installation services for energy efficiency projects. EPC mechanism has great advantages for building clients to conduct building energy efficiency retrofit projects and improve sustainability of existing buildings. Energy efficiency projects under EPC mechanism has been widely implemented in nation's industrial, construction, and transportation sectors. However, EPC mechanism is still unimplemented in some existing building retrofit projects. There are significant barriers to implementing EPC success, and these differ by country, sector and other circumstances. This research takes hotel buildings as example aims to identify the barriers to implementation of EPC mechanism into hotel buildings retrofit in China.

ENERGY PERFORMANCE CONTRACTING (EPC) MECHANISM

Energy Performance Contracting (EPC), also known as energy service performance contracting is financing package from Energy Service Companies (ESCOs), which includes energy savings guarantees and associated design and installation services for energy efficiency projects, which was emerged in America in 1970s after the first oil crisis. Energy Performance Contracting is a mechanism for procuring and implementing energy efficiency improvements today that are self-funded over time through guaranteed operational savings. Performance Contracting uses operational savings and avoided capital expenditures to fund repayment of capital for building/infrastructure improvements. However, EPC principle not only is a financing tool, but also a market mechanism. Energy Performance Contract in the ESCO business may be broadly defined as a contract between an ESCO and its client, involving an energy efficiency investment in the client's facilities, the performance of which is somehow guaranteed by the ESCO, with financial consequences for the ESCO (Taylor et al, 2007). Under an energy performance contract, the ESCO will provide financing for a specified set of energy efficiency retrofit measures, along with associated design, engineering, and installation services, the owner or user can achieve high energy efficient facilities and get potential savings with little or even no front investment. The Basic concept of energy performance contracting is shown in Figure 1. The first bar represents the total utility costs of one facility before performance contract. In the second bar, after retrofitting the energy savings are shared by client and ESCO during performance contract period. After performance contract, all the cost savings belong to client after the performance contract period, shows in the third bar.

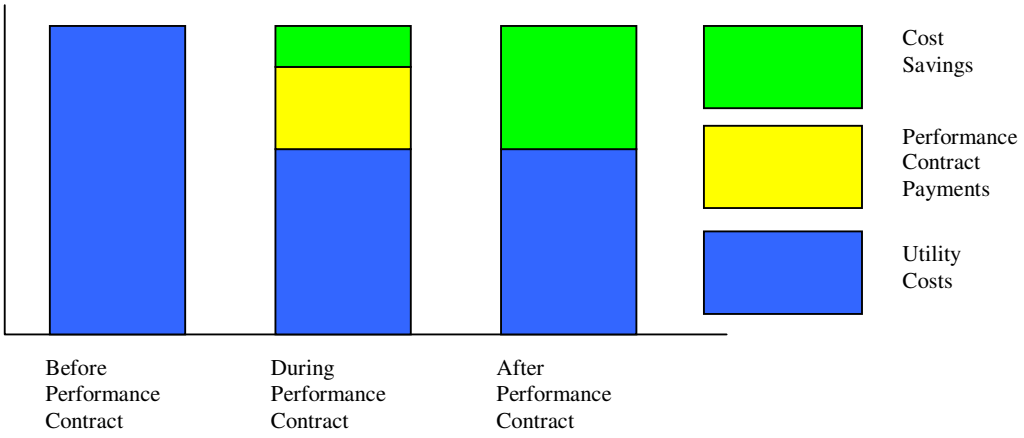


Figure1 *Basic Concept of Energy Performance Contract*

EPC was introduced to China in 1996 in partnership with World Bank and Global Environment Fund, The program aims to introduce EPC, improve energy efficiency, reduce greenhouse gas emissions, and protect global environment in China. The program is divided into two phases (Shen, 2007a). During Phase I (from 1998 to June 2003), three pilot energy service companies (ESCOs, also called energy management companies in China-EMCs or EMCOs) were created: Beijing ESCO, Liaoning ESCO, and Shandong ESCO. They altogether have established client-provider relationships with 405 users, implemented 475 projects, and invested 1.33 billion RMB. The project has brought in both energy conservation and environmental benefits: capacity of an annual energy saving of 1.49 million tce plus capacity of an annual carbon dioxide reduction of 1.45 million ton-c. Phase II refers to the period of 2003-2008. The objective of Phase II is to promote the adoption of EPC energy saving mechanism, foster and develop energy conservation service industry, expand investment in energy efficiency projects, and reduce carbon dioxide emissions and other pollution. Phase II includes two subprojects: 1) A Loan Guarantee Special Fund was established to help EMCo secure loans from commercial banks to implement energy efficiency projects. 2) The Energy Management Company Association (EMCA) was created in April 2004 to facilitate the operation of EPC and development of energy conservation industry in China (Shen, 2007a). Investment in energy conservation projects using energy performance contracting in 2007 up to over USD 1 billion was four times the 2005 level. Meanwhile, EMCA members increased from 59 to 308 (including 185 ESCOs) in the end of 2007 and implemented many energy conservation projects in the nation's industrial, construction, and transportation sectors (Taylor, 2009).

There are many ways to structure an EPC model. Two common EPC models are shared savings contract and guaranteed savings contract (Rezessy, et al; Han, et al. 2006; Bertoldi and Rezessy, 2005; Hui, 2002; Hansen 2003, Poole and Stoner 2003). The shared savings contract means the ESCO designs, finances and implements the project, verifies energy savings and shares an agreed percentage of the actual energy savings over a fixed period with the customer. This is also referred to as the "Full-Service ESCO". In guaranteed savings contract, the ESCO designs and implements the project but does not finance it, although it may arrange for or facilitate financing. The ESCO guarantees that the energy savings will be sufficient to cover debt service payments (Bertoldi and Rezessy, 2005; Hui, 2002; Hansen

2003). Besides the two main models, various models of EPC process have been implemented according to energy efficiency projects in different areas. The general process of EPC mechanism may be similar, which is comprised of three phases: Phase I Selecting contractor; Phase II Make an EPC agreement; Phase III Implementing EPC agreement. The common process can further be divided into the follow seven steps: Identify Project; Planning assessment; Select a contractor; Project design; Arrange financing; Negotiate EPC Contract; Construction and Implementation; and Measurement and Verification of Savings.

EXISTING RESEARCH ON BARRIERS TO EPC/ESCO

Despite the business concept of EPC is very attractive from a theoretical perspective, there are many barriers to EPC mechanism and ESCO industry. Vine (2005) made an international survey of barriers to ESCO industry faced in different countries, and listed the key barriers to EPC from end user aspect, which include: Financing, Perception of risk, Information/awareness/knowledge, EPC expertise, Access to energy-efficiency equipment and technology, Administrative, Reliability, and Credibility/confidence/ trust etc. Painuly et al. (2003) classified the barriers to ESCOs growth in developing countries into three categories: market barriers, institutional barriers and financial barriers. In developed countries, European Commission's Energy Service Company in Europe (Status report 2005) and the International Energy Association's Demand-Side Management Implementing Agreement's Task X identified some major barriers: lack of information and understanding of the opportunities that energy efficiency offer; lack of culture for project financing; public procurement rules that prevent the use of ESCOs; "low" price of electricity; safety and reliability concerns that hinder the introduction of new technologies; burdensome administrative procedures that allow only very large projects to be carried out; limited understanding of energy efficiency and performance contracting by financial institutions; administrative hurdles persist; limited government support; lack of motivation; and Measurement and verification protocols for assuring performance guarantees are not understood(Westling, 2003; Bertoldi and Rezessy 2005).

The development of EPC is later in China. China is a large developing country. Many barriers encountered in the development of EPC industry in China are discussed in previous studies (Fu, 1999; Wang, 2009; Yang et al, 2004; Xie, 2008; Shen, 2007; Wang, 2008; Zhang, 2008). Table 1 summarizes barriers to EPC in China.

Table 1: *Barriers to EPC in China*

Barriers	**Sources**
Information/awareness	Wang (2009), Fu (1999), Yang et al (2004), Xie (2008)
Financing	Wang (2009), Yang et al (2004), Xie (2008), Shen (2007b), Wang (2008), Zhang (2008)
Measurement/verification	Yang et al (2004), Wang (2009), Zhang (2008)
Institutional barriers	Wang (2009), Fu (1999), Yang et al (2004), Xie (2008), Shen (2007b), Wang (2008), Zhang (2008)
Risk	Yang et al (2004), Xie (2008)
Credibility/trust	Shen (2007b), Yang et al (2004), Zhang (2008)
EPC expertise	Yang et al (2004)

Previous researches, both in developed and developing country, mainly focus on barriers to the EPC/ESCO industry development. This research wants to pay more attention to explore barriers to implementing the EPC mechanism at project level. The following parts of this paper describe a qualitative research on barriers to implementing EPC into hotel buildings sectors.

EXPERT INTERVIEW

Above section has summarized barriers to EPC industry development. In order to explore barriers to implementing EPC in hotel retrofit projects, a series of semi-structured interviews with the industry practitioners have been carried out. The interviews involved talking to project managers, managers of engineering department in hotels, executives of hotels, contractors (ESCOs), and researchers. Altogether 15 interviewees were conducted. The details of the interviewees are shown in Table 2.

Table 2: *Details of the interviewees*

Sector	**Personnel interviewed**	**No. of interviews**
Hotel	**Manager of engineering department in hotels:** *South Union Hotel (H1)* *Golden Coast Lawton Hotel(H2)* *Haikou Huitong Hotel(H3)* *Ye Hai Hotel(H4)* *Haikou Tower Hotel(H5)* *Leaguer Resort Sanya Bay(H6)* *Xinyuan Hot Spring Hotel(H7)* *Sanya Beautiful Spring Spa Garden Resort(H8)*	8
	Executive manager of hotel: *Bohua Harbour View Hotel(H9)*	1
ESCO	**Project manager of energy service companies:** *Bard Energy Saving Engineering Ltd.(E1)* *Yangpu Oasis Energy Saving Ltd. (E1)* *Shenzhen Guoneng Power Investment Company(E1)*	3
Academics	**Researchers in sustainable construction and green building***(A1-A3)*	3

Because the interviewees were senior personnel, the interviews were not purposefully structured to facilitate free flow of ideas. At beginning of interview, I explained this framework to each expert in detail. Then the interviews were discussed around 5 issues: 1) Understanding of Energy Performance Contracting mechanism, 2) Difficulties to implement EPC mechanism, 3) Why do clients use or not use the EPC mechanism? 4) Problems in EPC process, 5) How to clear barriers mentioned above? Questions were open and interviewees

were encouraged to add any details that they considered relevant. The interviews were conducted between April and July 2010. They lasted from 1 to 2 hours and were taped and fully transcribed.

RESULT AND FINDINGS

All the barriers mentioned above are discussed by experts during interviews. This research focuses on hotel sectors. Most important barriers and special barriers for this type of project are discussed as follows:

Hotel leader's awareness

From above review, customers, suppliers, engineering companies, banks, finance sector, industry lack awareness and information of EPC. According to collected information from interviews, most leaders of hotel have willingness to reduce energy consumption. However, only few of them have heard about EPC.

> *I never heard about the EPC (H6, H8).*
> *I know about the EPC, I think it is another method for sales promotion of energy-saving production (H4).*

Hotel managers' lack of understanding and interest in EPC is a barrier to implementing EPC in hotel retrofit.

> *I think clients' awareness to EPC should be improved, they don't believe we can provide a win-win retrofit plan based on EPC mechanism (E1).*

Measurement and Verification (M&V)

Measurement and Verification (M&V) is one of most important part of EPC procedure, which is to identify the project result and energy savings. There is not a standard guideline to do this job in China. Sometimes hotel clients and contractors couldn't reach an agreement on how to measure project energy savings because of lack of measurement equipment and baseline data in hotel industry.

> *We had made a success retrofit in last year, I think it very important to identify the energy consumption baseline before conduct the retrofit (H2).*
> *It is very difficult to measure the energy saving accurately. Energy consumption is impacted by many factors, such as working hours of equipment, weather, and others (H7).*

Credit/trust

Both experts from hotels and ESCOs worried about their partners' credit. There is still lack of credit history for ESCOs and customers in China. This will impact project financing from the third party institute. Lack of credit and trust during project organization even causes project failure. Because there is not a standard for M&V, it is also difficult to agree with each other about the result of energy saving, if they don't trust each other.

> *ESCOs like to get up to tricks on M&V. Maybe big contractors certified by National Development and Reform Commission are much better (H3).*

Qualified staff and equipment
Shortage of qualified staff for ESCOs and hotels is another barrier mentioned by experts.

> *As contractors, ESCOs should give a technical support during the retrofit projects, however, sometimes I found the skill of their workers is worse than ours' (H3).*

Besides, some poor quality equipment is used in retrofit projects, which cause these projects failure.

> *……equipment quality cannot meet the preliminary requirement, there is a phenomenon called "saving energy but not saving money" because of short life of poor quality equipments (H1).*

Small scale
Two experts from ESCOs indicated their companies consider prefer industry retrofit projects rather than hotel retrofit projects. Because hotel retrofits projects are usually small with high relative transaction costs. In China, governments have provided many funding supports for energy efficiency projects. Also because of small scale of these projects, these projects cannot reach the requirement of support policies.

> *To be honest, the business of our hotel is not good. It is tight budget for us to update our energy consumption system. I have studied the support polices to these projects. Because of small scale of these projects, we cannot meet the requirement for getting a support funding from government (H7).*

Have sufficient fund
Some hotels have sufficient funds to implement energy efficiency upgrades themselves. They don't want to hire an expensive adviser and be bound to running a multi-year service contract. This will impede ESCOs to enter this market.

> *As a manager, I pay more attention to the operating performance of hotel. Benefit from energy saving affect little to the operating performance. Investment needed in energy efficiency retrofit takes up a small part of total operating cost. In our hotel, we prefer to conduct retrofit ourselves rather than contracting with an EPC contractor (H1).*

Operation status
Experts from ESCOs worried about the future operation status of hotel. Performance contract is a long term service contract. ESCOs invest project and get payback from future saving. Bad operation status of hotel is big risk for ESCOs.

> *Another risk for me is the operation status of hotel. If the business of the hotel is not good, the operating hours of equipment I supplied will be shorten. The energy saving and benefit share is calculated based on the operating hours. So the payback period will be longer (E1).*

> *We don't consider hotels with bad operating status. You know EPC is a long term contract. If the hotel is bankrupt during the contract period, we cannot get back our investment (E3).*

Above 7 barriers to EPC in hotel retrofit are most usually cited by interviewees. Besides these 7 barriers, other barriers such as financing, risk, and institutional barriers and so on are also

mentioned by experts. These barriers are commonly for development of EPC industry and have been discussed by previous research. This research focuses on barriers to hotel retrofit projects, the common barriers will not be discussed detail in this study. Having identified the barriers to hotel retrofit, so what are the possible solutions or recommendations to eliminate the barriers? Some suggestions we obtained during the interviews are given in Table 3.

Table 3: *Suggested solutions to the barriers*

Barriers	**Possible solutions**
Leader's awareness	Information and demonstration programs, training, education programs
M&V	Accurate measurement technology and equipment, M&V protocols
Credit	Accreditation system, standardization of contract procedures
Qualified staff and equipment	Education programs, training, quality regulation
Small scale	Reduce transaction costs, policy incentive
Have sufficient fund	Information and demonstration programs, education programs
Operation status	Fast payback retrofit measures, contract strain

CONCLUSIONS

This research aims to explore barriers to implementing EPC mechanism into hotel buildings retrofit in China. This research reviewed EPC mechanisms, and current existing research in this topic. After that, 15 expert interviews were conducted. This resulted in the barriers to EPC in hotel retrofit. The interviews further resulted in solutions to clears the identified barriers.

Seven barriers to EPC in hotel retrofit are summarised based on information collected from interviews. These are Hotel leader's awareness, M&V, Credit, Qualified staff and equipment, Small scale, Have sufficient fund, and Operation status. In order to clear the encounter barriers, some solutions are suggested as follow: education program, information and demonstration programs, training, policy incentive, accreditation system, standardization of contract procedures, and so on. The findings in this research are collected based on hotel buildings retrofit. Implementation of EPC mechanism in other type of energy efficiency projects should be also explored in future research.

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MODELLING OF FACTORS IMPACTING ADOPTION OF PRECAST CONCRETE SYSTEMS

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Abstract
Construction technology utilizing prefabricated concrete elements is known as a 'precast concrete system'. In Western countries, this system has been widely used in constructing bridges, office buildings and residential buildings. A precast concrete construction system provides the advantages of construction effectiveness, high levels of quality control, saving of construction time, minimisation of skilled labour, reduced manpower requirements on site, and saving in formwork requirements when compared with the traditional construction method (cast-in-place concrete). In Thailand, cast-in-place is the traditional construction system that has been mostly used to this point. Precast concrete floor slabs are the only a prefabricated elements used widely in Thailand. Only a few parties in the Thai construction market have adopted fully precast concrete systems. However, many factors have an impact on the adoption of precast concrete system. This paper presents and analyses a conceptual model that accommodates the numerous factors impacting the effectiveness of the adoption process. The results of a survey of 160 construction industry professionals in Thailand are presented and the significant factors which impact the adoption of precast concrete systems are determined through statistical analysis. The paper concludes with an analysis of the significant factors in the adoption of precast concrete elements and system.

Keywords: Precast Concrete System, Conceptual Model, Thailand

INTRODUCTION

Precast concrete elements are one of the most remarkable developments in the construction of concrete structures. In recent decades, precast concrete elements have been widely used for architectural and structural buildings. The construction method is mainly divided into two stages: manufacture of mass-produced components in a permanent construction facility, and assembly of components on the construction site. The use of precast concrete elements has increased in recent years because these precast concrete elements provide the advantages of construction effectiveness, high levels of quality control, saving construction time, minimisation of skilled labour, reduced manpower requirements on site and savings in formwork requirements. Numerous researchers have studied the adoption model within their individual fields of study. It should be noted here that although some adoption models have been developed particularly for the field of marketing, the author is not aware of any comprehensive model developed specifically for the precast concrete construction industry. This study attempts to model the various factors that influence this industry's effectiveness in adopting precast concrete elements. These factors can be broadly defined as enablers and include the product characteristics, communication channels, management support and

environmental impact. The performance and interaction between these enablers influence the degree of adoption achieved. Factor analysis was used to confirm and refine grouping of significant factors.

LITERATURE REVIEW

Adoption of the precast concrete construction continues to be a key stimulant to industrialization and economic growth in developing countries, particularly in the fast-growing Asian countries such as Thailand, China, Vietnam (Prilhofer, 2007; Schultes, 1995; Yeung, 2002). In recent decades, many researchers have studied the adoption model in various areas particularly marketing, but none have targeted their study on the adoption model of the precast concrete construction industry. A literature review was undertaken in this study, which closely examined existing models developed across all industry sectors with a view to developing a conceptual model specifically designed for studying the significant impact factors of adopting precast concrete systems (Brand and Huizingh, 2008; Obra and Melendez, 2006; Wu, 2004).

Construct	**Description of variables**	**References**
Product characteristics	Construction cost Construction schedule Waste material Skilled labour Safety Pollution reduction Innovation development Complexity of construction technology	Beatty *et al*, 2001; Christensen, 2001; Gibb, 1997; Geem, 2006; Puri and Adlakha, 2003; Schultes, 1995; Waroonkun *et al.*, 1998; Yeung, 2002
Communication channels	Direct sales Sale promotion Advertisement Information Word-of-mouth	Belch and Belch, 2001; Calder and Malthouse, 2005; Kotler and Armstrong, 1996
Management support	Training Policies support	Makame, 2007; Woodside and Biemans 2005
Environmental impacts	Quality control Quality guarantee Options	Aguayo, 1990; Christensen, 2001; Roger, 2003
Level of Adoption	Awareness Interest Evaluation Trial Adoption	Roger, 2003; Wu, 2004

Table 1: *Enablers and level of adoption*

As a result of the literature review, several variables were identified and grouped as either enablers of adoption or indicators of level of adoption. The enablers were divided into four main categories: product characteristics; communication channels; management supports and environmental impacts (Table 1). The performance of these enablers contributes to the level of adoption in the construction business sector. The level of adoption, which is significantly impacted by these various factors can be divided into five degrees: awareness; interest; evaluation; trial and adoption (Table 1).

'Product characteristics' concerns how the use of precast concrete components will provide significant benefits to the investor and environment. 'Communication channels' deals with how information about the benefits of adopting precast concrete technology will be transferred to architects, engineers, project owners and other users. 'Management support' addresses the industry's policy to improve the knowledge base of customers. 'Environmental impacts' is concerned with product quality to support the customer's choice. 'Level of adoption' concerns the individual customer's satisfaction when planning to adopt the precast concrete construction system.

A conceptual model of factors impacting the satisfaction of precast concrete components has been developed (Figure 1). The relationship between the above-mentioned constructs is represented by four hypotheses, described below:

- H1: Appropriate product characteristics enhance the level of adoption;
- H2: Effective communication channels enhance the level of adoption;
- H3: Appropriate management support enhances the level of adoption; and
- H4: A supportive environment enhances the level of adoption.

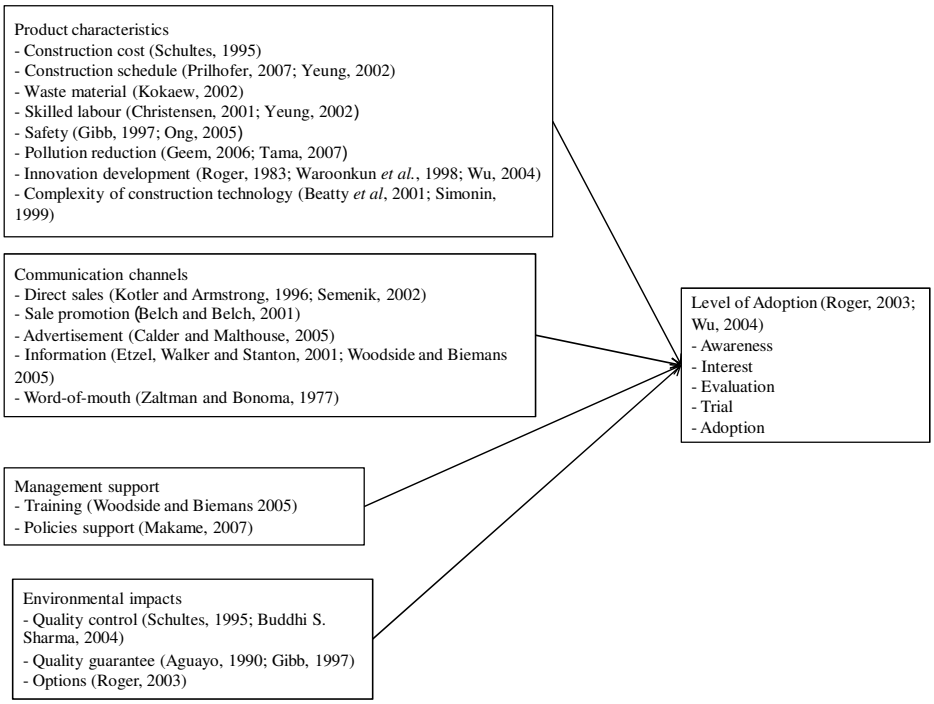


Figure 1: *Conceptual model*

RESEARCH METHOD

During April-May 2010, data collection for this study was undertaken with construction professionals in Bangkok and Chiang Mai, Thailand. The target group of respondents included design and construction professionals from construction projects involving precast concrete systems. In total, 525 surveys were distributed and 160 were returned, representing a response rate of 30 per cent which exceeds the minimum 1:5 ratio requirements for factor analysis (Hair *et al.*, 1998). The objective of this study was to refine and confirm the conceptual model, and identify the numerous factors which impact the level of adoption. Factor analysis was undertaken to summarise the information contained in a number of original variables into a small set of new factors (Hair *et al.*, 1998). Results from this analysis were used to identify the significant factors. The survey questionnaire contained two sections with a total of 29 questions representing individual variables in the conceptual model. Part 1 focused on measuring the level of adoption in the following degree: awareness; interest; evaluation; trial and adoption. Part 2 included questions relating to the enablers influencing the level of adoption, including: product characteristics; communication channels; management supports; environmental impacts. Other background information such as, years of experience, position, education, etc. was also solicited from respondents. This section was included to ensure that information was received from valid sources.

Each question in the survey required the respondents to provide a rating of the impact of enablers and the level of adoption. The question in Part 1 asked respondents for their opinion about the level of adoption, ranging from 'strongly disagree' to 'strongly agree'. Part 2 of the survey questionaire sought to ascertain respondents' perception of the factors influencing satisfication with precast concrete components, based on their experience. The scale in Part 2 of the survey questionaire ranged from 'strongly negative' to 'strongly positive' and the results were utilised for the majority of the statistical analysis because they enabled causal links between variables to be established.

DATA ANALYSIS AND RESULTS

Descriptive Statistics

Respondents were classified into five categories: designer (63%), construction manager (21%), project administration (9%), builder/contractor (5%) and project owner (2%). The respondents' level of education was classified into five levels: bachelor degree (64%), master degree (28%), diploma degree (4%), PhD degree (3%) and high school (1%). Respondent age was also noted: under 25 years (2.5%), 25-35 years (52%), 36-45 years (29.5%), 46-55 years (12%) and over 50 years (4%). The breakdown of respondents' construction experience was 0-5 years (25%), 6-10 years (27%), 11-15 years (15%), 16-20 years (28%) and over 20 years (15%).

Analysis of variance (ANOVA) was performed to ensure that respondents of different age, different education level, different positions and different length of experience could be considered as a single sample. ANOVA confirmed congeners between education levels at the 0.05 level of significance (Black *et al.*, 2000). However, when age, position and past experience were considered together, there was one variables in (use of precast concrete beam in construction) which had a significantly ($p < 0.05$) different mean value for three age

groups (36-45 years, 46-55 years and > 55 years). The mean values for this variable within their respective groups suggest that respondents aged 55 years and up do not trust precast concrete beam construction, it can be describe that the construction technology was developed rapidly during 20 years ago during the period of respondents' age around 36-45 years.

Table 2 shows the mean and standard deviation value for the respondents' level of satisfaction in adopting precast concrete construction systems. The overall mean and standard deviation values for the respondents' satisfaction were 3.58 and 0.47 respectively, which suggests that all questions representing the level of respondent satisfaction in the conceptual model were understood and respondents had a high level of acceptance in adopting the precast concrete system as part of construction projects.

It was found that the respondents were highly aware of and intended to adopt the precast concrete system but when it was implemented in a construction project as part of a structural or architectural building, the respondent's satisfaction level declined slightly. This may be explained by the fact that few past construction projects in Thailand were designed to be built entirely with precast concrete elements: precast concrete is normally utilized only for the floor in Thailand. This suggests that the owners of precast concrete factories should produce a variety of products and arrange courses to promote and teach about the precast concrete products.

Level	Description	Adoption Level of Precast Concrete System		
		Number	Mean	Standard Deviation
1	Awareness	160	3.48	0.62
2	Interest	160	3.54	0.69
3	Evaluation	160	3.84	0.62
4	Trial	160	3.26	0.86
5	Adoption	160	3.76	0.64
Level of Adoption Mean = 3.58; Std. = 0.47				

Table 2: *Mean and standard deviation of adoption level*

Factor Analysis

Table 3 presents the factor loading, eigenvalues and explained variance for the final four-factors solution. The enabler variables that were significantly low on the factor loading from analysis included: making precast concrete technology comply with the traditional method (A7, 0.48) and complexity of construction technology (A8, 0.48). The enabler variables of factor loading should be appropriate for analysis by exceeding the 0.5 threshold level (Coakes, 2005; Hair *et al.*, 1998). In the final four-factor solution, factor 1 was determined to be the most important explaining 38.42 percent of the total variance, most variable loading exceeding 0.5 and the initial eigenvalue of 6.91. Factor 4 is the lowest significant of variance, explaining only 6.09 percent of the total variance with the initial eigenvalue of 1.10. Generally, factors with initial eigenvalues lower than 1 have a poor contribution to the model (Hair *et al.*, 1998).

Factor	Description	Loading
1. Product characteristics	A1 (Construction cost)	0.56
Variance = 38.42%;	A2 (Construction schedule)	0.70
Eigenvalue = 6.91	A3 (Waste materials)	0.72
	A4 (Skilled labour)	0.76
	A5 (Safety)	0.76
	A6 (Pollution reduction)	0.62
	A7 (Innovation development)	0.48
2. Communication channels	A8 (Complexity of construction technology)	0.48
Variance = 10.88%	B3 (Advertisement)	0.50
Eigenvalue = 1.95	B4 (Information)	0.63
	D1 (Quality control)	0.66
	D2 (Quality gurantee)	0.61
	D3 (Options)	0.77
3. Management support	B5 (Word of mouth)	0.59
Variance = 7.27%	C1 (Training)	0.65
Eigenvalue = 1.31	C2 (Policies support)	0.87
4. Environmental impacts	B1 (Direct sales)	0.82
Variance = 6.09%	B2 (Sale promotion)	0.61
Eigenvalue = 1.10		

Table 3: *Varimax rotated factor loading for the final four-factor solution*

Regression

The conceptual model shown in Figure 1 was tested using single regression analysis. Table 4 details the single regression analysis results from the survey questionnaire. The result obtained through single regression provides some indication on the relationship between model factors and the contribution of each factor to the predictive power of the model (Hair *et al.*, 1998; Hatcher, 1994). The higher value of R^2 produces greater explanatory power of the regression equation, and therefore a better prediction of the independent variable (Hair *et al.*, 1998). The *t* value and the significance value both explain whether the addition of the predictor variable has a significant contribution to the model. A higher *t* value suggests a higher contribution to the model.

The combination of the independent variable explained 61.2% of the variance in the level of adoption (F = 23.166, p = 0.000) suggesting that the combination of variables does a reasonable job of predicting the respondent's adoption. Two main independent effect variables including Product characteristics and Communication channels ((t = 3.904, p = 0.000), (t = 3.408, p = 0.001)), were strongly significant in the model as well as Factor 3 (Management support) and Factor 4 (Environmental impacts) were less significant in the model. Each hypothesis will be addressed in the following details.

H1 predicted that appropriate product characteristics would enhance the level of adoption. This study showed that product characteristics were significant as a predictor to increase the adoption level (t = 3.904, p = 0.000). Thus, H1 is supported.

H2 predicted that effective communication channels would enhance the level of adoption. The results show that effective communication channels did significantly enchance the level of adoption (t = 3.408, p = 0.001). Thus, H2 is supported.

H3–H4 predicted that both management support and environmental impact should lead to enhanced respondent adoption levels. These two factors were shown to be less significant in term of effect on the respondent's level of adoption ((t = 0.257, p = 0.798), (t = 0.489, p = 0.626)). Thus, H3 and H4 are only partially supported.

	Beta	*t* value	Sig. level
R = 0.612 R Square : 0.374 (F = 23.166) (Sig = 0.00)			
Independent Variables			
Factor 1 (including A7)	0.270	3.904	0.000
Factor 2 (including A8)	0.257	3.408	0.001
Factor 3	0.012	0.257	0.798
Factor 4	0.025	0.489	0.626

Table 4: *The single regression analysis result*

SUMMARY

This paper details a conceptual model of factors impacting adoption of precast concrete systems. The research study described herein was undertaken with the aim of examining the validity of the model factors and sub-factors, and finalising the conceptual model. Model groupings were achieved via factor analysis. Single regression analysis showed the significant relationship between each model factor to predict the respondent's adoption level. Future research will undertake a series of case studies to verify the reliability of quantified links. Recommendations is also advises herein.

RECOMMENDATION

This study on the physical factors affecting the level of adoption at the conceptual model had the objectives to develop the precast concrete system technology. Improving the physical factors are recommended in Table 5 as follows:

Component	Major factors of the problem	Recommendations for improvement
Product characteristics	- Skilled labor - Safety - Waste material - Construction schedule	- The precast concrete system should be designed to minimize the use of skilled labor in terms of production and part assembling. When compared to other construction systems, this precast concrete system will use machinery as its major tool which will result in a higher degree of safety. - The precast concrete system should be designed to reduce the construction time and to use the least construction material. The construction time of the building structure system should be reduced by at least 60 %.
Communication channels	- Options - Quality gurantee and quality control - Information	- The precast concrete system should be used as the major channel for projects with repetitive construction patterns, especially for building structure. - The precast concrete system or the precast parts must be certified by the industrial standards and its efficiency and quality be certified by a reliable institute. - Information concerning the products and the system should be publicized.
Management support	- Policy support	- The government should support the system through its policy, for example reduction of import taxes for the production machinery.
Environmental factors	- Direct sales	- Information on construction technique related to the product must be presented by the sales representatives or manufacturer directly to the designer, project manager and the contractor to promote the use of the pre-cast concrete system.

Table 5: *Recommendations for improvements of the factors*

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OBSOLESCENCE AND THE END OF LIFE PHASE OF BUILDINGS

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Abstract
What is obsolescence? Numerous older housing blocks have been knocked down because of being obsolete. There is a general understanding that buildings, like machinery and durable consumer goods, should be replaced when they become obsolete. But is this true?
Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence is indispensible for the up keeping of the physical, economical and societal investments involved.
This article explores the characteristics and symptoms of obsolescence, how can they be diagnosed and when and to what extent is demolition an unavoidable consequence?
Due to the limited availability of empirical sources, the approach is mainly inventory and conceptual, based on literature search supported by previous empirical work.

Keywords: building management, building pathology, decision making, life cycle extension, obsolescence

INTRODUCTION

What is obsolescence? Numerous older housing blocks have been knocked down because of being obsolete. The recent discussion about the demolition of Ringo Starr's birthplace illustrates on the one hand the emotional character of the subject, but also that there is a general understanding that the life span of buildings, like machinery and durable consumer goods, is determined by becoming obsolete with demolition as a necessary end (Taylor, 2011). But is this true? Not for monuments and other structures with heritage or other intrinsic values that may not be demolishes, not for empty out of service structures on valueless land that no one will demolish, and even not for obsolete worn down property as long as the owners and users love it and it does not harm its environment. Even if obsolescence is defined as a condition that justifies demolition, there are other solutions like renovation, reuse and transformation to extend the service life of buildings. On the other hand, obsolescence is not a necessary condition for demolition, and pretended obsolescence is not necessary always the true reason for pulling down existing building (Thomsen and van der Flier, 2009b).

Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence is indispensible for the up keeping of the physical, economical and societal investments involved.

Since the awareness of the fundamental paradigm change from the massive new construction in the 20th century to the sustaining of the existing stock, the significance of careful maintenance and adaption is undisputed but still often ignored (Thomsen, 2010). The awareness of the huge ecological burden and the consequential need for physical and social sustainable improvement of the built environment further underpins the significance of useful life cycle extension of the building stock.

Obsolescence is not a natural phenomenon but a function of human action. Buildings are complex man-made artefacts and can only survive by means of regular reinvestments during its long service life. As a result the total life cycle costs will generally be a multiple of the initial building costs (Boussabaine and Kirkham, 2004; Woodward, 1997). These high costs demonstrate the relevance of avoiding and minimizing obsolescence and the need for knowledge how to achieve that.

However, the available knowledge about the prevention and management of obsolescence is scarce. Libraries are filled with publications about the initial phase of building; resources on the service life are scarce and on the terminal phase almost inexistent. Bibliographic search machines show an abundance of hits on obsolescence and demolition, but they are mainly casuistic and descriptive. The available theoretical knowledge is limited, empirical data are scarce and evidence based applicable expertise is hardly present nor accessible.

This article explores the characteristics and symptoms of obsolescence. Based on the available literature and following previous research, answers are explored for three research questions:

1. What is obsolescence, what is its role in the life cycle of buildings and its effect on the built environment?
2. How and to what extend can it be avoided, diagnosed and cured?
3. What is the relation to end of life phase of buildings, and to what extent is demolition an unavoidable consequence?

Goal is an inventory of usable and evidence based knowledge to prevent unwanted, unnecessary obsolescence and to optimize the sustainable use of building stock by life cycle prolongation and reduction of demolition.

Due to the limited availability of empirical sources, the approach is mainly inventory and conceptual, based on literature search supported by previous empirical work.
The structure follows the research questions and concludes with recommendations for further research.

OBSOLESCENCE AND THE END OF LIFE PHASE, A THEORETICAL APPROACH

What is obsolescence?

The Oxford Dictionary defines the adjective obsolete as 'no longer used or practised; outmoded, out of date', or 'worn away, effaced, eroded; worn out, dilapidated; atrophied', and the noun obsolescence as 'the process or fact of becoming obsolete or outdated, or of falling into disuse', or more specific 'the process whereby or state at which machinery, consumer goods, etc., become obsolete as a result of technological advances, changes in demand, etc. (OED, 2010). Merriam-Webster's Dictionary adds to the adjective 'no longer current, old-fashioned' (M-W, 2010).
In practice, the term obsolete is mainly used to point at the discarding of all kind of subjects. A search on Google Scholar resulted in about 300,000 hits, commonly articles like "Is xxx obsolete?", with xxx varying from market mentality to vectorcardiography and prisons, but of the first 250 none about buildings (GoogleScolar, 2010). Housing and property obsolescence is nonetheless a significant design and management issue. The degradation over time should be regarded as the fourth dimension in building as it largely determines the performance, usability, occupants satisfaction and life cycle costs of built facilities (Iselin and Lemer, 1993). Given the immobile, long lasting and capital intensive character of built property and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence is thus an essential professional skill of designers, developers and facility managers.

Obsolescence of building stocks

Obsolescence can have a wide range of causes. The fact that buildings are composed of a multitude of elements and materials with different life cycle characteristics makes an extra confusing complication. This is mirrored in the available literature, showing a confusing variety of categorisations like physical, economic, financial, functional, locational, environmental, political, market, style and control obsolescence, all focussing on a specific causal factor and subsequent explanatory and problem solving concept.
One main causal factor, inherent to the word obsolete, is overall acknowledged: the factor time i.e. age. But age alone is not a decisive clarification, considering the huge diversities in occurrence of obsolescence between and within buildings and building types. Why are some age old houses still very popular while others are demolished before the trees grow to maturity? For more clarity and a better understanding it is first necessary to order the subject by distinguishing the major characteristics: the nature of causes and effects, the different levels of scale, the building category and building type, and the kind of tenure and control.
Most categorisations of obsolescence are based on the nature of causes and/or on the effects.
Regarding the causes the most acknowledged and widely applied distinction is between physical factors, related to material processes, and behavioural factors, related to human actions, and the interactions between them. Where most of the attention was originally pointed at the physical decay of the buildings and building parts, the awareness of the behavioural and environmental impact has gradually grown (Nutt et al., 1976) and is nowadays acknowledged as decisive for most processes of obsolescence (van Kempen et al.,

2006). The effects are commonly divided in technical and economical obsolescence (Iselin and Lemer, 1993).
Regarding the scale, obsolescence can appear separately or combined on the level of building materials, parts and elements, constructions, separate buildings, blocks, quarters and neighbourhoods. It can be regarded as a range of diseases, spreading over and mutually affecting different levels of scale, i.e. timber blight and lacking maintenance can corrode the market position of dwellings and trigger filtering processes, while reversely the inflow of more vulnerable residents can seriously hamper maintenance investments.
Regarding the building category, there are essential differences between residential and non-residential buildings. Apart from differences in purpose, use, funding, management and legislation, housing is a rather stable function with a long life cycle expectancy, where non-residential functions like office, retail, leisure, trade and industry often have a short cycle of usage and adaptation and consequential different vulnerability for obsolescence. Building types, shapes and functions are often interrelated, sometimes very strong as e.g. water towers and churches, posing strong restrictions for reuse and transformation; sometimes less curbing or in contrary facilitating a wide range of functions, like manor houses converted in offices and back again in residences, and warehouses converted in apartments, the origin of lofts, space and structure being the main determining factors (Markus et al., 1972).
Tenure is decisive for property management and control. In this regard there are essential differences between rented and owned property, as well as between profit and non-profit and between single and joint ownership. (Itard and Meijer, 2008). This holds in particular for residential property, as social and institutional landlords are as a rule organisations with skilled professionals but limited control on usage and care, whereas single owner-occupiers generally lack any proficiency but have in principle full control on usage and care. Small landlords and condominium owners take a middle position, with limited control on usage and care and often lacking professional support. Similar relations can be found in non-residential property like shopping centres.
In relation with building category and tenure, building type has a strong influence on the usage and the appreciation of property. Detached, terraced, multi-storey, high-rise etc. have a significant influence on the property value. The inventory above is not exhaustive; real estate agents will immediately add size, location, situation, architecture, services and facilities (Isaac and Steley, 1999), illustrating the complex influences on property value development as itself a determining variable of obsolescence.

Obsolescence, a conceptual model.
Often used categorisations of obsolescence distinguish on the one hand internal and external factors (Iselin and Lemer, 1993) and on the other hand physical and behavioural factors (Nutt et al., 1976). Assembled in a quadrant matrix, similar to the one used for building evaluations (Leaman, Stevenson, and Bordass, 2010) results in figure.1.

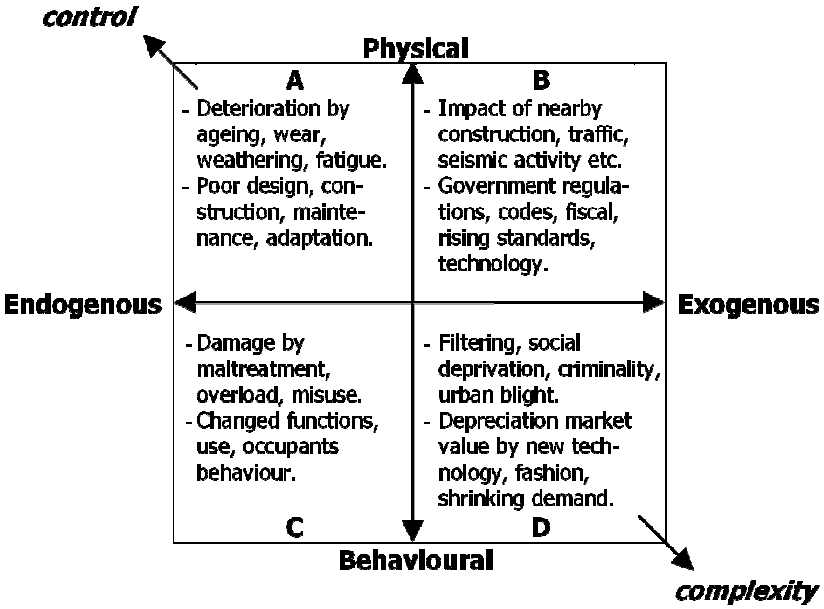


Figure 1 Obsolescence, conceptual model

Internal or endogenous factors are related to processes typical for the building itself. The processes can be physical, like degradation and deterioration over time, caused by ageing, wear and weathering or fatigue of materials and structures, or by poor design, construction, lacking maintenance and adaptations (quadrant A in figure 1). They also can be behavioural, like damage by maltreatment, overload, misuse or by changes in functions, use and occupants behaviour (quadrant C in figure 1). External or exogenous factors are related to influences from outside. They can have physical effects, like the impact of changing conditions in the environment by nearby constructions, traffic, pollution, noise, seismic activity etc., or by changes in government regulations, building codes and fiscal conditions, rising standards and functional requirements and new technologies (quadrant B in figure 1) They can also have behavioural effects like filtering and social deprivation processes in the neighbourhood, criminality, urban and planners blight, or like depreciation and loss of market position and value as a result of new technology, changing fashions and user preferences, the availability of better alternatives or simply a shrinking demand (quadrant D in figure 1).

The diagonal line from quadrant A to D also depicts the increase of complexity regarding scale and participants and the corresponding decrease of control. The physical factors in quadrant A are relatively uncomplicated and can be well controlled and managed by the proprietor. The mainly use related factors in quadrant C are more complex and less easily controlled, while the mainly environmental factors in quadrant B are generally beyond control of the proprietor, as well as the highly complex factors in quadrant D. From the opposite direction, threats coming from the exogenous behavioural corner can have very serious effects. Where direct control fails, proprietors answers have to be found in timely anticipation and intervention.

Many of the aspects in figure 1 are interrelated (Grigsby et al., 1987; Prak and Priemus, 1986). The interrelation can be demonstrated by looking at the actual environmental challenge of energy efficiency. The energy performance of buildings is on the one hand determined by the energetic quality of the physical design and construction (quadrant A)as measured in the EPBD (quadrant B), but on the other depending of the users behaviour (quadrant C). A low EPBD rating and high energy bill can weaken the market position (quadrant D) and consequently have either have a negative impact on the chances for

improvements in the direction of C, B and A, resulting in increased obsolescence, or be a stimulant for improvement actions. A similar reasoning can be applied on social deprivation, being another major contemporary threat.

1.1. Obsolescence and the life cycle of buildings.

Obsolescence is commonly regarded as the beginning of the end-of-life phase of buildings. Sources about the life cycle of buildings show a variety of terms. The building and development trade commonly refers to the development cycle, consisting of the development phase, including the design and the construction phase, and the usage phase, consisting of the actual use and the reuse or end-of-life phase (de Jonge and Arkesteijn, 2008). Sources regarding the life span, building pathology and mortality of buildings more often refer to the physical life or real life, being the period of physical existence, including the usage and end-of-life phase. This is in line with most national building stock statistics that in general only state withdrawal from the residential stock, in some countries subdivided by withdrawal by demolition and/or disaster, merging with other buildings and loss of function (Dol and Haffner, 2010).
The usage phase has now a formal definition: the service life, being 'the period of time during which a building or its parts meet or exceed performance requirements' (ISO, 2000). Bradley and Kohler state that the end of the service life can be the end of the physical life but can also be just the indication of the expected time horizon. They also refer to the economic life, being 'an assumed period of time over which the costs and benefits of buildings are assessed for purposes of making decisions about design and management', adding that this term when used for accounting or fiscal or other legal requirements is not necessary related to the likely service life time (Bradley and Kohler, 2007).
Analysing the influence of decay, several authors depict the life cycle as a function of a building's performance capacity over time (Awano, 2006; Iselin and Lemer, 1993; Markus et al., 1972; Miles, Berens, and Weiss, 2007; Nutt et al., 1976; Vroman, 1982). Following Markus cs., Iselin and Lemer illustrate obsolescence as the extending divergence over time between the declining performance and the steadily rising expectations. Miles cs. more specifically look at the economic performance of buildings, from the first investments in the development phase, the regular operation in the stabilization phase, the growing obsolescence in the decline phase through the final end of life. Combining these concepts results in figure 2, showing the effects of maintenance and reinvestment.

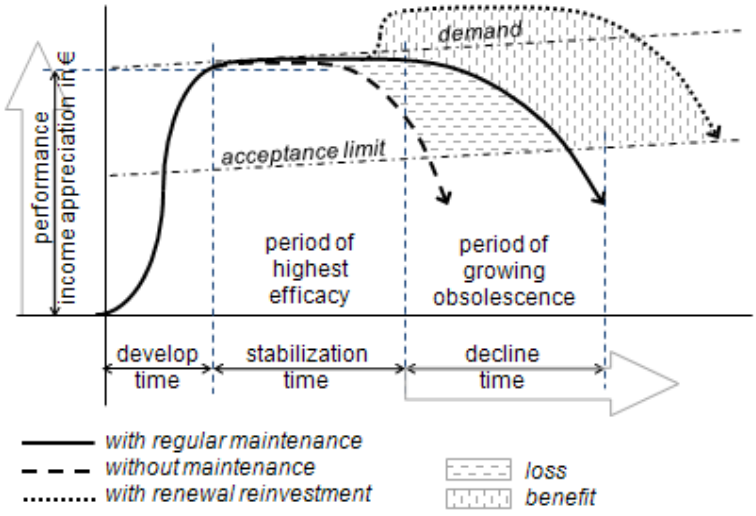


Figure 2 Obsolescence and service life (not to scale)

Maintenance is required to maintain a building's initial performance capacity. Without maintenance the performance will not meet the demand and eventually drop below the limit of acceptance of users or residents and the expected service life will not be reached, resulting in serious loss of efficacy.
In practice, both the demand and the limit of acceptance will gradually rise over time as a result of improved technology, rising standards and growing prosperity. Improvement and renewal are required to answer the accordingly rising expectations. By adding performance capacity the period of highest efficacy can be considerably extended and the service life prolonged. Assessment of the loss and benefits of alternative interventions in this way is part of nowadays professional property and facility management (Boussabaine and Kirkham, 2004).
Apart from proficiency, financial ability and insight of urgency play a decisive role. For some building categories and functions with a short life cycle like retail and industrial facilities, regular refurbishment and adaptation are accepted preconditions to uphold its market position respectively accommodate to changing needs. But in many other cases renewal and improvement is less obvious, due to lacking means and/or urgency. For example in the residential sector, only non-profit landlords maintain and improve their stock in a regularly planned way; most private landlords lack the means for substantial reinvestment, institutional landlords lack the urgency as they generally will sell their dwellings before they need major improvements, while the majority of owner-occupiers lack both means and urgency (Oxley, 2004; Thomsen and Meijer, 2007). As a result major improvements in the owner-occupied sector are generally combined with the purchase and financing by a new owner.
In the last decade, sustainability and more particularly energy efficiency is of growing importance for the market position of built property. Improving the energetic performance has become a strong rationale for additional investment in structural improvement of buildings and dwellings, imposing threats as well as opportunities for the existing older stock (Thomsen and Van der Flier, 2010).

Obsolescence and life cycle management: prevention, diagnosis and cure
Though highly theoretical, the conceptual models of figure 1 and 2 give in a nutshell the basic ingredients to analyse, avoid and cure obsolescence. In practice, the development of

obsolescence is much more complicated and the range of methods and instruments to avoid and cure obsolescence likewise broad.

Given the long life and capital intensive character of buildings, prevention is the most effective and efficient approach to avoid obsolescence. Prevention consists of systematic periodic analytic anticipation on all influences that are potential threats for the performance of buildings. Lijbers et.al. found four circumstantial factors for decay and obsolescence in the Dutch early post-war housing stock: design, construction, use and management, of which the design was by far the main causal factor (Lijbers, Thijssen, and Westra, 1984). A variety of surveys on different stock in different countries came to the same conclusion. They emphasize the importance of on the one side appropriate functional and circumstantial analyses underlying the functional program, including future developments (Iselin and Lemer, 1993), and on the other the building's spatial and structural flexibility to accommodate future changes (Brand, 1994; Maver, 1979; Till, 2009; van Nunen, 2010). Prevention should thus start in the earliest initial stage with an open eye to anticipating on changes, but should in fact never stop.

The diagnosis of obsolescence follows prevention as the next step in the systematic periodic analyses of stock performance. In the same way as prevention it requires in the first place an open eye for early symptoms and trends that may foster negative effects on all quadrants of figure 1, being the base of systematic maintenance and management. This implies in quadrant A the systematic periodical inspection of the property, to be implemented in maintenance schemes (Harris, 2001; Straub, 2008; Watt, 2007), but also in quadrant B, C and D as indications for possible improper use, changing circumstances and conditions, and last but not least evaluated and fed back as preventive input to be used when programming new development.

Apart from physical decay, obsolescence is more and more related to exogenous factors on a larger scale like unattractiveness of the neighbourhood and/or the availability of more attractive alternative options (Wassenberg, van Meer, and van Kempen, 2007). Nutt et.al. paid in their then breaking analytic models for housing obsolescence much attention to the allocation and movement of residents (Nutt et al., 1976). In the rented housing sector, but also in the retail, leisure and hotel sector, regular market analyses are necessary both for assessing the core business as for monitoring the buildings as main capital assets (Gruis and Nieboer, 2004).

Based on an international comparative evaluative survey of the regeneration of larger social rented housing estates, Van Kempen et.al. developed a comprehensive framework for the diagnosis and cure of decay and obsolescence (van Kempen et al., 2006). Though based on residential property, it gives a clear basis for housing as well as for non-residential property management.

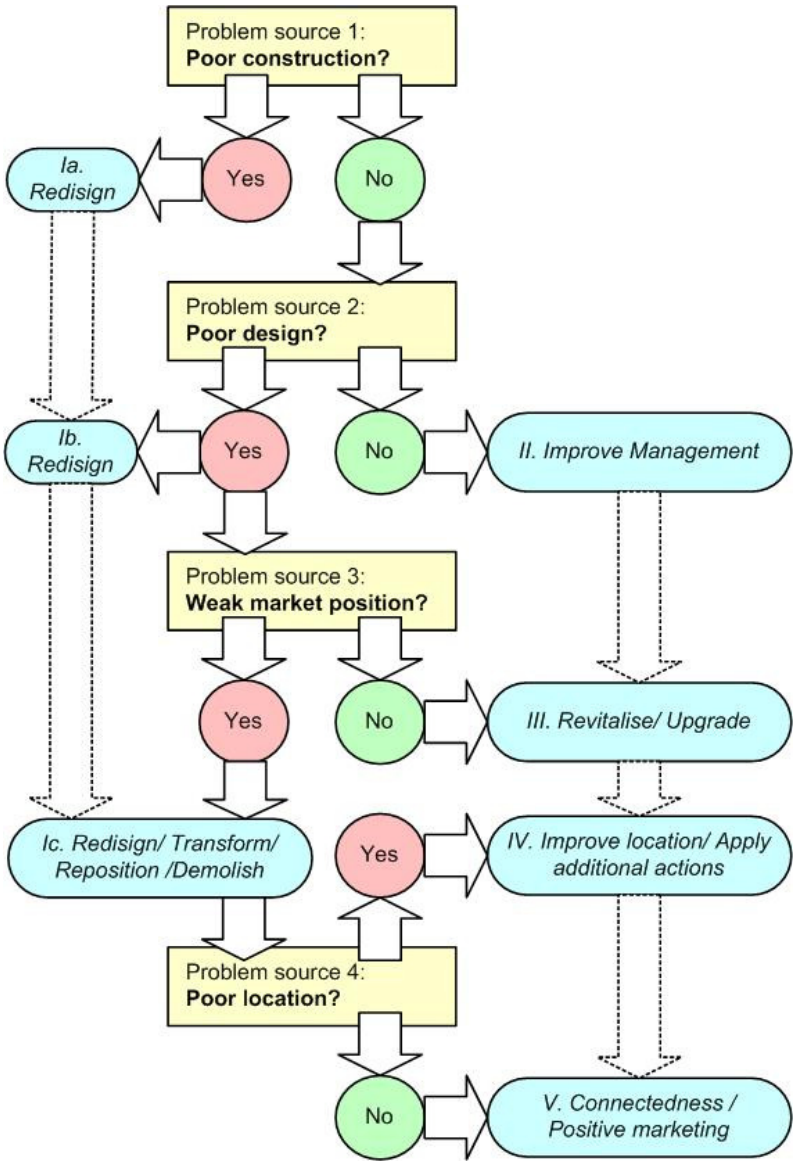


Figure 3 Managing housing obsolescence, analytical model (source: van Kempen 2006)

Obsolescence and demolition

The end of life phase is a normal part of the life cycle of buildings. Without adequate cure, obsolescence will eventually result in the end of the service life, generally by demolition. Exceptions are monuments and other structures with heritage or other intrinsic values that no one may demolish, and empty out of service structures on valueless land that no one will demolish. Even if obsolescence is defined as a condition that justifies demolition, there are other solutions like renovation, reuse and transformation to extend the service life of buildings. On the other hand, obsolescence is not a necessary condition for demolition, and pretended obsolescence is not necessary always the true reason for demolition. Apart from obsolescence, there can be many reasons to -or not to - demolish. To what degree these reasons become decisive motives depends on the interests and disposition rights and the capacities of the party involved.

Despite an abundance of case studies and descriptions (LibraryofCongress, 2010), empirical knowledge about the decision-making in the final phase of the life cycle of buildings and the underlying motives is scarce and fragmented. Data about demolition of non-residential property are generally not included in the statistics nor available from other resources. As a consequence, quantitative data are only available from the residential stock of the 19 out of the 27 EU members that supply any, of which only 9 on an a rather complete annual base, while the qualitative knowledge comes almost exclusively from the social rented stock and/or urban renewal areas of these 9 countries. Furthermore the definition of what is included in the records varies considerably.
Looking at the available data as shown in Figure 4, the rate of demolition differs considerably between countries, varying from 0,05% and below in France, the UK and Sweden to over 0,3% in the Netherlands.

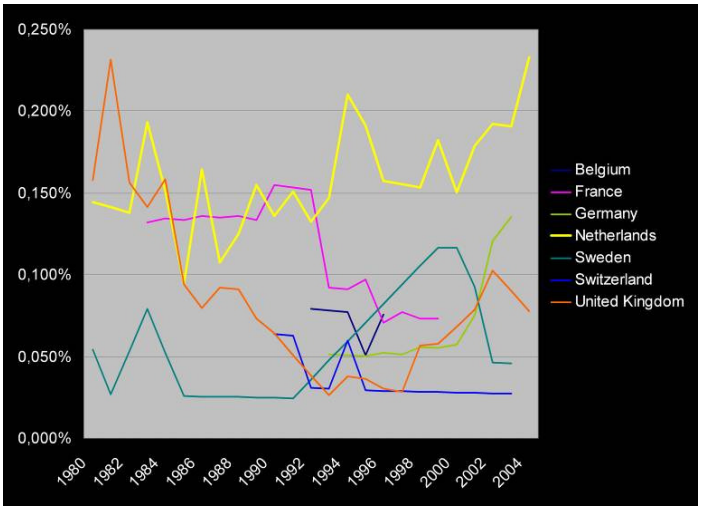


Figure 4 Demolition rate Western-Europe.

According to a survey of demolition by housing associations in the Netherlands, over 60% of the demolitions were motivated by functional and structural obsolescence, in the pre-war stock even over 90%. Including economic motives and oversupply, 87% of the demolitions were attributed to a kind of obsolescence and 13% to urban planning (Thomsen and Andeweg-van Battum, 2004). Additional questioning and information showed though that the decision making was also strongly influenced by social problems and more hidden profit driven motives like the land value, urban and asset policy and deals with the municipality and was biased by prejudices about the quality and costs of renewal versus new construction (Thomsen and van der Flier, 2009b).
Empirical data about demolition motives in the private owned stock are almost absent. The available information shows that, apart from acquisition for urban redevelopment, almost all of the demolition in the owner-occupied sector concerns detached dwellings after purchase by a new owner. The explanation is simple: residing owners do not likely pull down their homes and accordance between multiple owners in apartment blocks to do that is a rare exception; this in contrast with new owners who either decide to replace instead of refurbish the original dwelling, or are just in search of land for new construction.
The conclusion is all together that obsolescence does not necessary lead to demolition, nor that demolition is necessary preceded by obsolescence. It can certainly be a motive or at least a trigger for the decision between demolition or life cycle extension, depending on the interests, motives and capacities of the proprietor.

Recent studies point at the unwanted environmental, social and economic impact of demolition and conclude that life cycle extension by improvement, renovation and renewal is a better and more sustainable solution (Itard, Klunder, and Visscher, 2006; Power, 2010; Thomsen and van der Flier, 2009b). Though based on housing, the outcomes for non-residential stock with regard to environmental sustainability, e.g. building waste and energy use, will probably not be different. The conclusion is as yet that the limited building replacement capacity, being anyhow insufficient for mass replacement (Thomsen, 2010) should be used for life cycle extension of the existing stock. This underpins on the one hand the need for appropriate life cycle management as described above, but also the relevance of careful decision-making before the execution of final destruction.

Knowledge about the decision-making in the final phase of the life cycle of buildings and the underlying motives is scarce and fragmented. It is generally regarded as a black box, in which a complex range of interrelated and often conflicting interests and expectations of different parties are blended with the interests, considerations and expectations of the proprietor, with the latter as decisive condition for the outcome. Following a more elaborated analysis of the decision process and underlying motives of proprietors, physical quality and market demand can be considered as the main decisive variables, with tenure and asset management as main conditional factors (Thomsen and van der Flier, 2009b). Though explanatory in the Dutch setting, comparative findings are not yet available and use for forecasting or influencing the outcome is as yet beyond reach.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

This article explores the characteristics and causes of obsolescence resulting in a conceptual model of causes of obsolescence and effects. It distinguishes between on the one hand physical and behavioural factors and on the other endogenous and exogenous factors. It shows the inverse relation between the increase of complexity of types of obsolescence and the decrease of possibilities to manage it. Obsolescence as a process is described as the growing divergence between the declining performance of buildings and the rising expectations of users and proprietors. Obsolescence is often regarded as the start of the end-of-life phase of buildings. However, obsolescence is not an inevitable natural phenomenon but a function of human action, read decision making. It does not necessary lead to demolition as demolition is not always preceded by obsolescence.

Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character, its societal and cultural significance, and the high uncertainty about its future lives, minimizing obsolescence is important for the preservation of the physical, economical and societal investments involved. However, facing the paradigm change from new construction to maintenance and adaptation and the resulting huge task to improve the performance of the existing stock, the knowledge about the management of obsolescence is insufficient. Further research about the causes of obsolescence and about decision making about life cycle extension or demolition is therefore required.

Concentrating on the residential sector different questions should be investigated about the owner occupied sector and about the non-profit rental sector and different research designs are appropriate. Although the causes for obsolescence in both sectors of the housing market can be the same the decision making in both sectors varies resulting from different objectives and capacities of owner occupiers and professional housing managers. The availability of knowledge and data about management and decision making in both sectors differs too, as relevant knowledge about the owner occupied sector is very scarce compared with the non-profit rented sector.

For the owner occupied sector a twofold research strategy may be appropriate. On the one hand the collection of basic quantitative data about numbers of demolition and possible causal factors by means of surveys using the model, depicted in this paper and on the other hand explorative case studies to elaborate a conceptual scheme about the decision making in this sector. Different from the non-profit sector the decision making by residents in the owner occupied sector seems to be related with their housing career: decisions are often related to change in household composition or to a move to another dwelling. The capacities of owner occupiers are also much more limited than the capacities of professional housing managers.
In the social rented sector more quantitative data are available so it is possible to start testing assumptions about causes and effects of obsolescence and about relations with interventions by housing managers. Different from the owner occupied sector the decision making in the non-profit sector seems to be mainly related to asset management and policy objectives. Starting from the knowledge about the structure of decision making in this sector it may be fruitful to compare decision making between non-profit housing providers in different housing markets or countries to test the effect of external factors like housing policy, housing culture and housing market. This could be achieved by international comparative research as described by (Thomsen and van der Flier, 2009a).

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A PARADIGM SHIFT OR CHOKE?
THE FUTURE OF WESTERN EUROPEAN HOUSING STOCKS

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Abstract
The 20th century saw an enormous worldwide growth of the housing stock. In particular the building boom after WW-II, during which the housing stock in most countries was multifolded, focussed the attention of the housing sector primarily to the planning and realisation of new construction; the consciousness of the enormous maintenance and management task to come was still a far cry.
The begin of the 21st century shows a completely different situation that urges for a paradigm shift.
New construction in most western countries has faded down below an annual production of 1% of the existing stock, and often well below. Parallel to this, the ageing existing stock draws growing attention. The necessary investments in major repairs, renovation, adaptation and redevelopment count at present for a total turn-over well beyond that of new construction. Improving the energy efficiency to the required standards of tomorrow will give these investments a strong extra boost.
Though the change from new addition to the adaptation and transformation of the existing stock is well under way, large parts of the construction and real estate practice seems hardly aware and to stick to business as usual: new constriction, if not in greenfields then in brownfields. The knowledge about how and when to successfully maintain, manage, adapt, transform and redesign has still a way to go. At the same time, the awareness grows that housing problems are only partly related to the physical supply side and solving them requires more than bricks and mortar.
The paper illustrates the paradigm shift in Western Europe and explores the consequences for the future management of the housing stock.

Keywords: housing stock management, paradigm shift, construction market, life cycle extension, housing pathology

INTRODUCTION

The 20th century saw an enormous worldwide growth of the housing stock. In particular the building boom after WW-II, during which the housing stock in most western European countries was multifolded, has shaped nowadays housing stock. As figure 1 shows, two-third of the western European housing stock is built after WW-II; in most western European countries over 60% of the stock - in some countries like the Netherlands and Finland even over 75% - is younger than 50 years and over half is younger than 30 years.

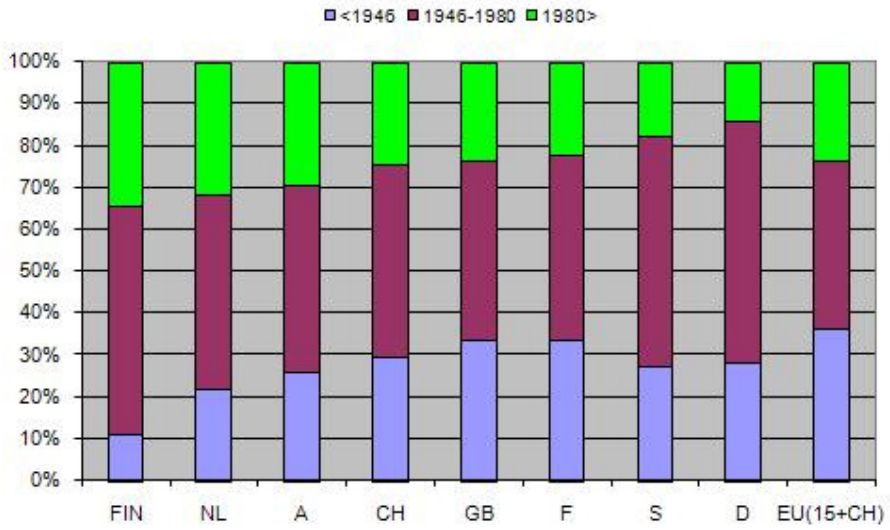


Figure 1, *Western-European Housing Stock, by age (8 W-EU Countries + CH)*
Edited from source: (Dol and Haffner, 2010)

The causes for the building boom were, like in the Netherlands, generally 4-fold: a production backlog due to the economic crisis of the 30'ies, loss by severe war damage of roughly one third of the stock, an unprecedented baby boom resulting in an explosive growing housing need, gradually followed by rising housings standards and dwelling space consumption (Vreeze, 1993). As a result, and despite massive new construction, crude housing shortages in the Netherlands continued till after 1990. In other countries like Denmark, the United Kingdom and France, war damage and the post war baby boom were less dramatic and/or resulted in a less massive housing production, and consequently in a relative older housing stock. But also in these countries the attention and attitudes of the housing and construction sector were primarily focussed to the planning and realisation of new construction; the consciousness of the enormous maintenance and management task to come was still a far cry.

The begin of the 21st century shows a completely different situation. As figure 2 shows, new construction in most western countries has faded down below an annual production of 1% of the existing stock, and often well below. As a consequence, the influence of new construction on the composition, quality and suitability of the existing stock is little and no longer a practical means to satisfy changing needs.

Though still relative young the existing stock is ageing. In particular the older part of the stock is increasingly facing deficiencies and shortcomings, large parts do not satisfy residents needs and preferences, are far from energy efficient and many post-war neighbourhoods are

in trouble. Reliable comparative data about the volume of the qualitative backlog are scarce, but the available data show an ongoing need for reinvestment, in particular in energy efficiency(Itard and Meijer, 2010). In the Netherlands, the total turn-over of major repairs, renovation, adaptation and redevelopment count at present for well beyond that of new construction(CBS, 2010). Improving the energy efficiency to the required standards of tomorrow will give these investments a strong extra boost.

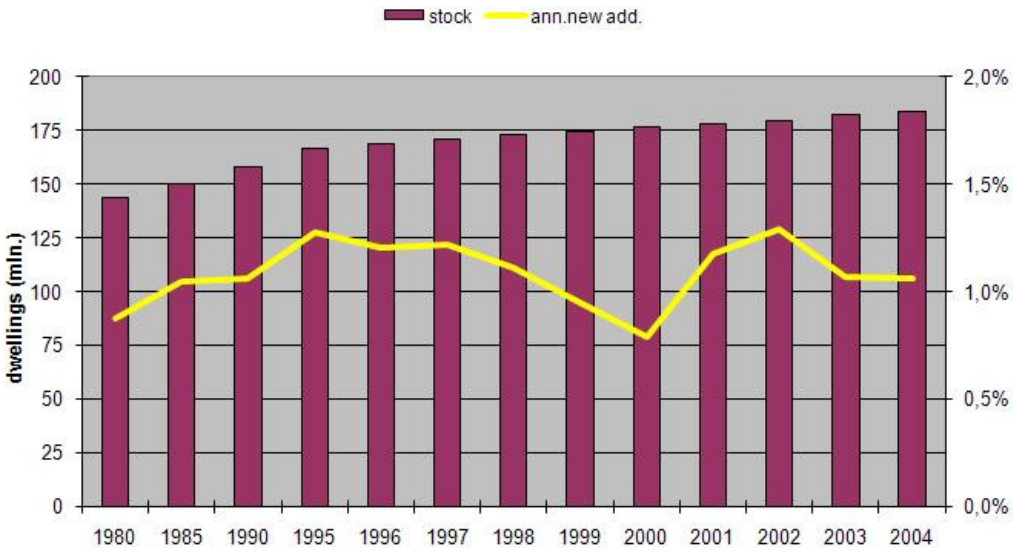


Figure 2, *Western EU housing stock, % annual new addition (8 W-EU countries + CH) Edited from source: (Dol and Haffner, 2010)*

Though the change from large scale new construction to maintenance and improvement of the existing stock is well under way, the knowledge about how and when to successfully maintain a healthy housing stock has still a way to go. At the same time, the awareness grows that housing problems are only partly related to the physical supply side and solving them requires more than bricks and mortar. This shows the relevance of housing stock (and building stock and land stock) management as a vital assignment of both proprietors and governments.

This paper gives some backgrounds of the housing production and housing stock development in Western Europe, explores the consequences for the future management of the housing stock and discusses what it indicates for the next future. As previous coherent research on this topic is hardly available, the content has an explorative character, based on an abundance of only partly cited sources. It also bears the limitations of a macro approach: an average water depth of 1 cm gives no guarantee against drowning.

BACKGROUNDS

The declining housing production in the past decades can have a variety of causes on the demand side, the supply side or the conditional context of the housing market. Though housing markets are largely specific, depending of country and region, most West-European countries show the same declining production, most probably due to the same or similar developments.

The following description is in broad outlines based on the Dutch situation and sources(ABF-Research, 2010; CBS, 2010), but if not otherwise mentioned applies also to most other West-European countries (except Ireland) (Ball, 2010; Eurostat, 2010; Oxley, 2004). Housing production is defined as the annual gross completion of new dwellings. This does not cover the annual growth of the housing stock, as a part of the new addition will compensate the annual loss by demolition, merging, loss, change of use and other subtractions.

Demand side causes

On the housing market, which is mainly a stock market, rising demand is the strongest thriving force for additional construction. In the past, the demand was mainly determined by demographic variables: at first the growth of the population, the main cause of the post war building boom; later after the family size started shrinking the growth of the number of households kept fuelling the demand up to now. In most West-European markets rude housing shortages have come to an end though, and some regions face even a shrinking demand.

Apart from the demographic side, an additional more hidden cause is economic prosperity, enabling a growing housing - land as well as floor space - consumption. Although partly included in the family size reduction, the effect of dwelling stock reduction by merging or replacement is of growing importance, even in shrinking markets and declining populations. The housing need in most West-European countries has nevertheless declined to a much lower structural level than in the previous century, and if not, high land and property prices suppress the effective demand.

The disastrous effect on the building production of the recent economic crisis shows the building trade's vulnerability for fading consumers' confidence and purchasing power.

Supply side causes

Supply side causes play another main role in the declining annual housing g production.

In the first place, a nominal stable annual number of newly produced dwellings will mathematically result in a declining relative growth of the stock. But the number of completed dwellings was not stable but instead declined, as secondly the quality and character of the building production gradually changed. Due to increased building standards of e.g. energy efficiency, the quality of new dwellings improved substantially. And due to changed policy and market conditions, the character of the housing production changed from often subsidised, modest priced mass greenfield production, to increasingly differentiated and generally substantial larger and comfortable market directed production, increasingly in existing urban areas. As also the size of building plots grew and land prices increased, the average building costs swell accordingly and not seldom doubled. So even with a nominal stable investment budget the number of dwellings to be completed within that budget had to shrink drastically. Instead, most national housing budgets were drastically reduced, government subsidies cut and, as the market did not fill the gap, the housing production declined.

A third and perhaps most critical limitation lies in the limited available building production capacity, in particular the availability of adequately skilled construction workers. The last decades saw a steadily decline of new hardhats entering the West-European labour market, a development that puts its shadow over at least the next decade and is only partly compensated by supply from new EU member states.

A fourth and up to now hardly investigated macro-economic limitation is the maximum available total payment capacity of a population for housing. According to a recent survey, the housing costs of Dutch families - tenants and owner-occupiers - have risen to the highest level in the EU(Ward and Özdemir, 2009). This at least indicates the likelihood of substantial

failing demand. Though in fact a demand side cause, the way housing developers anticipate on declining demand has direct negative supply side consequences.
A fifth cause often mentioned by the building trade are institutional hindrances by governmental regulations and bureaucracy, like building and planning regulations. On the one side the growing building and planning bureaucracy incontestably effects the progress of building production, on the other side it reflects the increasing complexity and public concern of the built environment with inevitable issues as sustainability and urban sprawl. Regarding the limited building capacity it is doubtful though to what extend these hindrances do cause a factual loss of production. New ways of integrated and digitally supported planning processes and decision making can otherwise considerably simplify procedures and shorten the procedure time.

Contextual conditions and constraints
Following the energy crisis of the mid-seventies of the last century, the eighties saw a wide spread policy shift in Western Europe, shortly summarized in the slogan "less state, more market". This shift marked the end of large scale subsidised mass - mainly social - housing programs. As already mentioned above, this resulted in a much lower market directed production. But not only subsidies faded away, also the government's policy attitude changed from active steering to a more reactive market approach.

All together these causes make clear why and how the housing production declined as it did. As the decline went very gradually and generally took place simultaneously with a range of other changes in the housing and planning field, the effects did not get much attention up to now. The following section gives an overview on these effects and impacts.

SOME CONSEQUENCES

The declined housing production has a range of consequences. The following overview, based on a wide variety of only partly mentioned sources, gives only an approximate indication.

Housing provision, housing quality and housing stock management
Compared with an annual dwelling production of over 3,5% like once in the Netherlands (1975), a production of 1% or less in the first place implies a crucial reduction of the changeability and adaptability of the existing stock by new addition and/or replacement,. As the volatility of the housing market demand is generally higher than 1%, changing market demands regarding quantity, quality, availability and suitability cannot anymore be solved by providing new additional dwellings but have to be accommodated in the existing stock. While the adaptability of the existing stock by renovation, transformation, addition, reuse and redistribution is much larger than often assumed (van der Flier and Thomsen, 2005), the opportunities for substantial addition of extra dwellings by e.g. transformation and reuse of non-residential buildings is very limited. This as a matter of fact underlines on the one hand the strategic importance of new production, but exemplifies on the other that qualitative improvement by integral stock management is the only viable way to improve the condition of the existing stock and - with the exception of very bad substandard and/or unwanted obsolete stock - a generally better choice than replacement by new construction (Thomsen and van der Flier, 2009).

A second effect of the declined new production is the steadily ageing of the existing stock. Though still relative young, in particular the older part of the stock is increasingly facing deficiencies and shortcomings. Reliable comparative data about the volume of the qualitative backlog are scarce, but the available data show an on-going need for reinvestment, in particular in energy efficiency (Itard and Meijer, 2010). In the rented sector, large parts do not satisfy residents needs and preferences and many post-war neighbourhoods are in trouble (van Kempen et al., 2006). The quality development of in particular the older owner-occupied sector needs growing attention and the energy efficient is still far from the Kyoto goals. On the longer term, in a few decades many parts of Western Europe will face a declining population, which in combination with an aged population and aged housing stock will have wide spread economic, social and environmental effects.
Although the addition of new construction is often reasoned as to improve the availability and suitability of the stock by offering residents a free choice, this is only valid in an open demand driven market with sufficient supply. Even if effective in some markets, an annual production of 1% of the stock or less largely limits this inefficient way of stock management. In general, redistribution by interference on the housing market, either direct by letting regulations or more sophisticated area directed instruments, may be a better and on the longer term more effective and efficient solution.

Building and construction sector
The shift from new construction to accommodation of the existing stock has indispensable - and eventually structural - consequences for the building and construction trade, two main causes being the character of the work and the commissioning.

As mentioned above, the total turn-over of major repairs, renovation, adaptation and redevelopment in most Western-European countries counts at present for well beyond that of new construction, causing an essential shift in the building construction practice. Compared with large scale new construction, working in often occupied existing dwellings requires completely different and difficult skills regarding technical, social and managerial craftsmanship, as well as the type, size and organization of the company. Typical renovation, maintenance and repair contractors are generally small to medium sized companies with flexible work units, increasingly staffed with independent shop keeping craftsmen. Large new construction companies are not suited for this kind of business, though some of them have started a specialized subdivision for large scale maintenance and renovation projects. On the side of designers, developers commissioners and government, the situation may even be worse as, with the exception of an increasing number of specialists, the knowledge about how and when to successfully maintain, manage, adapt, transform and redesign older stock has still a way to go.
Also, though the building construction sector as a whole acknowledges the need for a change, in practice many large scale new construction contractors try to maintain a conservative business-as-usual course, if not in greenfields then in brownfields. Together with a large share of housing associations and real estate developers they up to now propagated new construction as being better, cheaper, easier and less risky than renovation and pushed large scale brownfield redevelopment by acquisitions. Mainly as a result of this, the Netherlands saw a considerable increase of demolitions (van der Flier and Thomsen, 2006). Similar advances are visible in e.g. Austria, Ireland, Germany, The UK and Switzerland.

While most new housing construction is commissioned by developers, construction work in the existing stock is largely a consumer market, commissioned by either owner-occupiers or with decisive tenant involvement. The building production is in fact more and more divided

in two different segments: on the hand large professionally commissioned and managed projects of mainly new construction, and on the other hand small privately commissioned, hardly professionally managed works of mainly repair and renovation. While roughly covering an equal total turnover, the first covers less than 20% and the latter over 80% of formal building permit applications(Dutch data), (Van der Heijden, 2009).
In particular in the owner-occupied stock, most work consists of small to moderate maintenance and refurbishment jobs, often without assistance of an architect and partly without a building permit. A substantial share of the turnover involved takes place in the informal market of moonlighters and semi-DIY. The same happens to some extend in countries where tenants have refurbishment rights like in the Netherlands, the UK and Sweden and where as a result the average refurbishment investments of tenants have been estimated on over one third of that of owner-occupiers (REF). In case of substantial refurbishment and renovation by landlords, particularly with a rent increase, tenants usually have involvement and co-decision rights, entitling them to e.g. decide about the main design, finishing and furnishing.

The shift to a consumer market in particular effects the supplying industry. The building material industry - the mainstream of whose production is now directed to the replacement market(Thomsen, 2002) dominated by DIY and C&C markets - is increasingly converting into a multinational industry, serving a competitive end-user driven market and supported with substantial research, development and marketing budgets. As they more and more outshine the traditional building contracting trade, a growing part of the providing industry is intervening in the building market by appealing directly to the consumers with dealer networks, licensed contractors and franchise trades, including marketing, advertising, after sales services and guaranties, provisions that as a matter of fact are regular in most other markets. A further development may be the partly or total takeover of contractors - being the assemblers of their products - by the providing industry, as in some specialized branches is already emerging.
Within the building contractors branch, some promising recent developments show the rising growing awareness of the paradigm shift. In the Netherlands a group of maintenance contractors launched a model for performance based long term maintenance contracts for residential property. This initiative not only acknowledges the physical and economic importance of long term quality care but also implies a shift in tasks and responsibilities between property managers and contractors(Straub, 2009).

Governmental steering and legislation
Last but not least, the paradigm shift has consequences for governmental planning and control on different levels. In many Western-European countries, the main legal steering structure on building and planning dates from the building boom era, and is insufficiently fit for the changed circumstances. Improvement of the legislation is under pressure of a strong undercurrent of liberalisation and reduction of bureaucracy.
Traditional instruments for spatial planning are mainly restrictive, to prevent unwanted developments, while nowadays spatial problems require active steering, provoking wanted improvements. The fact e.g. that traditional zoning instruments are insufficient for the renewal of existing urban areas is meanwhile well noted, but the understanding that this more and more applies for environmental planning as a whole is not yet widespread (Houterman and Hulsbergen, 2010). New more effective intervention instruments are often expensive and/or - like some PPP (public-private-partnership)-constructions - on the edge to where public commitment legally and democratically may go. Renewal and revitalisation of existing areas will anyway need an area directed approach using a mix of spatial, physical, social and

fiscal instruments(Thomsen and Meijer, 2007). On the larger scale, urban sprawl, confined or shrinking cities and regions will need growing attention. Confined cities like The Hague have no expansion space left within their borders. To prevent uncontrolled speculative acquisitions as well as hardly less unlikeable public interventions, new legal instruments are indispensable. The same - but quite differently - applies for shrinking areas. In a few decades many parts of Western Europe will face a declining population, which in combination with an aged population and aged housing stock will have wide spread economical, social and environmental effects.

Regarding building regulations and enforcement, the above mentioned two separate segments of the building production lay a very different burden on the governmental bureaucracy. According to the Dutch situation, the one part of large, professionally managed projects, covering less than 20% of building permit applications, requires extensive and intensive expert interference, but the governmental burden can substantially be reduced by privatisation and certification(Van der Heijden, 2009). The other part of private hardly professionally managed small works, covering over 80% of building permit applications, requires a totally different approach with an emphasis on facilitating and supporting safe, healthy and sustainable solutions, increasingly by means of web-based applications.

On the subject of governmental steering and legislation, but in fact on all the consequences as discussed above, the conclusion is all together that the new paradigm comes with on the one side new problems and public assignments, but on the other side declining means for public planning, steering and enforcement. This is not only true where it comes to new requirements like energy reduction and sustainable development that need new approaches (Sunikka, 2006), but touches the core of the new paradigm: it requires new ways of policy development and in particular of understanding and cooperation between the parties involved.

CONCLUSIONS AND DISCUSSION

The turn of the last century showed a drastic reduction of the production of new dwellings. Though this reduction went slowly and silently, the underlying causes and consequences are structural and urge for a paradigm shift in the way the housing stock is maintained and managed.

Up to now this development draw little political attention. Coherent overall research is up to now only scarcely available. This may be partly due by the fact that the consequences were apparently limited on the short term, but they will be crucial on the long term.

The underlying causes can be divided in demand side, supply side and contextual causes and constraints. They each apart and all together underpin the structural decline of the housing production.

The consequences are manifold and widespread. With respect to housing provision and housing stock management, new construction is no longer a solution to solve quantitative nor qualitative shortages. Instead, qualitative improvement by integral stock management is the only viable way to improve the condition of the existing stock and - with the exception of very bad substandard and/or unwanted obsolete stock - a generally better choice than replacement by new construction. With respect to housing quality, the ageing of the stock requires increasing attention and an ongoing need for reinvestment, in particular in energy efficiency.

The shift from new construction to accommodation of the existing stock has also structural consequences for the building and construction trade. Compared with large scale new

construction, working in often occupied existing dwellings requires completely different and difficult skills regarding technical, social and managerial craftsmanship, as well as the type, size and organization of the company. This also applies to the side of the designers, developers commissioners and governments, who's knowledge - with the exception of an increasing number of specialists - about how and when to successfully maintain, manage, adapt, transform and redesign older stock has still a way to go.
The fact that work in the existing housing stock is almost entirely a consumers market drastically effects the market approach of the supplying industry and eventually the structure of the construction industry. Nevertheless many large scale new construction contractors and developers maintain a conservative business-as-usual course by propagating new construction as being better, cheaper, easier and less risky than renovation and refurbishment.
Regarding governmental steering and legislation in particular, the conclusion is all together that the new paradigm comes with on the one side new problems and public assignments, but on the other declining means for public planning, steering and enforcement.

For the next future, much will depend on the way how governments, property and building markets will acknowledge the need for a paradigm shift. And if they do, how the parties involved will find new ways of understanding and cooperation. After all, housing and planning policies are only partly related to the physical supply side, and finding solutions requires more than bricks and mortar. Housing is not a purpose at itself but serves a basic need that is conditional for the quality of human life. The awareness of this is not always ruling the decision making. Particularly in the building and property market, self-interest - either by clear and open price negotiations or more hidden by influencing policy, goals and conditions - is a natural mainspring that not seldom biases the outcomes. As an example, the decision making between renovation or demolition of older dwellings may serve as a touchstone regarding its crucial role in the future approach of the housing stocks. A range of recent research findings show that, from a social and physical sustainable viewpoint, life cycle extension is preferable above demolition and replacement by new construction(Itard, Klunder, and Visscher, 2006; Palmer et al., 2003; Power, 2010; Thomsen and van der Flier, 2009). Earlier findings showed a high and growing demolition rate in the Netherlands, partly attributable to profit related demolition motives of the housing associations(van der Flier and Thomsen, 2006). But also other parties in the decision making and building process - including municipalities - put in their influence for self-interest. Dutch municipalities for example have strong interests in new construction as in that case the municipal costs of new infrastructure will be included in the land price, while in case of renovation there is no coverage for the also necessary renewal of the infrastructure at all (Thomsen, 2005). Also, the growing scarceness and high prices of land for new development in dense urban areas puts a high and single sided pressure on the decision making about the future of older neighbourhoods(Adams and Watkins, 2008).
It will be the assignment of governments on various levels to provide checks and balances for the decision making and prevent inequitable outcomes. To facilitate this responsibility and strengthen public support, these checks and balances should include sufficient guaranties for transparency of the decision process and involvement of the residents and citizens involved.

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BIM-BASED USER PRE-OCCUPANCY EVALUATION METHOD FOR SUPPORTING THE DESIGNER-CLIENT COMMUNICATION IN DESIGN STAGE

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Abstract
This paper introduces a BIM based user pre-occupancy evaluation method (UPOEM), which is applied in architectural design stage for the aim to improve the efficiency and effectiveness of the communication between designers and clients.
There are constants interactions between the clients' requirements and designers' solutions during the early design stage. However, there are some problems emerged during the designer-client communication process which may affect the effectiveness of designer-client communication, such as, inexperienced clients have difficulty in understanding 2D drawings, and the lack of an efficient method to guide the clients to review the design against their requirements.
The building information model (BIM) and BIM tools have provided a better platform to demonstrate both of the graphical and non-graphical information of the design. However the BIM tools paid less attention on facilitating clients to understand how their activities are accommodated in the building model, or helping them to express their requirements and feedback on the design. Therefore, this proposed method simulates the end users' activities in the future built environment based on building information models, so as to improve the clients' understanding on the design; a clients requirements and feedback interface is also designed to help clients express requirements and review the design. A framework of applying the UPOEM in conventional designers-users communication meetings is proposed in this paper.

Keywords: BIM, User activity simulation, Pre-Occupancy Evaluation

INTRODUCTION

Although design process varies, the common ground is a design process always started from a briefing stage, and ended in forms of design drawings. RIBA (2000) defined the outline of work of architect in the life cycle of a building project in the book "Architect's Job Book" (Figure 1).

RIBA Outline Plan of Work 7th Edition, 2000

Preparation		Design			Pre-Construction			Construction		Use
A	B	C	D	E	F	G	H	J	K	L
Appraisal	Strategic Briefing	Outline Proposals	Detailed Proposals	Final Proposals	Production Information	Tender Documents	Tender Action	Mobilization	Construction to Practical Completion	After Practical Completion

Figure 1: *Outline Plan of Work in a Building Project*

The communication between designers and clients in the briefing and design stage is usually based on the requirements of clients and the solutions of the designers (shown in Fig 2). A project brief should define all the design requirements, and is the foundation on which the design will develop. Generally, the design process is cyclical, and there is constant interaction between the brief and design proposals (RIBA 2000).

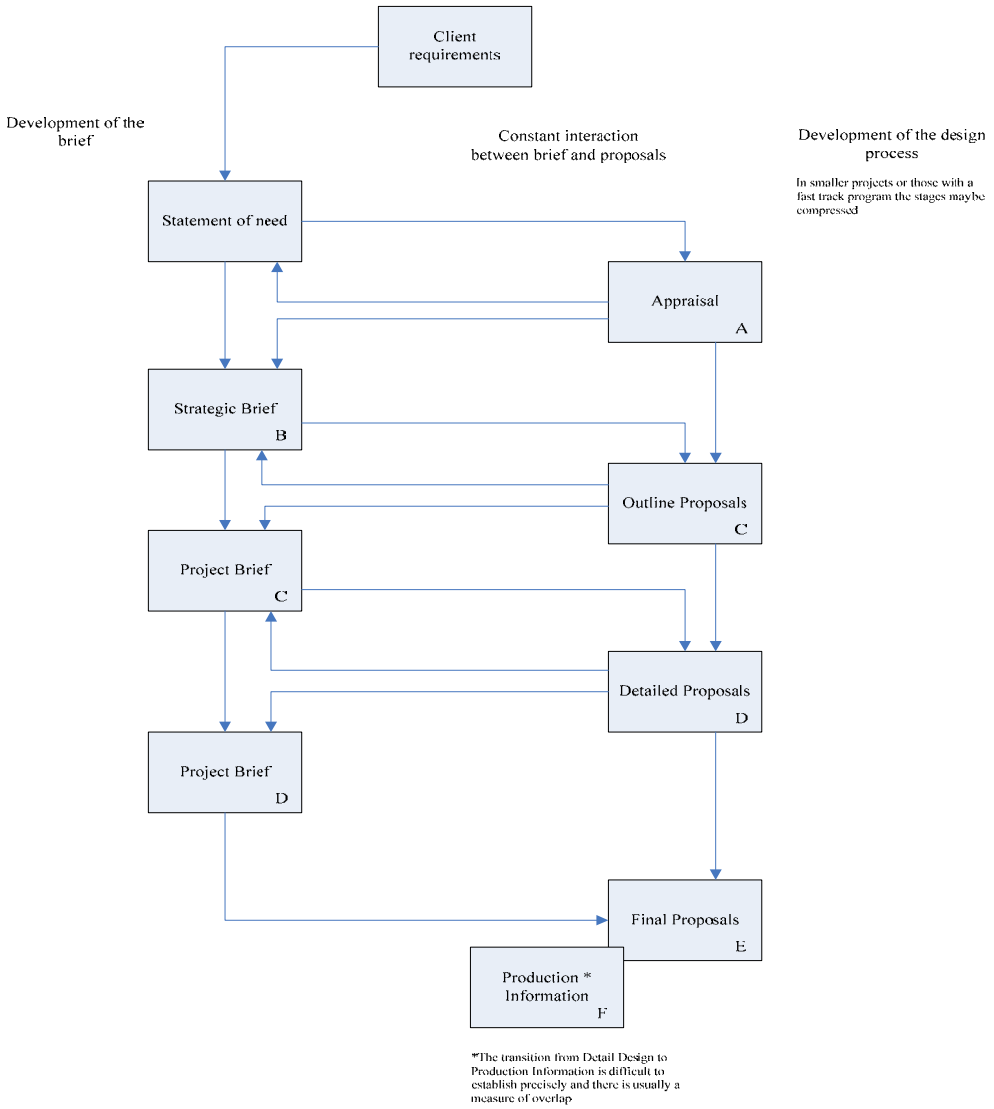


Figure 2: The process of brief and design development (Source: RIBA 2000)

A considerable gap between the designer and client is, unlike architects, users are usually not trained and their comprehension in three-dimensional space is limited. Problem usually stems from a fact that users cannot imagine how the design will be emerged after construction phase (Lertlakkhanakul, Choi, & Kim, 2008). The inability of users to read drawings also affects them to specify the client brief (Barrett, 1999).

In addition, another problem which would also affect the efficiency of designer-client communication is about the requirements management during the designer-client communication process. Kiviniemi (2005) found that there is a lack of mechanism for designers to record, manage and track changes of the clients' requirements during the design stage, which will lead to the result that the end design solution is significantly different from the clients' requirements. Then Kiviniemi designed a building requirement IFC specification

to manage requirements information during design process and provide the possibility of linking requirements to the objects of the design model. Although such requirements models were established, there is still demand for a framework/method to guide the clients to define, manage and track changes of the requirements, and facilitate them to review design against requirements in communication process with designers, especially in the context of virtual environment.

For the aim to solve the problems mentioned above and enhance the efficiency and effectiveness of the designer-client communication, in this paper, a user pre-occupancy evaluation method (UPOEM) is proposed.

First, virtual reality technologies will be applied to improve clients' understanding of their built environment. A virtual environment which can demonstrate both the building and users' activities in the built environment will be established. The reason of simulating end users' activities is that the buildings usually play a key role of accommodating user's organizations and equipment, and enable their activities. Ekholm and Fridqvist (2000) stated that, while the development of bubble diagrams in space planning process, the activities are considered as the criteria to define the size and relationship between these bubbles (representing spaces), but not the building's spaces themselves. Therefore, it is helpful to visualize the end-users' activities and provide a platform for them to evaluate to what extent the built environment could match their requirements.

Second, a *requirements and feedback interface* will be designed to facilitate the clients to manage requirements and review the design. This interface is intended to remind clients of the requirements of the given design solution, and guide them to evaluate the design against these requirements. Both the requirements and evaluation results are recorded as the attributes of each room will be saved in a database during the development of the design process.

RELATIVE WORKS

To achieve the specific objectives, the building information modeling (BIM) technology is used in the UPOEM to provide accurate building information, and the structured requirements documentation method is used to build up the pre-occupancy evaluation module. Thus this section introduces the relative works of these two aspects.

Features of BIM tools

Building information modeling (BIM) is the process of generating, managing the building data during the lifecycle of the building (Lee et al., 2006). It uses three-dimensional, real-time, dynamic building modeling software to increase the productivity during the process of design and construction (Holness, 2008). This process produces the Building Information Model (BIM), which includes building geometry, spatial relationships, geographic information, and quantities and properties of building components. On one hand, the building information model can provide "earlier and more accurate" visualizations of a design. On the other hand, it is an object-based parametric model, which contains not only the geometry and topology attributes, but also carries various properties if they are analyzed, priced, interpreted and procured by other applications. Most of the current BIM tools default to a minimal set of properties for most objects and provide the capability of adding an extendable set, so users or an application can add properties to each relevant object to conduct certain kind of cost

estimate, simulation (Eastman et al., 2008). Since the BIM tools can generate accurate building models for the demonstration of design, and the extendable object-based properties can provide a possibility to store the information generated during the designer-client communication process, the BIM technology is therefore used as the basis of the UPOEM.

User activity simulation in buildings

Lots of literature has addressed the user activity simulation models, which aim to simulate and predict occupants' activities in a given building and to evaluate the building or organization performance such as evacuation, circulation, building control system, energy saving, and space usage. In the early time, static building models including the user activities were built by Eastman and Siabiris (Eastman and Siabiris, 1995). After that, much research have studied on predicting pedestrian movements in urban planning and emergent evacuation in buildings (Kerridge, 2001; Kuligowski and Peacock, 2005).These studies have enriched the area from many perspectives, such as the environmental consideration. Zimmermann (2006) used the multi-agent technology to simulate individual's activities in a building for energy saving purpose. Lertlakkhanakul et al. (2008) built up a collaborative virtual environment for end users to interact with building models of smart houses. In order to investigate the space usage of the buildings, Tabak et al. (2007) used workflow model and activity schedule model to simulate users' activities in office buildings. Lately, Tabak (2008) has also developed a human behavior simulation system named USSU to mimic the behavior of human beings when scheduling activities. The output of this system is a movement pattern in terms of end users' activity schedule, including relevant moving routes in a building. However, the system requires a large amount of user input data, and has no connection with the building information model.

To facilitate the designer-client communication, the UPOEM in this paper will therefore establish an alternative simplified user activity scheduling method based on Tabak's work, which allows the end users to specify their activities in a new building within a relatively short time. In addition, these end users' activities are simulated within the 3D building model generated by BIM tools, and the communication is further supported by structured requirement documentation.

Requirement documentation and hierarchies

The clients' *requirements and feedback interface* designed in the UPOEM aims to connect the design solution with clients' requirements and feedback. This section therefore introduces the related requirement documentation methods or hierarchies.

Most of the time, the documentation of client requirements is in form of traditional building program, which is generated mostly by interviewing clients, owners, and end users. In many cases, the original client requirements are not clear, and designers have to turn them into more accurate requirement descriptions or requirement attributes (Whelton and Ballard, 2003). Kamara (2002) summarized several structured requirements capturing and documentation methods, including Quality Function Deployment (QFD), Client Requirements Processing Model (CRPM), Total Quality Management (TQM), and Failure Mode and Effects Analysis (FMEA). As for the research about requirements hierarchies, there are also a lot of relevant works. The International Centre for Facilities (ICF) has published several volumes documenting their standards for Whole Building Functionality and Serviceability (WBFS) since 1992 (ICF, 2009). The purpose of these standards is to help organizations to define their functional requirements for the buildings and serve as a checklist together data and evaluate the existing buildings from the portfolio management or tenant

viewpoint. Though the WBFS provides a high-level, strategic view for evaluation of building, it has no connection between requirements and design tools. On the other hand, EcoPro, a software application developed by VTT (Technical Research Centre of Finland), is intended to help building owners to define the sustainability requirements for their building projects (Kiviniemi, 2005). Kiviniemi then designed a building requirement IFC specification based on the requirements hierarchies of the WBFS and EcoPro. The research aims to manage requirements information during design process and provide the possibility of linking requirements to the objects in the design. A solution for cascading requirements which simplifies the database structure significantly is also identified. However, there is still no attention given to the clients for collecting their feedback against these requirements. In this context, Kiviniemi's requirements specification has become part of the research basis for the requirement documentation method used in UPOEM. In addition, a feedback questionnaire is used with the requirements specification together to facilitate the clients to review design solutions in this study.

DESIGN OF THE UPOEM

The rationale of UPOEM

In the conventional architectural design process, clients first specify their requirements, such as space program, and then the designer proposes the preliminary design according to this brief.

The rationale of UPOEM is to build up a 3D virtual environment not only contains the building but also the end users' activities. This integration aims to facilitate the clients and designers to understand how the end users' organization will be accommodated in the given building, such as, the location of end users' activities in the new building, or the adjacency relationship between different functional rooms. During their "daily" activities, end users can evaluate their working or living environment in a "familiar" way. So this simulation provides a platform for the clients (including end users) to conduct a post-occupancy evaluation of their built environment in the virtual reality environment.

Therefore, the UPOEM provides two more processes based on the conventional process: (1) user activity specification and simulation; and (2) pre-occupancy evaluation

Components of the UPOEM

Three components are designed in UPOEM to support the designer-client communication process (as shown in Figure 5).*Building information module:* this module's purpose is to use BIM tools to build up and update the building information model based on the design given by the designer. *User information module*: this module is intended to collect end users' information, facilitate them to specify their activities and generate the activity simulation model. *Pre-occupancy evaluation module*: this module aims to conduct a pre-occupancy evaluation based on the virtual environment and collect users' requirements and feedback.

Framework of applying UPOEM

The UPOEM is usually applied in the consultation meeting involving the designers and the end users in the architectural design stage. The timing of this meeting is usually after the

outline proposal is created by the designer. Then users are invited to discuss the design and give their feedback. The times of such interactions depend on the scope of the projects and duration of the design period, and sometimes would last until the design solution is finalized. There are four main steps for the implication of the UPOEM in practice:

Preparing the building information model: The building information model is built by BIM tools based on the drawings given by architects. When users give feedback on the design, the building information model needs to be updated for further evaluation.

Specification of user activities: By using the user organization information module, users specify their activities and the functional spaces they will use in their future working environment.

Simulation of the user activities: After preparation of both building model and user information, the activity simulation model is generated for the pre-occupancy evaluation.

Pre-occupancy evaluation: The users' feedback or further requirements are collected in this step via the pre-occupancy evaluation module.

User activity simulation

This user information module is to specify user information including roles and activities of the organization and generate the users' activity schedules. Then an activity simulation model is generated based on the end users' activity schedules (Table 1).

The activity specification method applied in this paper is a simplified and easy to use activity scheduling method based on the work of Tabak (2008). Tabak divided users' activities into skeleton activities and intermediate activities. He used different scheduling method to schedule the individual skeleton activity, interactive skeleton activity and intermediate activity. It mimicked the behavior of real human beings when scheduling activities.

Table 1: *An example of user's activity schedule*

Activity	Start time	End time	Location
Research work	09:00	11:30	Office
Teaching	11:30	12:30	Lecture room
Lunch	12:30	14:00	Canteen
Research work	14:00	18:00	Office
Leave	18:00		Exit

Activity scheduling method applied in UPOEM

In the UPOEM, the users' activities are also divided into skeleton activities and intermediate activities. But it made no distinction between planned, unplanned skeleton activities.

Scheduling the skeleton activities: all of these skeleton activities are treated as planned activities referring to users' working routines. Users are requested to arrange their skeleton activities in the new building via a user activity scheduling interface.

Figure 3 shows the interface for the users to specify their activities in the new building. End user can specify their skeleton activities including start time, end time, and location of each activity based on their daily working routines or agenda of one specific working day. They can specify their locations of each skeleton activity by inputting name of rooms directly or picking the room name from the 2D layout by clicking the button representing each room.

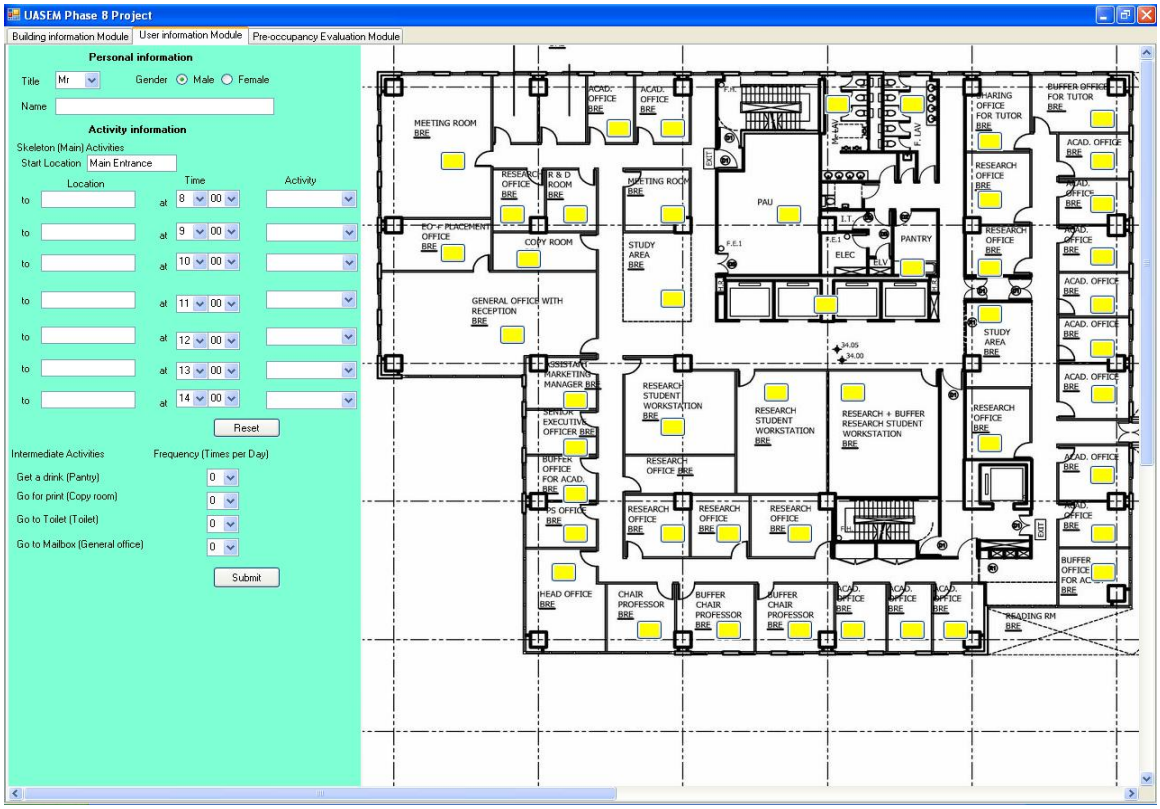


Figure 3: *Interface for user activity specification and scheduling*

Scheduling the intermediate activities: The method of scheduling the intermediate activities in UPOEM is less concerned with predicting the accurate occurrence time of each intermediate activity, but demonstrating the spatial factors of the design solution mainly (such as, adjacency relationship, circulation, walking distance and traveling time between two location in the building). The process of demonstration is usually proportionally shortened to several minutes for adoption in real life designer-client consultation meeting (e.g. 16 minutes represents 8 hours a day). Therefore a simplified intermediate activity scheduling method is proposed for this purpose. It has two features: (1) the occurrence time of all these intermediate activities depends on the time elapsed since the previous occurrence; and (2) a linear probability distribution method is used to simplify the S-curve method used by Tabak. This simplification saves the time of determining the shape of the S-curve, and is easy for the users to describe their daily activities. The intermediate activities (such as get a drink, go for print, go to toilet and go to mailbox) are described by daily frequency. And the mean duration of these intermediate activities are assumed to be a certain time for each.

The algorithm to calculate the occurrence time of a given intermediate activity in a certain time span with an N frequency is as follow:

Step 1. RC = Random (0,1.00).
Step 2. IF (PC > RC)
THEN // The intermediate activity will happen at this time.
PT = CT; // Records the activity happening time to PT.
AC = AC + 1; // Increase the activity counter.
ELSE // The activity will not happen, increase the time.
CT++ ; // The interval of time increase is set to 0:05.
GOTO Step 1;

Step 3. IF (AC = N)

THEN // The activity has happened at the user indicated frequency.

End Algorithm;

ELSE

CT++ ; // The interval of time increase is set to 0:05.

GOTO Step 1;

The parameters used in the algorithm are given the definition below:

ST = The starting time of the simulation, predefined at 9:00 am.

ET= The ending time of the simulation, predefined at 17:00 pm.

CT= The current time.

PT= The time when the previous activity happened, which equals to ST at the beginning.

RC = The probability of an activity will happen at random. Ranged 0 – 1.00.

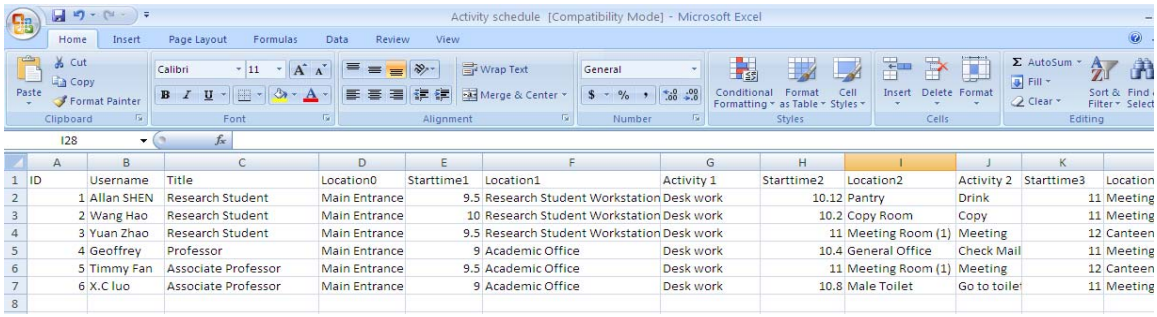
N = Frequency of the activity. (Times of occurrence of the activity take place during the simulation, and are inputted by the users.)

AC = Activity counter. Indicates how many activities have already taken place. Set to 0 at the beginning.

PC = The probability of an intermediate activity will happen in a given time. PC is calculated by the formula:

$$PC = (CT - PT) / ((ET - PT) / (N - AC)) \quad (1)$$

After determining the occurrence time, these intimidate activities are inserted into the intervals of the skeleton activities. Then the whole activity schedule including both skeleton and intermediate activities is generated and saved into the database (Figure 4). The activity simulation tool will generate the end users' activity based on this schedule.



	A	B	C	D	E	F	G	H	I	J	K	
1	ID	Username	Title	Location0	Starttime1	Location1	Activity 1	Starttime2	Location2	Activity 2	Starttime3	Location
2	1	Allan SHEN	Research Student	Main Entrance	9.5	Research Student Workstation	Desk work	10.12	Pantry	Drink	11	Meeting
3	2	Wang Hao	Research Student	Main Entrance	10	Research Student Workstation	Desk work	10.2	Copy Room	Copy	11	Meeting
4	3	Yuan Zhao	Research Student	Main Entrance	9.5	Research Student Workstation	Desk work	11	Meeting Room (1)	Meeting	12	Canteen
5	4	Geoffrey	Professor	Main Entrance	9	Academic Office	Desk work	10.4	General Office	Check Mail	11	Meeting
6	5	Timmy Fan	Associate Professor	Main Entrance	9.5	Academic Office	Desk work	11	Meeting Room (1)	Meeting	12	Canteen
7	6	X.C luo	Associate Professor	Main Entrance	9	Academic Office	Desk work	10.8	Male Toilet	Go to toile	11	Meeting
8												

Figure 4: *Saved user activity schedule information*

Activity simulation model

This activity simulation model demonstrates the single or groups of users' activities in the 3D environment. It is built up based on the users' activity schedules and building information model via the virtual reality software 3DVIA Virtools. A program is written for loading the users' activity schedules in the format of excel files and generating the activities in relatively short time. In this model, both graphical information (3D avatars representing different users) and non-graphical information (text instruction, activity statistical data and symbols) are provided to facilitate the demonstration and data analysis.

Graphical information to enhance users' virtual experience of the built environment

Usually the demonstration time is shortened proportionately to adapt to the communication duration. During the demonstration, users can follow the movement of the avatars to observe their daily activities in the new building according to their schedules. They can choose different end users and switch between them. Multiple observation angles are provided to observe each user's activity, such as overview (with zoom in and zoom out function), third person and first person view to enhance their virtual experience within the built environment. End users can easily change different angles to observe their working environment (Figure 5). One of the advantages of this kind of navigation is that, users can observe the design model as they already live in this building and avoid aimless roaming. This can improve the efficiency of the designer-client communication, especially when there is time constraint.

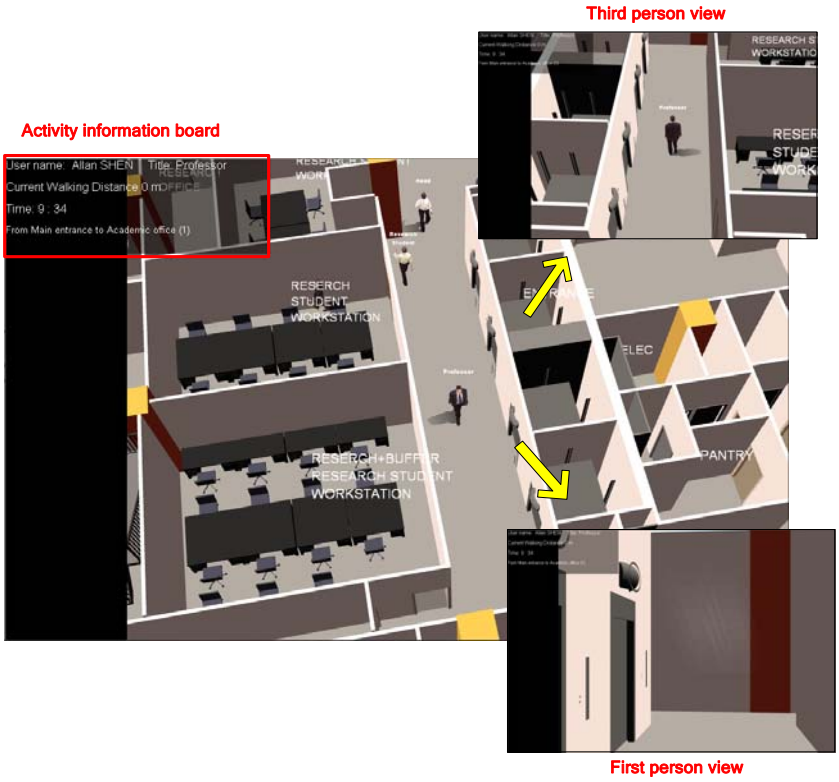


Figure 5: *The activity simulation model*

Except following the avatars, users can switch to the normal observation method as the same as those functions provided by other design (or review) software (e.g. Revit Architecture) to exam the design. The self-control walkthrough and flythrough are also available in this activity simulation model.

The activity simulation model can not only demonstrate individual user's activity but also accept multiple users' activity schedules and simulate the interactive scenarios such as meeting and teaching. Figure 10 shows five users attending a meeting according to their schedule on a certain working day. As the involvement of the avatars, users can obtain a sense of scale in the room and the "feeling" of it being crowded or spacious. They can also have the sense of distance while they are following their aviators from one location to another. The focus of this model is to facilitate users to understand the factors most related to users' movement and spatial comfort.

In the process of design development, more details are added into the building model. Then the users can understand more specific design details besides the layout, such as the interior decoration, lighting and the view outside the building, which depends on the capabilities of the building simulation model.

Non-graphical information to support the demonstration

Besides the graphical walkthrough, one of the features of this activity simulation model is that it provides statistical information to illustrate users' activities. For example, Figure 9 illustrates a normal working day of a department in a university, when one of the professors is walking from main entrance to his academic office. The activity information board on the left-up corner of the model displays the name of users, title, time, current activity and walking distance.

During the designer-client communication, questions such as "will the layout design ease the communication between employees?" or "will traffic flow easily?" are always raised by the designers, especially when users' traffic efficiency is emphasized in the design (e.g. airport and hospital projects). The users also usually concern about whether it is for him/her to travel around the building. So the walking distance or travelling time is a crucial index to measure the convenience or efficiency of the design. In this model, the distance is measured and displayed during users' movements. Other data such as the total walking distance of all the users, and the circulation time of each user can also be measured for different evaluation purpose.

Movement patterns are also important for designers to evaluate the layout. The movement path can be traced to illustrate the connection between different functional rooms (Figure 6 left). These movement tracing curves can help users to understand the adjacency relationship between different functional rooms easily. This is easy for them to specify adjacency requirements during the communication process. In the meantime, movement tracing curves with different color are used to show the movement pattern of different roles in one organization. For example, in a campus office building, the circulation of professors and research students are illustrated by different colors (Figure 6 right). This can support the circulation design in the organization and avoid disturbance between different roles.



Figure 6: *Tracking curve of user movement*

Pre-occupancy evaluation

Pre-occupancy evaluation is the application of post occupancy evaluation (POE) in the pre-construction, pre-occupancy or pre-project stage. Post-occupancy evaluation is defined as "the process of evaluating buildings in a systematic and rigorous manner after they have been

built and occupied for some time" (Preiser, 1988). It systematically evaluates the buildings in use from the perspective of the people who use them. It also assesses how well buildings match users' needs, and identifies ways of improving building design, performance and fitness for purpose. The British Council for Offices (BCO) illustrates that “a POE provides feedback of how successful the workplace is in supporting the occupying organization and individual end-user requirements” (N.A.Oseland, 2007). Virtual reality techniques have been used to conduct the pre-occupancy evaluation in some research work (Palmon, Sahar, Wiess, & Oxman, 2006).

In the virtual environment based pre-occupancy evaluation process, the evaluation objects are the building models. There are many building performance simulation tools can generate rich building information for this evaluation, such as architecture, lighting, thermal, and acoustic. In this paper, the evaluation factors focus on the spatial properties of the layout in the early architectural design stage. It is because during the designer-client communication, the functional factors (size, location and adjacency) and visual factors (appearance and view) are the basic factors most concerned by the clients.

Based on the activity simulation model, this pre-occupancy evaluation module aims to: (1) Remind the clients the defined requirements; (2) facilitate the clients to specify more requirements; and (3) collect the feedback from the end users against these requirements and save these requirements and feedback in a systematic way.

Therefore, this module aims to provide a platform to systematically manage the following information: (1) Pre-defined requirements from the brief; (2) Information from the existing design model; (3) Further requirements developed by clients during communication; and (4) Feedback from the clients on the design solution.

A database containing clients’ requirements, feedback and data from existing design model is designed to support the pre-occupancy evaluation process. The requirements of building project covers space requirements mainly including requirements on area, location, adjacency, circulation, flexibility, fixtures and etc. The extension of this evaluation method in other aspects such as site, building envelope or HVAC system will be discussed in future research.

Kiviniemi (2005) categorizes the space requirements into two main requirements objects: (1) space program instance (SPI) and (2) space program type (SPT). The space program instance contains the requirements of space such as area, occupancy type, max occupancy number, location, number of space units, adjacent spaces. The space program instance can be linked to several space instances in the design model. The space program type defines the identical requirements shared by several space instances in the requirements model. It contains the requirements about activities, function, space program fixtures, indoor climate, acoustics, lighting, flexibility, safety, comfort and etc.

According to virtual environment provided by the activity simulation model, some requirements from the space program are selected for the basis of pre-occupancy evaluation. The space program instance and space program type is also distinguished in this pre-occupancy evaluation module (Figure 7) .

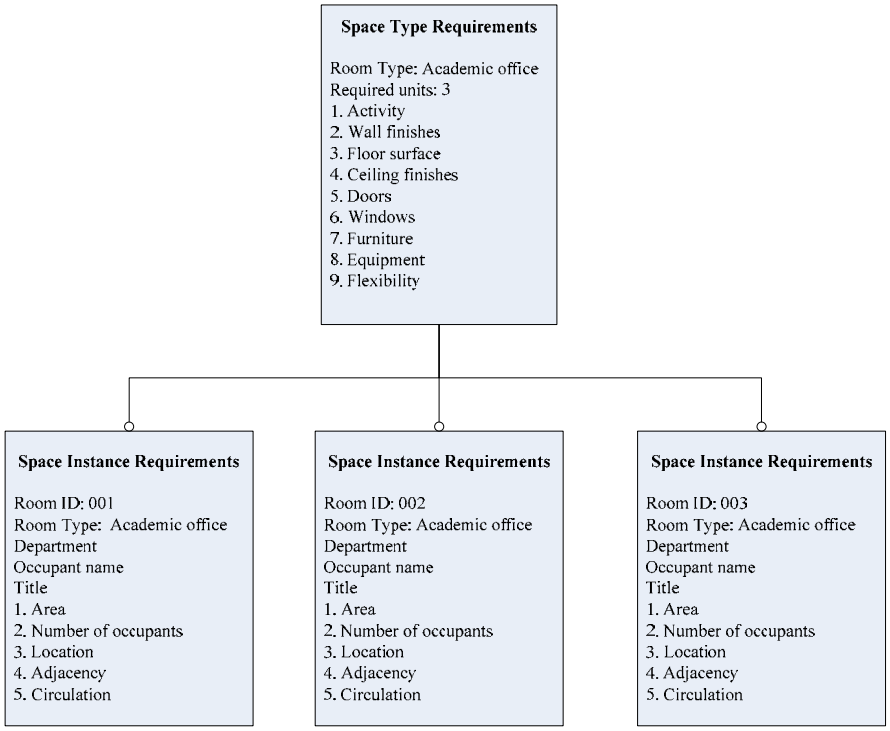


Figure 7: *relationship between space type requirements and space instance requirements*

In this way, the structure of requirements model can be simplified significantly. According to this structure, the clients' feedback of the design solution is also combined with the requirements information.

Pre-defined requirements: these requirements are extracted from the existing project brief. During the design-client communication process, new or more specific requirements may be continually generated, thus this module can record the change and generation of project requirements during the communication.

Design solutions: during the designer-client communicating, most of the design information is illustrated in the form of user activity simulation model (containing building model). Therefore clients are asked to give their feedback during the observation of the user activity simulation model. Some of the non-graphical information, such as area of each room, is extracted from the building model and stored into the database of the pre-occupancy evaluation module.

Clients' feedback: Questions about end users' spatial satisfaction are asked to obtain feedback on the design solution, for example, "Does this room have enough space to work without crowded feeling?", or "Does the layout can match your daily workflow?" The users can give response at different levels or give comments. The feedback is saved directly into the database in form of excel files. Designers can easily get access to these files and find them classified by different user names thereby facilitating the management of these files.

Design of the clients' requirements and feedback interface

On the pre-occupancy evaluation interface, users can trigger the user activity simulation model to observe the design solutions during their "daily life". After observation, they are requested to fill in the space instance requirements and feedback form of the rooms they

observed. The room ID is the link between the user activity simulation model and the requirements and feedback interface. For example, when a client observing the user activity simulation model, the room ID is shown on the top of each room, and the client can open the corresponding clients' requirements and feedback form on space instance via the interface (Figure 8). A 2D layout is used to help the clients to give feedback on each room. Clients can press the button representing each room and the space instance requirements and feedback form is popped up. The space type requirements and feedback form can be opened by clicking the space type requirements button.

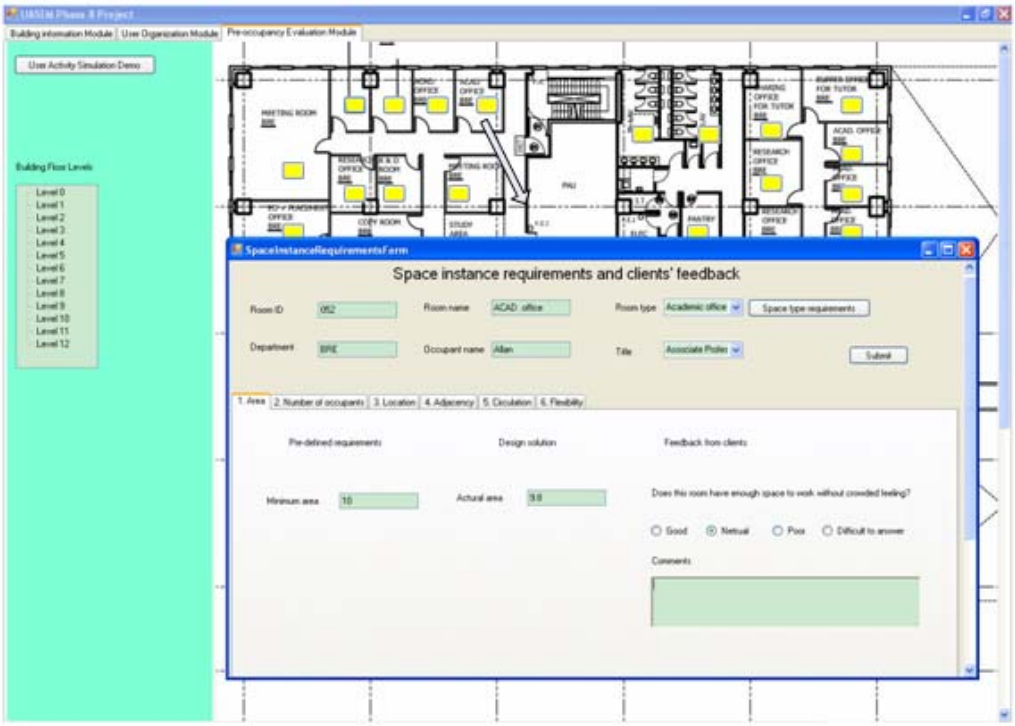


Figure 8: *Pre-occupancy evaluation module interface*

CONCLUSION AND FUTURE WORK

This paper proposed a BIM based user pre-occupancy evaluation method (UPOEM) to facilitate the design-client communication in architectural design process. User activity simulation technology is used to enhance the visual experience of the clients, and a requirements and feedback interface is designed to facilitate clients to develop requirements and review design solution. A framework of implementation of the UPOEM in real project is also proposed. It is expected that the clients can have a better understanding of their future built environment via observing the user activity simulation model. The efficiency of design review will be also improved by the support of the requirements and feedback interface.

This method will be tested in a campus project in further study, which aims to validate the effect on improving the clients' performance during the designer-client communication.

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RELEASING THE POTENTIAL OF BIM IN CONSTRUCTION EDUCATION

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Abstract
When setting out to teach a group of construction students the lecturer is faced with a class who have a variety of learning style preferences and have brains with a variable ability to process information and that ability varies further with the type of processing required. They also come to the class with varying previous experience and knowledge and with varying social skills. In order to facilitate the learning the students need to be actively engaged in a task designed to cause them to interact with the information they are supposed to be learning. However learning is a complex process that requires considerable management. BIM has the potential to assist construction education in this as it can make information available in a manner that is much more accessible to visual and kinaesthetic learners (the majority of learners). It is not in itself a universal panacea to the problem of teaching construction students. The challenge for construction educators is to use this new form of information provision to enable us to move away from lecture formats and reshape our teaching delivery to a format that is better aligned with the learning styles and processes that suit most learners.

Keywords: Construction education, learning styles, learning processes, Building Information Modelling.

INTRODUCTION

For the purposes of this paper the American General Contractors (2006) definition of BIM has been adopted:

> Building Information Modelling is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a Building Information Model is a data rich, object oriented, intelligent and parametric representation of the facility from where views and data appropriate to various users' needs can be extracted and analysed to generate information that can be used to make decisions and improve the process of delivering the facility.

The generally accepted convention of describing construction assembly and time related modelling as 4D and cost related modelling (including the quantification of work for estimating purposes) as 5D has been adopted.

BIM at least in the sense of 3D modelling is fast becoming a reality in the commercial world (McGraw Hill 2008) including New Zealand (Boon 2009). It also has the potential to become a powerful tool in the world of construction education. At its simplest it enables construction students to see in a 3D virtual model how buildings are assembled. This in itself is a considerable advance on trying to get students to learn building construction through

interpreting 2D information. Beyond this BIM has the potential to allow faculty to radically rethink the teaching and learning process for construction students. If the BIM models provide information, that is readily understood by the student, as to how buildings are assembled, faculty should be able to spend less time "telling" students about construction detailing and thereby create more time for the students to learn by interacting with BIM models in the processes of construction planning, measurement and estimating.

This paper explores this issue by firstly looking at how people learn and then considering how BIM can be used to enhance the students learning experience in construction education. The latter is done firstly from a theoretical perspective and then by way of case studies of the authors own experiences.

EDUCATIONAL THEORY

This section is written from the perspective of a construction educator attempting to understand the process they are engaged in rather than as an expert in teaching and learning. MacKeracher (2004) makes the point that *"Learning is something done by the learner rather than something done to or for the learner. Learning proceeds independently of (and sometimes in spite of) education and schooling"* (p5) Understanding how learners approach learning and process information is therefore critically important. This brief review of literature is broken into three sections, learning styles, brain styles and the learning process.

Learning Styles

There is general agreement in the literature that learners vary in the way they approach learning. How such variation is categorised to form a typology of learning styles differs between authors.

MacKeracher (2004) refers to Curry's (1983) three layer onion metaphor as a way of analysing students approach to learning. The outer layer is composed of behaviours that are more observable, less stable and more easily influenced by external conditions. The middle layer is concerned with information processing styles that are less directly observable although modifiable by the learner adopting new strategies. These information processing styles can be categorised using tools such as the Grasha-Rechmann Student Learning Style Scale (Grasha ,1993) which measures three paired styles: social (competitive / collaborative) emotional (avoidant / participatory) and the needs for structure (dependent / independent). The third inner layer is concerned with cognitive personality styles affecting an individual's approach to adapting and assimilating information. Styles in this layer can be assessed using instruments such the Myers-Briggs type indicator (Myers 1985).

MacKeracher (2004) also refers to Suessmuth (1985) typology of personal learning style preferences:

1. *Language learners* prefer to hear (auditory) language or see (visual) language. They are best at remembering information in word form.
2. *Numerical learners* prefer to hear (auditory) or see (visual) numbers. They are best at remembering and using information in numerical forms.
3. *Auditory – visual – kinaesthetic (AVK) learners* prefer to learn through personal experiencing and need sensory stimuli. They need to manipulate material and be totally involved; they may become distracted if not entirely involved. (p81)

Materna (2007) refers to the work of a number of authors to present a three part model:

1. *Auditory learners* who learn best by listening. Such learners are comfortable with traditional lectures and learn best if they have listened to information before reading about it.
2. *Visual learners* who needs to see information before they learn well. The learning of this group is greatly aided by pictures, diagrams, flowcharts as well as text information.
3. *Kinaesthetic – tactile learners* who learn best by doing. They need to be actively engaged in experiments, exercises or preparing their own material in order to learn.

Materna (2007) acknowledges that learners are capable of using more than one style and in some cases are skilled "combination learners" capable of using all three styles. However she quotes a number of authorities to suggest that "40 – 65% of learners are visually dominant, 20 – 30% are primarily auditory and 5 – 15% are primarily kinaesthetic learners" (p49).

Intelligence

Theories concerning learning styles only help to explain the manner in which a person prefers to approach the learning experience. They do not explain how the brain processes information or the nature of intelligence that enables the learning process.

During much of the 20th century theorists tended to view intelligence as a singular or general thing. The IQ test being an example of a means of measuring that singular intelligence. However in the latter part the century theorists developed the concept of multiple intelligences. Notable work includes Howard Gardiner's eight intelligences. Gardiner defined intelligence as "the capacity to solve problems or fashion products that are values in one or more cultural settings". His eight intelligences are:

1. *Logical-mathematical* the ability to compute and apply mathematical concepts and logic to complex situations.
2. *Linguistic* the ability to use language to describe, express, develop arguments, persuade and influence.
3. *Musical* the ability to understand, interpret, create and perform music.
4. *Spatial* the ability to visualise and perceive through the use of hands and other body parts. The ability to interpret and graphically represent ideas.
5. *Interpersonal* the ability to perceive emotions and respond accordingly.
6. *Intrapersonal* the ability to have personal insight and understand own emotions and responses.
7. *Bodily-kinaesthetic* ability to use parts of the body
8. *Naturalistic* the ability to understand and classify patterns in the natural environment. (adapted from Materna 2007).

Within the context of this paper the concept of spatial intelligence is particularly interesting. It is this type of intelligence that students need to develop in order to be able to interpret drawings and understand how building components fit together. Materna (2007) makes the point that within the education system generally we have promoted the development of the first two intelligences to a much greater degree than the others.

Whilst agreeing with the concept of multiple intelligences Sternberg (1988) does not classify them in terms of specific abilities in the way Gardiner does. Sternberg argues that successful intelligence is a mixture of analytical, creative and practical thinking behaviours. He defines these as:

1. *Experiential intelligence (creative)* the ability to deal with different situations and develop new ideas for dealing with situations

2. *Componential intelligence (analytical)* the ability to process information effectively using abstract thinking and logical reasoning.
3. *Contextual intelligence (practical)* the ability to adapt to the environment, street smarts and ability to change behaviours in a new environment.

Sternberg's analysis seems to provide a different perspective. It can be argued that in order for a person to be competent in the area of construction technology they need to bring all three dimensions of Sternberg's intelligences to apply to develop their spatial intelligence in Gardiner's terms.

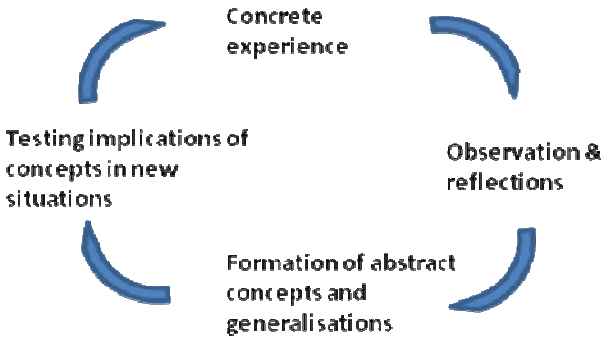
Materna (2007) also refers to the work of Perkin's (1995) who supports the concept of multiple intelligences but focuses on three dimensions.

1. *Neural intelligence:* Efficiency and precision of the neurological system.
2. *Experiential intelligence:* Accumulation of life experiences in different areas.
3. *Reflective intelligences:* Metacognitive abilities or personal strategies for problem solving and self management.

This analysis provides additional insights into the learning process as it identifies both that learners bring all their past experiences to the process and that the learner needs to process the information in accordance with their own reflective intelligence abilities and preferences.

The Learning Process

There seems to be a reasonable consensus that learning is an iterative (or circular) process. Authors such as Mackerchar (2007) refer to the "Kolb Cycle" although David Kolb (1984) refers to the "Lewinian experiential learning model "(p21).

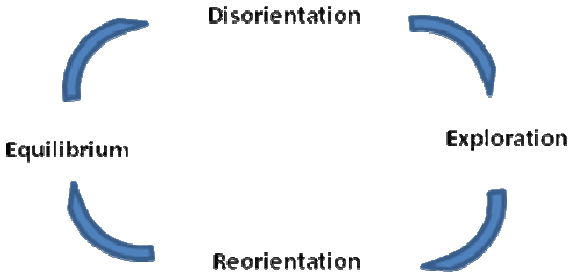


The Lewinian Learning Cycle from Kolb 1987 p21

The implications of the model include that the learner needs some kind of experience as a start point which they can move on from, to reflect on and then conceptualise in an abstract sense and then further experiences in increasingly challenging situations in order to test and affirm their concepts and generalisation. Kolb is of the view that as part of the learning process the experience and the observations and reflections should be shared with others.

Taylor (1987) provides a useful alternative that aligns with the author's own experiences. She argues that the experience can start with *disorientation and confusion* when the learner is confronted with a new situation. This can result in a loss of confidence and unless the learner can find a way forward (with or without assistance) they may stay in that situation for a protracted time. If successful in moving forward the learner enters what Taylor calls the *information phase* within which the individual becomes engaged in searching for information to solve the problem. Taylor argues that when learners have gathered enough information they usually withdraw to think things over. Following this period of reflection Taylor says the individual enters a *reorientation phase* within which they synthesize and make sense of ideas. It is in this phase that the learner is engaged in the act of learning. They are then able

to proceed to the *equilibrium phase* within which they refine and elaborate on their understanding. It is normally necessary to engage in discussion with others in order to complete this phase.



Taylor's learning Cycle (adapted from Taylor 1987)

Gavin and Taylor (1992) have elaborated on the dangers of the learner struggling in the disorientation phase and suggest that the learner may instead of moving forward enter a "decremental cycle of learning" in which they will seek to blame others, build a case to support their negative feelings and may even exit the learning process altogether, rather than seek to understand the disorientation they are experiencing and enter the exploration phase.

Cross (2009) acknowledges that learning is not necessarily a linear process. Some people learn in an incremental (step by step) process whilst others may appear to make no progress and then move forward in large and apparently unpredictable ways.

Learning as a Social Constructivist Activity

The final piece of theory of relevance to this paper is the notion of learning as a social constructivist activity. Within educational theory there are two schools of thought; objectivist and constructivists. Feyton and Nutta (1999 p50-51) summarise these as:

> *The objectivist (also known as behaviourist, instructivist, rational, or directed learning) viewpoint assumes that the role of the teacher or instructor – is to transfer or transmit knowledge to a student, who is a more or less passive recipient. In this model, the content of "what is to be learnt' is considered to be a stable entity that can be organised into a structure involving a series of steps or subcomponents that are often followed in a sequence. The teacher – directs the process of transmitting the sequence of structured content.----*
>
> *In contrast, the constructivist approach incorporates the notion that learners build a knowledge base through personal experience. Knowledge is not viewed as something to be poured into an empty vessel. Constructivists maintain an emphasis on learning by problem solving and apprenticeship in real-world contexts (Brown, Collins and Duguid 1989).*

Cross 2009 describes constructivist's theories as being concerned with "knowledge creation within individual minds and through social activity" (p31). In order for the learner to learn they have to actively reconstruct the knowledge in their own minds. Cross uses the work of Vygotsky to look at the social aspects of learning, suggesting that when a learner interacts with a "more knowledgeable other" progress can be made with a task that is beyond the current ability of the learner. However Cross extends beyond interaction with the expert to emphasise that the "social" dimension of "social constructivism" includes the need for other people interacting with the learner to observe in action, engage in discussion or provide emotional support. Cross uses the metaphor of scaffolding to support the learning activity in

progress (the authors of this paper, as members of the construction industry feel "propping" would have been a better term). Learning is seen by Cross as a transition that needs support. Once the new knowledge is integrated into an existing framework of knowledge in the learners own mind the scaffolding can be removed.

Cross (2009) describes the role of the teacher within the concept of social constructivism as being to design tasks and activities, integrate appropriate assessment, provide relevant feedback and act as facilitators of dialogue during the learning process.

Summary of Educational Theory

This overview of education theory suggest that when setting out to teach a group of construction students the lecturer is faced with a class who have a variety of learning style preferences and have brains with a variable ability to process information and that ability varies further with the type of processing required. They also come to the class with varying previous experience and knowledge and with varying social skills. In order to facilitate the learning the students need to be actively engaged in a task designed to cause them to interact with the information they are supposed to be learning. The task should enable them to move through the type of cycle described by Kolb (1984) and Taylor (1987). This cycle includes a period of reflection that each student will hit at a different time and need a different period of reflection. Repetition through the cycle with increasing levels of complexity is necessary. As they move through the cycle the learner needs some (but a varying) degree of interaction both with people with expertise (the lecturer) and fellow students. If the task is too challenging the students may experience disorientation and if not able to move out of this situation (with or without assistance) may become negative and even withdraw. How students engaged with the learning experience presented to them depends on their earning style, past experiences and prior knowledge. If they succeed in moving through the learning cycle they will learn something but not necessarily what the lecturer intended.

EXPERIMENTS IN USING BIM IN THE LEARNING PROCESS

From the theoretical discussion above it is possible to conclude that an ideal process for learning construction subjects such as technology, scheduling and measurement should:

- Present the subject matter in a visual manner with some verbal explanation but allow those who wish the freedom to explore for themselves.
- Should be delivered in an environment that allows social (informal) interaction, student – teacher and student – student.
- Allows students to proceed at their own pace.
- Gives the teacher the ability to identify those experiencing disorientation and time to work with them to move them to the next phase.
- Gives students time to reflect when they need to.
- Provides repeat experience.

To a certain extent construction subjects have always allowed elements of this approach. Technical subjects are inherently visual and students learn by doing (drawing, scheduling, measuring etc). BIM has the potential to improve this process particularly in regard to the first bullet.

At Unitec we have been teaching our architectural technology students drafting of 3D models for about five years. However it was only in early 2009 that we started to take a serious

interest in the wider issues of BIM and consider its potential as a teaching tool for construction management and quantity surveying students.

In order to build our understanding of the potential of BIM beyond basic 3D models we formed a small development group of recent graduates and senior students and tasked them with:

1. Creating some 3D models
    a. A very detailed model of a house
    b. An industrial building
    c. A four storey teaching block. In this case separate architectural, structural and services models were produced.

    These were created by obtaining 2D drawings and redrawing them as 3D models.
2. Learning to connect the 3D model to a M.S. Project schedule to produce an animation of the construction sequence (basic 4D modelling).
3. Use additional software to compare the architectural, structural and services models for the purposes of coordination and clash detection.
4. Use software to measure and estimate in accordance with quantity surveying practice and rules, directly from 3D models (5D).

From this exercise we gained:

1. An initial stock of 3D models to use as teaching tools
2. Confidence that it was possible for the students to integrate the models with limited assistance.
3. An understanding of how to link model to schedule and produces a sequence animation.
4. Confidence that students would be able to use software to measure from 3D models.

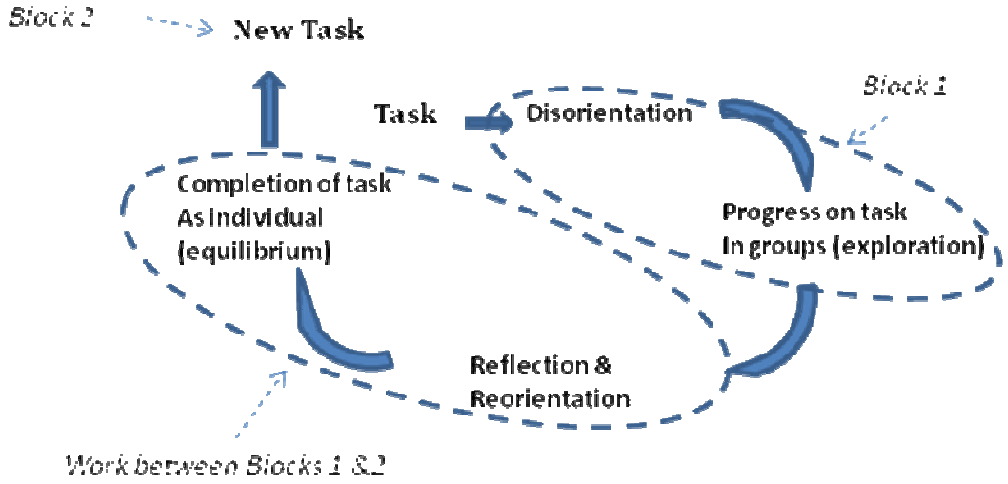
From this exercise we also learnt that what was possible to achieve by way of scheduling and measurement was limited by the way the 3D model was built, by the information that had (or had not) been placed in the drop down boxes that are associated with each object in the 3D model and the limitations of the interrogating software both integrating software and 5D software, to read the information in the boxes. Our learning caused us to undertake substantial rebuilding of the 3D models.

In parallel with the activities described above we experimented with the use of 3D models to assist a year one measurement class. In this case the students were required to measure from simple 2D drawings (as in previous years) however a 3D representation of the drawings was also prepared and set up to run as a rotating model on the projector in the classroom. It was also made available to students through our online teaching support system (Blackboard). This seemed to significantly enhance the students understanding of and ability to interpret the 2D drawings and enable them to make progress with their measurement (avoid disorientation). Whilst this experiment barely tapped into the potential of BIM it did make us realise just how much students struggle with understanding 2D drawings.

Our second experiment was with third year construction economics students on the Bachelor of Construction programme. The aim of the course is to teach students measurement and pricing of building services. We decided to incorporate the use of measuring and estimating software that extracted information directly from 3D models for the first time, thereby introducing the concept of 5D modelling into the programme. The course is a final year

course delivered as a Block course in two blocks each of two days mainly to part time students. It was delivered in a computer lab to approximately 25 students. To assist in delivering the course we obtained the assistance of a specialist from the software company and staff from a QS practice with expertise both in services and the software.

We have been teaching block courses for a good number of years now and have evolved a pattern of delivery that was influenced by an interest in "problem based learning" based on the work of authors such as Boud and Feletti (1997) and Savin-Baden (2004). The pattern has many individual variations dependent on the subject matter and inclinations of the course lecturer however its generic form is as illustrated below. This seems to accord with much of the educational theory presented above, providing for loop learning, social interaction, and engagement through a variety of learning style preferences etc.



Generic format of block course delivery used by authors with reference to Taylor's (1987) learning cycle

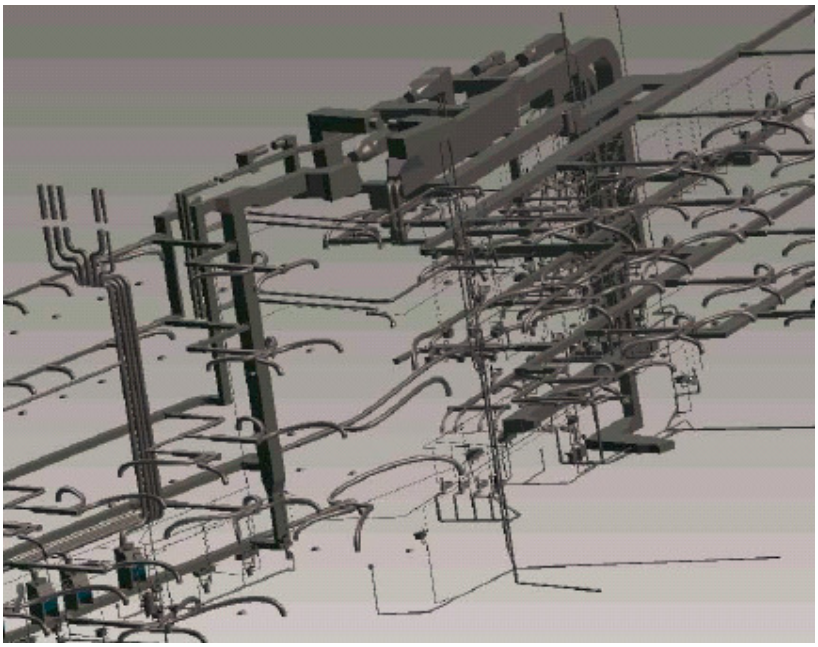
The building used for the course assignments was the four storey teaching block which we had modelled in 3D described above. Most of the students were already familiar with the building and the 3D model as it had been used in a services technology course they had taken the previous semester. This course had also included a site visit. This coordination with the previous course and 3D model reduced the possibility of the students becoming disoriented through being unfamiliar with the services they were required to measure and price. It was also their third course in measurement and pricing so they were familiar with the basic approach and processes.

Delivery of the course was designed around a 3 part assignment requiring the students to:

1. Produce an early stage estimate based on gross floor area
2. Produce an elemental cost plan
3. Produce a schedule of quantities based on the New Zealand standard method of measurement and an estimate of the cost of the work.

Designed in this way the assignment provided three learning loops with increasing complexity. The first was done entirely within day one of the first block and enabled the student to become familiar with using the software. The second was started within block 1 and completed as an individual assignment before block 2. The third was started in block 2

and completed before the end of the semester. Students also had to complete an end of semester examination.



Screen shot of 3D model of services

The first block started with a short formal teaching session on using the software. The students were then required to work at their own pace working in collaborative clusters as much as it suited them. The lecturer and industry experts circulated and coached the students through difficulties as they encountered them. From time to time presentations were made to the whole class on common difficulties. The industry people also gave short presentations on issues such as dealing with inadequate and inaccurate information, quality assurance and sources of pricing information.

Overall the course went well. Significant student collaboration was observed particularly they helped each other when they become stuck (typically with the use of the software). Their interaction with the industry people increased as they became more familiar with them. Two students displayed noticeable symptoms of disorientation as they struggled to master the software. One worked their way through the difficulties and successfully completed the course. The other entered a decremental cycle and did not.

There were significant issues with the 3D model. Some confusion was created where we had used generic models of objects such as pumps, heat exchanges, sanitary fittings etc, taken from an object library, which were not a good likeness to the actual equipment specified. This problem will be overcome in the future as more manufacturers provide online libraries of their equipment as BIM objects. In addition the model had errors in it and little specification information had been entered into the drop down boxes (equipment type, capacity, etc). Whilst it can be argued this represents a ‘real world experience” (the drawings are always incomplete and contain mistakes at the time of estimating) it does increase the learning challenge to students. They have to struggle with the “what” as well as “how” to measure and price. This must increase the chances of disorientation and therefore seem desirable to avoid. To improve this situation it is necessary for us to embed in the model significant amounts of

specification information that currently resides in a separate specification document. Whilst the process of entering the data into the drop down boxes that are associated with each object in the 3D model is straight forward it is labour intensive and for a resource lean academic institution provides considerable challenge. However once this is done it is easy to envisage that the students will have the ability to better connect in their own minds text based specification information (contained in the drop down boxes) with the 3D object they are looking at.

A further noticeable impediment to the students understanding was the issue that whilst the literature on BIM tends to imply there is one single model, whereas at the current stage of evolution of BIM there are in fact several models. The students therefore had significant difficulty in understanding where in the building (as depicted in the architectural model) the services (contained within a separate model) were actually located. These difficulties were at a fundamental level concerning issues such as whether the piping was in an exposed situation, contained in a duct or run between ceiling and floor slab. This limited their ability to describe the difficulty of installation and reflect that in their estimating. Until BIM models become fully integrated, this problem will remain with us.

CONCLUSION

Learning is a complex process that requires considerable management. BIM has the potential to assist construction education in this as it can make information available in a manner that is much more accessible to visual and kinaesthetic learners (the majority of learners). It is not in itself a universal panacea to the problem of teaching construction students. The challenge for construction educators is to use this new form of information provision to enable us to move away from lecture formats and reshape our teaching delivery to a format that is better aligned with the learning styles and processes that suit most learners. Specifically BIM models if constructed in sufficient detail and they contain sufficient embedded specification information, can empower the student to visualise the building component they are attempting to understand and then access specification information relevant to that component. If this is done successfully much of the disorientation that can occur in the early part of the learning process arising from not understanding the building components they are dealing with can be avoided.

Moving beyond the experiences we have described here we see the next step is for us to use BIM's 4D capabilities to enable to students to better understand the assembly process through the production of assembly animations. We envisage that in time this will extend to include temporary work such as formwork, propping etc.

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EXPLORING DIFFERENT COMMUNITY ATTITUDES TO SUSTAINABLE TECHNOLOGIES

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Abstract
The adoption of sustainable technologies to mitigate high energy use by home owners has not been extensive. As a result of legislation there are a number of initiatives to help resolve this situation, some which recognise that communities could be a good site of influence to effect this change. Communities have different socio-economic backgrounds, which may constrain their choices. This affects their attitudes to sustainable technologies, and how they might go about adopting them. This paper refers to pilot research studying attitudes in two socio-economically different communities in Birmingham, aiming to inform a larger study about successful interventions. These communities underwent the adoption of sustainable technologies via different interventions, here defined as an identifiable activity bringing sustainable energy technologies into an area. The interviewees presented a positive attitude to the intervention in their area, but displayed a difference in their perception of a sense of community. Socio-economic data raises important questions about a community's capability to intervene which was supported by the interviewees. The pilot suggests that interventions can enable interactions which allow positive information transfer necessary for increasing acceptability of sustainable technologies, which will be explored in the larger study.

Keywords: communities, sustainable technologies, attitudes, intervention.

INTRODUCTION

In 2008, the UK Government passed the Climate Change Act, obliging the UK to cut its greenhouse gas emissions by 80% by 2050, to mitigate against potentially dangerous climate change. As part of this, there has been some UK policy encouraging the generation of energy from renewable technologies (DTI, 2005). There is also a role for community based generation of energy (Hain *et al* 2005).

However, change has been slow. Information campaigns have not lead to as wide an uptake of sustainable energy technologies or energy efficiency measures as governments had hoped (Owens & Driffil 2008), and it is often difficult for governments to know which will be the best intervention and best use of resources, especially in times of economic hardship.

This research is a pilot for a larger study which aims to look at the success of interventions using communities to direct change in sustainable energy behaviours in individuals, and was designed to inform the larger study. The pilot aims to identify some important areas of study,

to establish what can be found out from individuals about successful interventions, and to establish whether the style of intervention is important. Individual attitudes are related to the process of an intervention; if people have a positive attitude to sustainable technologies themselves and the process of sustainable technology interventions in their area, interventions are potentially more likely to be successful. This is important if we want to see the widespread adoption of such technologies in order to address climate change. This paper will look at the responses of individuals from two different communities: residents of Moseley, who are benefitting from a community-led project; and residents of Northfield, who benefitted from a top-down intervention. This pilot was useful to inform a larger study looking at how different types of intervention in different contexts can encourage positive attitudes towards sustainable energy technologies.

The Communities

Moseley is situated to the south of Birmingham city centre, and is one of the more affluent neighbourhoods of the city. It is a well educated area, with a reasonably high average income, and a skilled workforce (see figure 1). The neighbourhood has a strong sense of identity that became evident in 1978 in retaliation to the threat of a relief road that was planned to run through the centre of the 'village'. The local residents succeeded in stopping this road, and formed the Moseley Society in 1979. Since then a number of groups and associations have arisen in the area including Moseley Forum, of which Sustainable Moseley (SusMo) became a working group in 2007 (Moseley Forum 2010).

SusMo are working to cut carbon emissions across their neighbourhood. In January 2010 they became one of 14 communities across the UK to win a British Gas Green Streets award. With this they will install photovoltaic (PV) panels on a number of community buildings and one home, as well as other energy saving measures such as condensing boilers, loft insulation and solar thermal panels in other homes. For this project, SusMo formed partnerships with the local Mosque, St Mary's Church, Moseley Church of England School, and MaDAHAL Allotments, and developed close working relationships with all of them. This project will be referred to as a community-led intervention for the purposes of this paper.

	Moseley	Northfield
Education		
No Qualifications	24.06%	34.64%
Level 1 (1 -4 General Certificates of Secondary Education or equivalent)	10.09%	18.45%
Level 2 (5+ General Certificates of Secondary Education or equivalent)	14.04%	19.47%
Level 3 (2+ Advanced levels or equivalent)	8.73%	6.79%
Level 4/5 (First Degree, Higher Degree or equivalent)	39.33%	13.34%
Other (Level unknown)	3.75%	7.32%
Income		
Average weekly household income	£500	£450
Occupation		
Managers & Senior Officials	14.45%	11.19%
Professionals	28.12%	9.69%
Associate Professional & Technical	18.10%	12.63%
Admin & Secretarial	10.80%	15.91%
Skilled Trades	6.03%	12.87%

Personal Services	5.36%	8.05%
Sales & Customer Services	5.17%	7.01%
Plant & Machine Operatives	5.20%	10.35%
Elementary	6.75%	12.30%

Figure 1: *Table showing education, income and occupation statistics for Moseley and Northfield. Office for National Statistics 2011*

Northfield has a very diverse cross-section of financial situations, with pockets of deprivation and vulnerability. It has a varied education profile (with a high proportion of people with no qualifications), a slightly lower average income than Moseley, and a more varied skill level among the workforce (see figure 1).

Birmingham Energy Savers is a large project being run by the local authority, Birmingham City Council (BCC). It aims to cut carbon emissions as well as create local jobs and help fuel poor or vulnerable households. During the pilot phase over 50 households (mostly within Northfield), 6 business premises and 2 social enterprises were fitted with PV panels, paid for by BCC. BCC will recoup the outlay by taking the Feed in Tariff – a mechanism whereby an amount (approximately 40p) is paid per kWh generated to the owner of the technology, as an incentive for generating energy renewably. This project will be referred to as a top-down intervention for the purposes of this paper.

LITERATURE REVIEW

There are many descriptions and theories of how society might change so that people will readily adopt more energy efficient technologies (Geels, 2005). Although change in individuals is required, the extent of the change needed to address global warming needs to be more widespread and comprehensive. Thus, the debates and theories need to address the fundamental problem of the way individual agents act in a wider social and structural situation. Theories of community (e.g. Bourdieu 1986, Wenger 1998) argue that individuals are overpoweringly influenced by history, identity and norms such that they are obliged to act in particular ways. However, theories of psychology (Ajzen 1991) see individuals as independent agents with attitudes, motivations and behaviours continually interacting with other individuals. In practice, most conceptions work with individuals, groups and their context simultaneously, and therefore we need to explore individual attitudes at the same time as exploring the way in which individuals see communities, technology and different types of intervention.

Attitudes

Attitudes and behaviours need to be modified if sustainable energy technologies are to be widely adopted. Attitudes towards these technologies will be influenced by many things, including the amount of factual knowledge a person has access to (Stutzman and Green 1982), their evaluation of the outcome of this behavioural choice, and the likelihood of that outcome (Kaiser *et al* 1999). However it is a paradox that apparently pro-environmental attitudes are not reflected in behaviour (Owens & Driffill 2008). Kaiser *et al* (1999) refer to the theory of planned behaviour (Ajzen 1985) in trying to explain this. As well as attitudes, a person is influenced by social norms (the expectations of significant others) and values when thinking about whether or not to behave in a certain way, such as adopting certain technologies. If both attitudes and social norms are conducive to this, an intention to perform

a particular behaviour is formed. This intention is then affected by contextual factors outside one's control.

A definition of 'attitude' throws up another interesting point. Allport (1935) defines attitude as a learned predisposition to respond to an object in a consistently favourable or unfavourable way. Just as people may have attitudes about sustainable energy technologies, so too may they have attitudes about governance arrangements. People may have negative attitudes towards a local authority (Frith and Bennetto), or towards particular community group members (McAreavey 2006, Derkzen and Bock 2009). This will affect the success of different types of interventions.

Communities

Most research on communities is focussed on their emerging internal conditions in relation to wider social norms, whether to do with crime, health or enterprise. This often relates to the breakdown in communities and the reduction in social capital (Putnam 2000). However the theory of social learning postulates that we acquire and evaluate our activities from our social context (Bandura 1977). This provides a much more positive role for community in determining meaning, identity and action of its members, giving opportunities for action and change. The Government would like to move responsibility and empowerment to communities which would then become important locations of decision making and action (DEFRA 2008). Therefore, policy issues of subsidiarity, collaborative management and ownership in common are starting to surface (Krishna 2003). The role of communities as agents of management and ownership or as givers and receivers of social capital has been studied within the social capital discourse (Bourdieu 1986; Shorthall 2004; 2008). However some commentators are sceptical of the abilities and capacities of local communities to deliver effectively with local action being far more complex and conditional than the theory suggests (Upton 2009; Andersson and Gibson 2006).

An understanding of socio-economic status (SES) can help to understand why particular interventions (for instance, community action) are confined to certain contexts. As Liberatos et al (1988) explain: "According to Weber, differential societal position is based on three dimensions: class, status, and party (or power). Class is assumed to have an economic base. . . and is indicated by measures of income. Status is considered to be prestige or honour in the community [and implies] 'access to life chances' based on . . . factors such as family background, lifestyle, and social networks". Therefore, occupation, education and income are used most often to measure SES. Income as an indicator clearly falls into Weber's economic or class realm, influencing opportunities for education, and providing access to certain lifestyles. Occupation is a good indicator of SES since different occupations are perceived differently in terms of prestige, require different amounts of education, and give different monetary pay-offs. Education confers differential status and provides the qualifications to acquire differential occupations and income, and so is a useful proxy for economic variables (Liberatos et al 1988). The idea of social and human capital (Coleman 1988) is also useful here – resources achieved through social connections (social capital) and nonmaterial resources as education (human capital) are readily connectible to processes directly affecting well-being, and access to life's chances (Bradley & Corwyn 2002).

Thus, different communities will not respond in the same way. Interesting questions arise as to what gives communities cohesion and whether communal action can arise other than neighbourliness. Yet there are many examples of communities operating successfully in different ways, whether in top down interventions through some authority structure, or

bottom up using the collective action of members. It is their 'success-in-context' in achieving the aim of sustainability that is of interest here. In particular, there is the potential for concerns about sustainability and energy issues to provide a new cohesion and meaning to communities (Wals 2007), providing a locus around which the community can work together.

Technological Change

In an attempt to conceive of the problem of the lack of transition to energy sustainable technologies, researchers have used concepts of socio-technical regimes. Theories of technical change had hitherto been based in a techno-economic view of the world, whereby the non-adoption of proven energy efficiency technologies is the result of social barriers – usually consumer ignorance or market distortions (Guy & Shove 2000). However, Rip and Kemp (1998) have shown that firms and technologies are embedded within wider *social* and economic systems: "socio-technical regimes". Smith et al (2005) show that the current socio-technical regime of energy production is dominated by rules and practices relating to long established centralised, large-scale power technology, and high voltage alternating current grid infrastructures, which make it difficult to make individual choices about how the energy one consumes is produced. In this regime, people have relinquished responsibility to gain convenience and dependability. However, transition from a regime of energy production based on fossil fuels to a different regime is necessary, given the legislation described above. This requires individuals to accept responsibility, and the technology and the way it is introduced needs to encourage this.

The interface between people and technology is therefore complex; people make choices about and use energy sustainable technologies as individuals in a social world. Owens and Driffill (2008) show that a large number of social factors come into play to influence energy behaviour, such as trust, habits, cultural norms, as well as financial constraints and these become important concerns in any intervention.

Interventions

Local and central governments are best placed to make large changes to the contexts in which sustainable technologies may or may not be adopted. Smith et al (2005) point out that governments have a role in guiding transitions of socio-technical regimes. Foxon et al (2008) explore this further by looking at the different pathways such guided transition could take. Hischemoller et al (2006) also suggest governments as key players in governing the transition to sustainable technologies. However interventions are not always successful; Owens and Driffill (2008) point out that government messages that driving contributes to climate change are difficult to act on when price signals provide a powerful counter-incentive to getting the train (HM Treasury 2010) and these continue to remove responsibility from individuals.

However, increasingly there is a role for communities to govern that transition in their localities, sometimes with government support (Walker et al 2007), or in partnerships with other agencies (Shucksmith 2000). Partnerships often come with their own difficulties for the community members, who may feel unable to put their priorities on an equal footing as the priorities of professional agencies (Mayo and Taylor 2001). However, this is not always the case – Mackenzie (2006a, b) gives the example of the North Harris Trust, a community trust that owns the North Harris Estate, and has installed a wind turbine.

METHOD

Studies of such complex situations and their change are difficult to undertake, thus requiring detailed studies of individuals, communities and their contexts. Thus, pilot studies are needed to determine what can be found and how best to find this. This investigation sought to determine differences in attitude in the communities and the impact of the interventions on this. A social constructionist approach was adopted where social life is understood to be constructed rather than objectively determined (Easterby-Smith et al 1991). This approach was taken in this pilot study because whether or not an individual decides to sign up to a project like BES or Green Streets, and adopt a sustainable technology, is a personal choice made on the basis of personal perceptions. Thus the focus is on individuals and their experience. This approach seeks to unpack these perceptions; to better understand why individuals respond in the way they do to sustainable energy projects.

In this pilot study, in-depth interviews were used to explore how we can find out about individual attitudes, as well as they way individuals see their communities, technology and different types of intervention. Four interviews were carried out with beneficiaries of different sustainable technology projects – two Northfield residents who had benefitted from BES, and two Moseley residents who had benefitted from SusMo's Green Streets project. Of the Moseley residents, one was having PV installed on his own house; the other was speaking as a representative of the mosque which was having PV installed on its roof. The sample size was small since this was a pilot, but this allowed the attitudes and experiences of each interviewee to be properly explored. Interviewees were asked to explain how they became involved in the projects they were benefitting from, if they had noticed a change in their energy bills (where applicable) and how they felt about energy. Interviewees were then asked to discuss their views on climate change, and whose responsibility they considered it to be to do something to tackle it. They were then invited to talk about their community in general, before moving onto perceptions of and attitudes towards the agencies (SusMo or Birmingham City Council) who were delivering the projects they were benefitting from, including if there had been any change in these.

RESULTS

The Moseley residents were both involved in SusMo's Green Streets project. As the technologies were not yet installed only provisional energy attitudes were explored. One interviewee explained that his family was not wasteful with energy at all, but were looking forward to being able to spend even less on energy. The other interviewee felt that once the PV was installed on the roof of the Mosque, people would be able to see it, making it easier to educate them about saving energy. Both interviewees were concerned about climate change, and explained what they personally were doing to combat it. Both were members of SusMo; one was starting to encourage food growing initiatives at the mosque, and the other was going to attend a course on energy advice. Both interviewees noted a sense of community in Moseley which seemed to cut across ethnic and religious groups:

> *"There's a strong sense of community in Moseley, it's diverse, people get on".*

Both interviewees knew their neighbours well, as well as the wider Muslim community. They perceived the wider community of Moseley to be fairly well informed about climate change, and to be doing their bit. One interviewee was impressed with SusMo members for

giving up so much of their time for Green Streets, which had in a way negated the need for any local authority initiative in the area, the other explained how SusMo had to do this kind of work, since the local authority had fewer financial resources and were moving too slowly.

> *"Nowadays, the government don't have money for anything, what can they do, just give you money to do these things, but now they haven't got any money to give, so it's up to us"*

The Green Streets project has changed the Moseley interviewees' attitudes towards themselves and their role within the community;

> *"I'm a completely different person to how I was last year. I did have all these things in the back of my mind, these are the things that you do when you retire, but this year I said, you know you don't have to wait until you retire, you do them now"*

and their attitude to sustainable energy:

> *"we have these habits [of not being wasteful], but it's nice now to incorporate the environment, and put these habits to a greater cause"*

The Northfield residents were both council tenants who were at home during the day. They both noticed a saving in their energy bills. Both interviewees thought that climate change was an important issue, and that something should be done about it. Both interviewees saw a very strong role for the council in providing facilities that allowed the opportunity for green behaviour, such as recycling facilities, water butts and composters, or PV panels, as was the case here.

> *"well things should be done about [climate change] cos it can't go on like this forever can it? . . . . but somebody's got to start the ball rolling for other people to get involved"*

They also saw a role for the local authority in helping those who could not afford to 'be green' even if they wanted to;

> *"at the end of the day if I didn't get the solar panel fitted on the roof I couldn't have afforded to do it on my own".*

Neither Northfield interviewee noted a particular sense of community in their local area, were not close to their neighbours, nor members of community groups. However there may be an opportunity to change this as a result of BES – with their experience of the technologies the beneficiaries could act as trailblazers, and discuss the technologies with other members of the community – enhancing social capital as more links are made between individuals. The interviewees mentioned the difficulty of getting started without such prior knowledge:

> *"for a community that gonna come together without the actual experience of the solar panel, it's harder, but like us as a community then that have it fit in, it's good for us to be involved"*

The interviewees mentioned that people were asking them about their PV panels since they had been installed:

"Oh I've had them knocking on the door! . .and stopping me in the street asking me for phone numbers and that [to find out how they can get panels aswell]"

The Northfield interviewees do see a role for individuals, but their discussion of that role was set in the context of council facilitation;

"it is, [laziness] . . . it's like when you see bits of furniture and everything lying all around, they've only got to make a phone call to the bulk rubbish [a council service] and they come and fetch it, it's what you pay your poll-tax for!"

Both interviewees were pleased with the local authority for having instigated BES, which allowed them to have the PV:

"They're doing something really worthwhile".

Both interviewees also discussed issues of trust – they trusted BCC to do a good job, to use reputable companies, and to deal with any problems that would emerge with the technology. Both feared 'dodgy' or 'cowboy' companies, and felt that a company being registered with the council was a stamp of approval.

"The council would never take up for instance a dodgy company to come here and do certain type of job. Normally when they came here, you know it's a proper company that register with BCC. So BCC wouldn't send like a dodgy company come to your house and stuff like that so I would feel more comfortable doing it with the council"

DISCUSSION

According to the interviewees, both the Northfield and Moseley interventions although different, were successful. The pilot suggests that success could best be defined for the larger research study as having a positive attitude to the intervention, saving energy, and having the potential to induce a wider, community based change in behaviour. The pilot also suggests that the style of intervention is important. Thus, an in-depth study needs to investigate how the style of intervention in different contexts can lead to positive attitudes towards that intervention, and hence greater adoption of sustainable energy technologies.

Moseley residents believed that in difficult economic times, BCC must target its resources where they are most needed. Moseley, being a more affluent area, cannot benefit from BCC led interventions. Therefore Moseley's only option is a community-led intervention. This pilot raises an interesting question about why community led interventions are possible in Moseley and directs us to look at the 'capability of the community'. This can be characterised by socio-economic status (SES), which if measured by education, occupation and income (Liberatos et al 1988), can be said to be high, certainly higher than that of Northfield. Nearly 40% of Moseley residents have a very high level of education, and nearly a third of its residents are professionals, of which nearly a half are teaching and research professionals (Office for National Statistics 2011). Bradley & Corwyn (2002) consider capital (social, human and financial) to best embody the meaning of SES. Moseley clearly has a wealth of capital (as shown by its large number of community groups made up of

active, capable and resourceful individuals) particularly so within SusMo itself (many members participate in multiple groups). SusMo's committee is made up of individuals with high levels of education and sustainable technology related experience (human capital), and its members can support each other and share skills within the group (social capital). This capability enabled SusMo to inspire the two residents interviewed here, and include them within SusMo itself. This led to a positive attitude to the project between the interviewees, and therefore a willingness to adopt the sustainable energy technologies.

The community of Moseley is diverse – there is a strong Muslim community, and numerous other communities of interest based around community groups. SusMo's Green Streets project by formally partnering with the mosque, the church, the local allotment association, the school, was able to incorporate all of these communities and build a community of place cutting across faith and interest groups. Therefore the in-depth study should also investigate the potential of interventions in such areas to draw sub communities together and create 'community cohesion' which enables further activities. Moseley does indeed have a strong sense of place and having won awards for its farmer's market and 'Moseley in Bloom', it has become a place that people are proud to live in and be part of. This is reflected in the ability of SusMo's project to interest all faith and interest groups, and more generally in the large number of community groups to be found in Moseley (which provide social capital for their members). Such support enables residents to become involved in projects such as Green Streets, and act on their own initiative to tackle issues around climate change. This can also lead to human capital, further facilitating such projects as residents become more able to become involved, and learn the skills needed to organise and run them.

SusMo's intervention in this particular context (of a capable community) has clearly led to positive attitudes amongst residents amongst the Moseley residents interviewed here. The two interviewees are well informed about climate change, and saw individuals as having a key role to play in its mitigation. Both interviewees explained how they *personally* were 'doing their bit', by reducing their consumption of energy by changing their behaviour, and by becoming involved with SusMo both as beneficiaries and as committee members. It is clear that SusMo provided these residents with the opportunity to be involved in the management and running of a climate change project leading to positive attitudes towards the technologies and the process of intervention. The suggestion for an in-depth study would be to investigate how the style of intervention here can lead to positive attitudes and thus 'success in context'.

BCC's Birmingham Energy Savers is specifically aimed at communities in need and is well positioned to intervene in communities like Northfield. The SES of Northfield as a whole is diverse, and residents have a wider spread of educational attainment, but with a much larger proportion of people with no qualifications at all. Since educational achievement can influence occupational level, it is not surprising to see many residents in lower skilled jobs, with not such a large proportion of residents in one particular highly skilled area. However, the financial status of the Northfield council tenants interviewed here is straightforward – they must be of a lower socioeconomic status, and have lower financial capital in order to qualify for a council tenancy. In such circumstances, these residents would ordinarily be unable to adopt sustainable technologies, being constrained as they are by their financial context.

The two Northfield interviewees had varying levels of understanding about climate change, but saw a strong role for the local authority in mitigating its effects. This is unsurprising,

these tenants would not have been able adopt such sustainable energy technologies as PV without council aid. BES was the only opportunity these residents have to choose to do something about climate change in such a manner. As council tenants they also rely on the council for the maintenance of the technologies, as they rely on the council for the maintenance of the rest of their houses. Therefore they trusted the council over any other agent to install these panels.

This pilot gives evidence that the BCC intervention in this particular context led to a positive attitude to sustainable energy technologies in the two people interviewed here and thus 'success in context'. The residents trusted the council over other organisations to install the technologies, saw a strong role for the council in leading this type of project, and saw them as doing something "worthwhile". They were therefore willing to be a part of Birmingham Energy Savers and agree to the installation of the sustainable energy technologies. Neither Northfield interviewee noted a particular sense of community in their local area, were not close to their neighbours, nor members of community groups. This suggests that as a result, they had little structure through which they could act together with others and little opportunity to gain access to any skills or knowledge that other residents may have had about issues of climate change and sustainability.

The suggestion for an in-depth study would be to investigate how the style of intervention here (top-down) might be most appropriate to engender positive attitudes towards sustainable energy technologies and facilitate their uptake. The pilot also suggests that it would be interesting to further explore how a top-down intervention could also lead to an increase in community groups and action (social capital) and hence draw communities together in the future. The BES beneficiaries here, with their experience of the technologies could act as trailblazers, and discuss the technologies with other members of the community – thus increasing community cohesion and thereby the capability of the community as a whole.

CONCLUSION

The value of exploring attitudes to sustainable energy interventions in this pilot study has been to identify some important areas of study, to establish what can be found out from individuals about successful interventions, and to establish whether the style of intervention is important. This pilot does indeed suggest that the style of intervention is important to establish 'success in context', and this requires further study. It also raises important questions for further study about how interventions encourage 'community cohesion'; involving sub communities working together to interact and affect each others' attitudes.

The Northfield council tenants, having financial concerns and feeling less of an identity with the community, had 'success in context' from a top down intervention from a trusted body - BCC. An in-depth study would provide more conclusive evidence for whether top-down or community interventions are more appropriate in helping communities that are unable to act unsupported, and whether or not the local authority is the most appropriate and trustworthy body to suggest the take-up of these technologies; thereby effecting a positive attitude towards them.

The Moseley residents, being from a more affluent area, were unable to benefit from Birmingham City Council's project, but were more able to make use of their connections with friends and neighbours in the community in order to self organise. An in-depth study

would provide more conclusive evidence for whether or not community interventions are appropriate in these communities since residents are skilled and can support each other to make such interventions work, and inspire the rest of the community. This is not to say that top-down interventions in communities like Moseley would *not* be successful. Therefore an in-depth study would also provide more conclusive evidence for whether or not community interventions in communities like Moseley (who can afford to be more critical of their local authority, being less dependent on them) can lead to *more* positive attitudes about sustainable technologies and the process of interventions, than would a top-down intervention. It would further refine whether the 'capability of the community' is necessary for 'success in context' here, and whether this can be developed in less cohesive communities as part of the intervention.

In a study looking for more successful interventions, it is important that we find out about individual attitudes, as well as they way individuals see their communities, technology and different types of intervention. This pilot study highlights some areas for investigation within top-down and community-led interventions. Potentially an in-depth study could also look at a third approach to interventions: the *facilitation* of a community-led intervention.

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ETHICAL AND SUSTAINABLE EMPLOYMENT IN CONSTRUCTION: THE CASE OF BLACK AND MINORITY ETHNICS' (BME'S) ENGAGEMENT

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Abstract
The instability of employment resulting from fluctuations in demand and the widespread use of contracting systems poses major problems of attractiveness to the construction industry. This practice has considerable negative impact on the industry. Therefore, as much needed investment is cut from training in the sector, the issue of skills shortages can be very devastating in the event of an upturn which is indeed certain. Consequently, it is anticipated that the construction industry should look to expand its recruitment base to become progressively multicultural and reflect the diversity of the population. As a result, this review of literature on the sustainable aspects of increasing the engagement of the BME population who, hitherto, have been underrepresented aims to highlight the situation. It is worth noting that the white population has been seen to be aging while BMEs have quite a younger age profile making it sustainably intelligent to proportionally engage them for the future of the industry. Furthermore, it is ethically prudent to involve the sections of the population whose involvement has, until now, been very minimal. It is probably, for instance, a recipe for bitterness and resentment where religion becomes a tool for marginalisation in the industry.

Keywords: BME, ethical, sustainable, diversity and employment.

Introduction

Demographic changes have resulted in societies becoming more and more ethnically diverse and as a result organizations around the world cannot afford monolithic blocks of workforce and still compete on the global scene. Therefore, an unparalleled impetus for a relatively large number of studies on the effects of diversity at work has been created and the construction industry is no exception. The need for the inclusion of minorities for the industry to be representative of the larger population is, in effect, paramount and has been covered in several studies (Caplan et al, 2009; Ahmed et al, 2008; Caplan and Gilham, 2005; Sodhi, 2004; Steele and Sodhi, 2004; Egan, 1998; Agapiou et al, 1995; Harrison, and Davis, 1995; Latham, 1994). However, studies into diversity at the workplace have generally yielded mixed results with some demonstrating that diversity can have negative effects by giving rise to communication difficulties thus affecting group cohesion and resulting in dysfunctional conflict (Jackson, Joshi, & Erhardt, 2003; Williams & O'Reilly, 1998). Yet, others (e.g., Caplan, et al 2009; Ahmed et al, 2008; Dinsbach, 2005; De Vries & Pettigrew, 1998; De Vries, 1992) indicate otherwise and hence see no reason why such problems should occur.

According to (Schaafsma, 2008) little attention has, so far, been paid to why inter-ethnic relations may be more harmonious in some work settings but rather more problematic in others as indicated by Jackson et al. (2003) and Milliken & Martins, (1996) while asserting that generally, relations between workers with different ethnic backgrounds have only been explored as potential mediators of the effects of diversity on work group outcomes. There is, as a result, little research into the experience of ethnic minority and majority employees and managers about how working in a diverse environment involving different ethnic groups can

have positive or negative impact on productivity. Therefore, this review seeks to fill this gap by bringing to the fore the possible barriers that need to be understood and surmounted in order to create a positive inter-ethnic work relationship in construction. How do ethnic minority and majority members compare in dealing with inter-ethnic relations at work? And, whether either report on more positive or more problematic inter-ethnic relations. Is the former group over-blowing their experiences or is the latter covering up incidents of discrimination and how such issues are dealt with?

Ethnic minorities in The UK: Background and socio-economic Consideration

With a trend increase in immigration of more than 100,000 per year, the past four to five decades have seen Britain change from being a country of net emigration to one of net immigration (IPPR, 2010). Notwithstanding that improved economic performance in the UK relative to overseas has tended to increase immigration and rising UK inequality has had an even larger effect. Additionally, immigration policies at home and abroad have also helped to increase net immigration, particularly in the 1990s. According to the Labour Force Survey, some 4.5 million individuals living in Britain in the year 2000, 9% of the population, were born in another country (LFS, 2001). Many of these individuals of foreign origin work, and contribute to economic prosperity and well-being. And as supported by several studies, (e.g. Zimmermann, 2008; Dustmann et al, 2003; Shields and Wheatley Price, 2002; Dustmann and van Soest. 2001) differences in education, the demographic structure, culture, and skills of foreign-born individuals may have advantages in some labour market segments, but disadvantages in others and construction is classed in the latter category.

However, these disadvantages may diminish depending on the changes in the underlying factors and over time, immigrants may adjust in many respects to their UK-born peers, from the accumulation of skills, collection of information, and adoption of new habits. It is worthwhile to note that understanding how labour market performance of immigrants differs from UK-born, and from each other, how these differences relate to observed characteristics, and how they change over time is an important pre-requisite for migration policy. Also, it is significant to note that while adaptation and labour market performance of immigrant populations has been subject of intensive research in the US, Canada, Australia, and also in some European countries, according to Dustmann et al (2003), relatively little is known about the absolute and relative performance of the immigrant community living in Britain.

Notwithstanding, it is generally the case that when immigrants arrive in the destination country, their labour market productivity is likely to be different from that of their indigenous counterparts; a situation attributable to different levels of education, socio-economic characteristics, and different demographic composition. But even if an immigrant is compared, for example, with a UK-born of the same education and age, they may differ in labour market outcomes, like wages and participation. One important reason for this is that the skills immigrants have acquired in their home country are often not directly transferable to the host economy. Furthermore, immigrants may also lack certain general skills immediately after arrival in the host country especially fluency in communicating in the host's language as well as the observance of certain cultural practices. However, they may adjust over time to a level commensurate with the skills requirements of the labour market and in most cases acquire new skills. At this point, they may match or even do better in the level of local economic performance as well as assimilate into the hosts culture and hence the community.

Also, as Dustmann et al, (2003) note differences in demographics, education, or skills may but only be some of the reasons why immigrants differ in their labour market outcomes as they tend to settle in areas of more economic prosperity to take advantage of high levels of employment and wages and in most instances close to their predecessors and relations of similar origins. Consequently, this leads to selective settlement, as is the case in the South East and London regions and may cause a less even spread of immigrants and hence concentration in particular industries. This could result in more favourable labour market outcomes of immigrants and so underestimate the differences in economic outcomes between the hosts and immigrants and their descendants. Apparently, this ideal situation does not usually apply to immigrants as labour supply outstrips demand causing in its wake further unemployment thus worsening their plight.

The Recession and Future Skills Requirements

As has just been hinted in the preceding paragraph, it is usually the case that in an efficient labour market where the supply of skills is aligned with labour market demand, the supply and demand matching processes are seen to be deficient where there are mismatches between demand and supply for skills. Therefore, it is easier to assume that skill shortages, skills gaps and general unemployment have been controlled in the current situation. This fact is consistent with the Construction Trade Survey (2009), where organisations across the construction industry all reported a considerable decrease in skill shortages to a record low. For instance, the recent Construction Products Association Trade Survey (Q3, 2009) reported that only 6% of building contractors had difficulties in obtaining the main site trades, a complete contrast to two years earlier when it was 78%.

Yet, looking at the recruitment activity, one in ten employers (10%) felt that there had been times when they lacked the number of skilled workers they required (ibid). Again, around half (52%) felt that they had been operating at around full capacity given the number of skilled staff they employed and still a third had not had enough work for their workforce (ibid). Also, it is worth noting that a more recent review of the Migration Advisory Committee's (2009) recommended shortage occupations listed civil engineers, mechanical engineers and welding trades while noting that although falling employment and vacancies and a high redundancy rate indicate that the labour market is in turmoil, it should not be assumed that all labour shortages disappear upon the acknowledgement that the removal of some construction-based occupations from the original list is in response to changing economic circumstances. Table 1 below shows the recent unemployment rate for construction as it compares with all other industries in the UK.

	Construction Industry	All Industries
England	8.3%	6.9%
Wales	10.3%	7.2%
Scotland	9.1%	5.8%
Northern Ireland	11.8%	5.6%
UK	8.6%	6.8%

Table 1: *Unemployment rate in Construction Compared with All Industries by nation (UK: 2009).*

Source: Office for National Statistics, Labour Force Survey (2009)

As the data highlights in table 1 above, the construction industry has been significantly affected by the economic downturn, with the unemployment rate not only higher nationally, compared to the figure for all industries at 8.6% against 6.8% but it is even higher in each

country as indicated in the table above. Here it is significant to note that the unemployment rate across the Northern Irish construction industry is twice as high as the rate for all industries.

Therefore, it must be stressed that the impact of the recession across the construction industry has radically affected the mismatches between demand and supply. While on the one hand skills shortages and skills gaps have decreased dramatically, this has contributed to worsening unemployment. Although skills shortages are currently at an all time low, lessons need to be learnt from the previous recessions. One of the biggest risks to the recovery of the construction industry, according to the ConstructionSkills (2009) is a shortage of skills as people made redundant seek new careers outside the industry and new entrants unable to get jobs, look elsewhere.

Employment and Participation

Unemployment has been a serious cause for concern among first generation immigrants as generally, most literature in the UK on employment and participation differentials compare outcomes of whites with those of ethnic minorities in general. This practice calls for further cause of concern as the distinction between immigrant and UK-born minorities, if drawn could have given a different picture of the level of unemployment in either situation for redress. In this way the pool of labour resource is easier to identify. Exceptional to this is the work of Blackaby et al. (1997) who based on the 1991 UK Census of population, investigated the incidence of unemployment and found that foreign-born ethnic minorities have a higher unemployment rate than UK-born minorities. Also, they found no evidence that the latter perform worse than white UK-born majorities. Additionally, Blackaby et al. (1997), also confirmed by Dustmann and Fabbri (2002), based on data from the Fourth National Survey on Ethnic Minorities (FNSEM) and the Family and Working Life Survey (FWLS) survey found substantial differences between different ethnic groups, for instance the suggestion that Pakistanis and Bangladeshis have particularly low employment probabilities compared with the other Asian counterparts (Modood, T. and Berthoud, R. (1997). Conversely, a comparative study by Wheatley Price (2001) based on the Quarterly LFS data for the years 1993 and 1994 found that white and non-white immigrants have initially a lower probability of being employed, compared to white UK-born individuals but this disadvantage decreases over time, although it does not completely disappear. In similar sequence, an analysis of ethnic minority immigrants and UK-born ethnic minorities, base on the FNSEM and the FWLS by Dustmann and Fabbri (2002) found that minority immigrants have lower employment probabilities compared to white UK-born individuals and minority UK-born individuals, a disadvantage which falls slightly over time.

Also, with respect to earning differentials, the first study on wage adaptation of UK immigrants by Chiswick (1980), analysed the 1972 General Household Survey (GHS) and found no significant earnings gap between white immigrants and white UK-born individuals, but a 25 percent gap between white UK-born individuals and non-white immigrants. Also, Chiswick (1980) found neither evidence for adaptation of non-white immigrants nor wage gap between white and non-white UK-born individuals. Pooling 20 consecutive cross-sections of the GHS (1973 to 1992), Bell (1997), through a more recent study performed a more exhaustive analysis, which distinguished between West Indian, Indian, white and Old Commonwealth immigrants and found different adaptation rates and entry wage differentials across these groups. While ethnic minority immigrants have an initial wage disadvantage that slowly decreased over time, white immigrants have initially higher wages which adapt downwards, a negative adaptation trend attributed to the possibility that white migrants who

remain in the UK are negatively selected, results confirmed by Denny et al. (1997), also using GHS data (from 1974 to 1993). Of particular significance is that, they found a large wage differential between non-white immigrants and white UK-born individuals, however, there was no wage gap between white UK-born individuals and white immigrants.

Self-Employment

Dustmann et al, 2003, has stressed the scanty work on self-employment of immigrants on the whole. However, Borjas' (1986) analysis of self-employment probabilities for immigrants in the US and UK-born individuals and subsequently extending this analysis to assess self-employment probability differentials among different ethnic groups in a separate study (Borjas and Bronars 1989) stands out. For the UK, Clark and Drinkwater (1998) used the General Household Survey (GHS) and the FNSEM (Clark and Drinkwater 2000) and found that ethnic minority immigrants are more likely to be self-employed than ethnic minority UK-born individuals or their white counterparts. This revelation supports a justification of attempts to create their own employment where they fail to progress in finding one while reinforcing the means of escape from discriminatory practices. However, contrasting with findings by Borjas (1986) they also found that ethnic regional concentration affects self-employment rates negatively as a result of mismatch between supply of labour and demand for it.

Language and Level of Education

Again, according to Dustmann et al, (2003), few studies in the UK analyse the determinants of immigrants' language fluency, and the effect of language on economic outcomes. Studies by Shields and Wheatley Price (2002) based on the FNSEM found that higher education levels are associated with higher degrees of language proficiency, and that longer migration duration has a positive influence on language fluency. They further found out, by analysing the occupational success of non-white immigrants, that those who are fluent in English language have, on average, wages about 20 per cent higher than non-fluent individuals. This was further confirmed by Dustmann and Fabbri (2002) using results from both the FNSEM and the FWLS who further established a positive relationship between language, employment and earnings although this relationship did not necessarily indicate a causal effect of language on earnings (Dustmann and van Soest (2001).

Further afield in Continental Europe, studies have evidenced a high level of discrimination thus hindering the integration of ethnic minorities in the labour market (Zimmermann, 2008). A recent study in Hungary reports that members of the Roma minority are more likely to lose their jobs than Hungarians (Kertési, 2004). According to the Bureau of Democracy, Human Rights, and Labour report of 2006, most Roma people in Hungary live in abject poverty and their unemployment and inactivity rate is as high as 70%, ten times more than the national average. Also, in Slovakia the Roma suffer a permanently higher ratio of long-term unemployment than the majority Slovaks (Vasecka, 2001). In fact, there is evidence that in 1999 the number of unemployed Roma stood at 80.5 thousands out of a total population of about 400 thousands, and among the unemployed 83% Roma people had no educational qualification. Similarly, differences in earnings and in the duration of unemployment between the Latvian majority and non-Latvian minority reported an enormous ethnic wage gap in 2005 of 9.6% (Hazans, 2007; Hazans et al., 2007). These studies found that in 2002-2005 the median duration of unemployment period was 3 months longer for the non-Latvian minority and in almost all cases the basis for such gaps have been the level education, language proficiency and low level of integration.

Even so, regardless of the factors mentioned above, higher education does not guarantee a better labour market placement of ethnic minorities for over-education by BMEs in the UK has been reported (Battu and Sloane, 2002; Alpin et al, 1998). In some EU member states, like the Netherlands, Germany and even the UK, higher education in the country of origin does not pay off during the early years in the labour market (Hartog and Zorlu, 2007). While language requirements for higher level jobs and non-transferable skills may explain this finding, discrimination is certainly said to be the latent contributor. Moreover, economists often find inexplicable differences in the labour market outcomes of ethnic minorities and the majority population to which they attribute discrimination as the sole factor (Kertési, 2004; Hartog and Zorlu, 2007). Citing a level playing field, Caille (2005) render a more positive outlook for France in respect of the finding that among pupils in 6th grade in 1995, immigrant children had a higher probability to complete high-school than non-immigrant children. The table below gives a picture of the situation in some selected EU countries.

Country	Minority/Majority Group	Participation Rate	Unemployment Rate	Hourly Wage
Denmark	Total Population	76.3	4.5	278.3
	Turks	62.2	17.8	170.7
	Iraqis	37.7	26.9	138.4
	Bosnia-Herzegovinians	7.2	12.9	177.4
	Other non-Western	55.8	28	164.8
Hungary	Hungarian Majority	40.47	9.84	
	Africans	48.13	10.0	
	Arabs	48.14	5.21	
	Chinese	65.01	0.68	
	Croatians	41.37	7.25	
	Polish	53.07	6.81	
	Armenians	51.13	5.68	
	Rutheneans	48.27	8.11	
	Serbs	40.44	8.17	
	Ukrainians	47.95	8.39	
The Netherlands	Dutch Majority		9.0	10.4
	Turks		21.0	7.1
	Moroccans		27.0	6.9
	Surinamese		16.0	8.5
	Antilleans		22.0	8.0
Romania	Romanian Majority	41.6	11.5	
	Hungarians	38.0	11.3	
	Ukrainians	42.8	11.1	
UK	White Majority Population	81.8	3.8	11.8
	Indians	80.1	6.4	12.2
	Pakistanis	55.2	12.8	10.2
	Bangladeshis	48.7	19.4	10.1
	Other Asians	75.1	8.3	10.2
	Black Caribbeans	81.0	11.0	11.4
	Black Africans	77.7	11.8	9.9

Table 2*: Labour market situation of selected ethnic minorities Compared with the Majority population in Denmark, Hungary, the Netherlands, Romania, and the UK*
(Sources: Zimmermann et al, 2008)

As shown in table 2 above, the rate of unemployment disparity between majority and minority populations is significantly high in all the countries listed. Although this refers to the whole economy of which construction is a subset, it helps to give an idea of the need for inclusion in the various sectors of the economy. In the case of the Netherlands, this has been attributed to the policy of integration adopted. Initially, attempts to integrate the different ethnic groups have been a source of considerable debate as these discussions centred on the socio-economic integration of ethnic minorities. For example, compared to other European countries such as Germany, France, and the UK, the labour market position of non-western minority members is relatively unfavourable (Koopmans, 2003). Although employment among ethnic minorities has increased over the past few years, the average unemployment levels among ethnic groups still hovers around 4 times higher and the net participation rates are lower than the Dutch native population. Additionally, long-term unemployment is relatively high among non-western minority members and many of the employed occupy lower job levels (CBS, 2007; SCP, 2003). By and large, this can be explained by factors at the level of the different ethnic groups themselves, as already indicated earlier involving their lower levels of education, their often one-sided work experience and limited social networks. This said, however, institutional factors basically underlying conscious or unconscious discrimination by employers also play a major role (SCP, 2003; Veenman, 2001).

Generally, the integration of ethnic minorities into Dutch society has been described as a failure and it has been argued that the adoption of a multicultural approach in the 1980s is largely to blame for this contrary to the approaches in other countries with a multicultural policy like Sweden and The United States. For example, multicultural rights were ascribed to ethnic minorities where the use of mother tongue for instruction in primary schools was permitted. This is said to be a major setback and did not actively promote Dutch language training thus reinforcing immigrants' image as a problematic and low-skilled group, with a concomitant disadvantage in employment (Koopmans et al, 2005).

Consequently, the low level of participation among Black and Minority Ethnics in construction and their high unemployment levels generally have been blamed on their educational standards and efficiency in communication here in the UK and elsewhere in Europe. This said, however, the incidents of over-education among ethnic minorities cited in the UK with the accompanying high level of unemployment does not justify this fact. Furthermore, ethnic minorities are well represented on construction related programmes in higher education here in the UK yet this is not reflected in their participation in the construction industry. It is without doubt that barriers to their participation exist in industries such as construction for in others like catering and cleaning they are known to be well represented even though they may lack the levels of skills required, they get the necessary on the job training and are able to progress with the limited communication skills they have.

CONCLUSIONS AND FURTHER RESEARCH

Finally, labour market barriers in the United Kingdom derive from a variety of sources including public perception which has been thought to be prejudiced against people of other races other than the white majority. Ethnic minority workers may be disadvantaged by their own characteristics; what might be regarded as internal barriers yet other distinct factors and external barriers are at play. Labour Force Surveys (LFS) data indicate that 16% of those whose first language is not English claimed that language difficulties caused them to have problems in finding or keeping a job. Also, data from the Fourth National Survey of Ethnic Minorities report that lack of English language fluency reduces average predicted

employment probabilities by 20-25 percentage points. In most dimensions of economic and social well being (such as income, employment, education, social class, health, housing etc.) there is a clear ethnic hierarchy with Indians and Chinese at the top, Black Africans and Caribbeans somewhat lower down and Pakistanis and Bangladeshis at the bottom.

Therefore, United Kingdom policy interventions and existing national legislation should focus on removing racial barriers to labour market integration; while it is clear that the weak labour market outcomes for ethnic minorities are due to a number of other causes as well that cannot be are beyond legislative control. In particular, in the United Kingdom, policy is driven by the 2000 Race Relations Acts that focuses on extending the duties required in the public sector to the private sector and as construction is mainly in the latter but heavily controlled and financed by the former, a lot of improvement of policy initiatives in place when properly implemented and monitored may help stem the tide as recent positive stance on ethnic minority issues is encouraging.

These developments make further study on interethnic relations at work all the more warranted and targeting construction as the driver of most economies will go a long way to achieve the desired effect. In the workplace, people may have to interact with members of ethnic out-groups who they would perhaps avoid in their private lives. This may result in tensions, however if the workplace is oriented to a context in which people inculcate tolerance it may help to develop more positive attitudes toward each other as well as the common objective of fulfilling assigned tasks. There is also the need to consider whether the conditions of minorities are hyped and if some members of the native majority do not suffer similar fate yet shy at reporting it.

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REDEVELOPMENT OF INDUSTRIAL PROPERTIES IN HELSINGBORG, SWEDEN: FROM THE MUNICIPAL PERSPECTIVE

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ABSTRACT

The structure and purpose of urban areas varies over time. For 50-100 years ago it was often desired to have closeness between the city centre and adjacent industries and infrastructure, e.g. the harbour and railways. Today these land areas are coveted for housing and commercial interests. In the beginning of the 21st century the municipality of Helsingborg in the southern part of Sweden decided to convert the south industrial harbour area in Helsingborg into housing and offices. The purpose of this paper is to elucidate the factors that can influence future relationships between various stakeholders in urban redevelopment projects, special attention will be given to efforts made in early stages of how to manage and organise the project from an overarching vision into an action plan for project implementation. Interviews with participants in the project management team for the development of the H+ area in Helsingborg and with involved municipal officials lead to mapping the expectations for the future development. Partial results shows that open communication between involved stakeholders and public officials give a good base for participation and engagement. Transparency and goal definition along the project planning characterise a well performed property development process. Thus, creating an interest by developers to invest and establishes a baseline for stakeholder management in forthcoming phases of the project.

KEYWORDS: Property Development, Urban Planning, Project Management, Relationships

INTRODUCTION

Cities of today are often segregated considering both aspects of economy and immigration (Andersson, 1999). Sweden is not an exception, but in a global perspective Swedish cities are less sharply divided along the socioeconomic dimension. The Swedish housing policy focus first and foremost on counteracting socioeconomic segregation (Bolt, 2009). The ethnic segregation seems as a consequence of poor integration on the labour market with results of socioeconomic divided cities. The aim of Swedish authorities is to achieve a social mix in

neighbourhoods with a variety of housing solutions, and not only for distressed neighbourhoods (Bolt, 2009). Andersson (1999) claims that improving the living conditions and accessibility to strategic resources for people residing in certain areas is necessary but it not the only measure in order to achieve an undivided city. The undivided city is an alluring mirage, but though urban development the gap between the reality and the mirage can be reduced. Although, it may appear as though land use changes and development takes place automatically in a city it requires a public support and approval from city planning officials in order for such change to take place (Nallathiga, 2010). Similarly, to stimulate urban redevelopment, policy-makers must address the economic problems and fears faced by land-owners, who are major stakeholders for achieving success (Hayek et al., 2010). Adams et al. (2001) divide landowners into active and passive. Active landowners are those who develop their own land, enter into joint venture development or make their land available for others to develop. Passive landowners take no particular steps to market or develop their land, even though they may intend to do so in the distant future. There is a delicate balance between public activities, for instance, the control of land use and the right of landowners to develop land according to their own wishes (Larsson, 1997).

How the structure, purpose and socioeconomic status of urban areas varies over time and how this change affects housing policies is a relevant area to study. For 50-100 years ago it was often desired to have closeness between the city centre and adjacent industries and infrastructure, e.g. the harbour and railways. Today these land areas are often coveted for housing and commercial interests and due high development costs often built with expensive solutions with little room for a social mix.

Renewal of the city has to, according to Hulsbergen and Stouten (2001), be anchored in the urban environment and neighbourhood problems have to been solved before a socioeconomics change can be possible. Residents and local entrepreneurs are important stakeholders in this process. By allowing the public to be a part of the planning process a link is created between the built environment and public concerns (Clark, et.al, 2010). According to Meen and Andrew (2004) a social mix can be achieved, in communities, through planning decisions. Graaf and Dewulf (2010) pointed out three characteristics of urban planning, analysing internal and external environments, stakeholders' participation and implementation. Internal environment can be controlled and influenced by the organisation. The external environment cannot be controlled, instead to deal with it the organisation has to reduce the level of uncertainty. Stakeholder participation and networking is needed to ensure effective implementation of plans. Implementation is about finding solutions and practical alternatives in urban planning policies, although urban policy is about achieving changes that will benefit localities, this goal probably will not be fulfilled if people cannot voice their needs or take action to effect change on their own (Seyong-Kyu 2001). To ensure stakeholder participation, especially by stakeholders from an external environment, various analysis and mapping techniques are available (e.g. Olander and Landin, 2005, Bourne and Walker, 2005, Olander, 2007).

The purpose of this paper is to elucidate the factors that can influence future relationships between various stakeholders in urban redevelopment projects, special attention will be given to study efforts made in early stages of how to manage and organise the project from an overarching vision into an action plan for project implementation. In this sense every project has several outputs, a product or a service delivered for internal or external customer and project knowledge which is related to the outcome (Kasvi, et. al, 2003). A project is temporally limited and the people involved and the lessons learned are dispersed when the

project ends. People often even change during the course of the project. Sometimes it may be hard to find people that have been involved in the project from the beginning. In combination with employee empowerment and information decentralisation Kavi, et al. (2003) states that knowledge will be fragmented with loss of organisational learning as a result. Thus there is a need to study how knowledge within an organisation is transferred from project to project, not at least when it comes to communicating with stakeholders, in an internal as well as external environment. How a project is organised is one relevant factor in order to achieve a successful stakeholder management process (Olander and Landin, 2008). No actor in the development process pursues strategies, interests and actions entirely on their own, to a greater or lesser extent, the performance of each actor is linked to that of others and is set within a broader structural context (Adams et al. 2001). All participants in an urban development process must be able to make informed decisions about their costs and benefits (Hayek et al. 2010). For the urban renaissance to be sustainable it is going to be necessary to ensure that as many stakeholders as possible is involved in its performance and that its benefits are more widely distributed (Ward, 2003).

The information in the research presented here is acquired from four interviews during the winter of 2010. Two of the interview respondents are working at the municipal office of Helsingborg, one of them as development director and the other one as city planning manager. The other two of the interviews belong to the project organisation responsible for the development area H+ in the south city centre, which today is a large extent an industrial area. The representatives from the project organisation were the project manger and the project coordinator. The project is currently in its early stages working with the depth layout plan. In the early stages there is uncertainty as to how the project will be affected by external factors such as stakeholder influence. However, there is the clear possibility in this stage for various stakeholders to affect project outcomes (Olander et al. 2010), which can enable project managers to find effective solutions to specific problem raised by stakeholders. During the course of the project this opportunity will gradually decrease. Thus, the aim with the interviews was to visualise the forthcoming views and structure of the development process for the current project. The interviews are limited to officials at the municipality of Helsingborg in order to provide a picture of their vision of the development process for the project and their vision for the future outcome of the development. Despite their limited financial resources, municipalities can foster local support by creating a common vision for an area and can create a demand for reusing sites by helping the public understand the benefits (Hayek et al. 2010).

REDEVELOPMENT OF THE SOUTH HARBOUR IN HELSINGBORG (H+)

Helsingborg is a city placed in the expansive Öresund region (the south-west of Sweden and eastern Denmark). Helsingborg is a segregated city with a clear division between the north and the south parts of the city centre. Around the millennium shift the first thoughts about H+ arose. It is an extensive project with an area about one million square meters, which is similar with 140 soccer fields, situated south of the ferry terminal in the city centre of Helsingborg. During the same time the municipality of Helsingborg began the project, ‘South of change’. The Project ‘South of change’ began in year 2001 with the purpose of making the south part of the city centre of Helsingborg more attractive in close dialogue with the city residents. During this dialogue a vision was created of linking the city with the water in the south parts of the city centre. Ten years earlier had the railway in the north part of the city been buried in a tunnel and the result was a success for the urban development in these areas.

In the Swedish planning process, the municipalities have, by law, significant control of land development within their boundaries. It is the municipalities that exclusively decide which property developments to approve and can with a development agreement control the outcome of such developments. Additionally, vague national rules and legislations concerning the planning process add to the uncertainty perceived by property developers (Riksdagens revisorer 2001, Olander and Landin 2008). The risk is that the municipality uses its advantage in the process to force the developer into an unbalanced development agreement (Kalbro 2002) that adds costs to the property development project.

Up-coming ideas for urban development in the city of Helsingborg

During the second half of 19th century the city became industrialized with the result of a population growth and around the year 1900 the city had 24 670 inhabitants. This created a need of workers housing. The earlier undeveloped area south of the city centre had rapidly grown to become a neighbourhood for the working class, often overcrowded and with low standards. These workers largely worked in the new industrial area, the South harbour. The north part of the city was now to a large extent the living area for the wealthy citizens with a higher socioeconomic status. Today this segregation has to some extent persisted and clearly defines the city of Helsingborg from a socioeconomic perspective.

The current redevelopment named H+, stands for more than just changing the structure of the buildings and activities in them. The name stands for urban renewal with the purpose of connecting the north and south part into one city and thus builds off segregation. H+ can be compared with an integration project, by physical changes as well as by creating a psychological change among the city residents. The intent is to raise the image of the south part of the city and by overcoming both the physical as well as psychological barriers between the north and the south part. Although the municipality adopts a variety of methods, they see the physical changes as a way to speed up the process of achieving these goals. The results from the project 'South in change' has become the basis for the H+ vision, which is, that everyone should feel welcome, the area will offer housing, businesses, trades, leisure activities and meeting points.

During the year 2006 the city council made a decision to begin the planning process for the H+ area. Two years later the process took a new direction after a structured competition for the design of the area. The results from the competition have formed the basis for the later work of planning the redevelopment of the area. Before the juridical process concerning the planning of the H+ area there has been an extensive process of understanding the value creating capacity of the development project from a number of various stakeholder perspectives. It is during these periods' ideas, models and visions that later on will form the base for the performance of the planning process in terms of efficiency, cost and time.

Today the municipality owns 60 % of the properties in the area and the other 40 % is owned by business practitioners and developers. It is a clear trend that developers buy properties in the H+ area with expectations of future developments. The harbour area is built of infill lots and no one today knows the degree of the impurity and the extent of cleaning-up that is needed before any new development can start. First after this analysis is ended the clean-up process can begin. Another condition that has to be solved before the development of the H+ area can begin is the railway south of the city. Today the railway build a barrier between the south harbour area and the south parts of the city centre. A necessary prerequisite for the success of the H+ development is the construction of a railway tunnel to overcome this barrier. The development area is divided into seven smaller parts and the expansion scheme

between these parts is important for the attractiveness of them. An organic city growth will tried to be obtained and the construction process will start in the most attractive parts of the development area. A mixed urban fit is sought with a variety of housing, tenancy and ownership solutions together with variety of trades and businesses. The university is already located in the H+ area which is of strategic importance for the future of the H+ development, further the municipality hope that the university will be a help in improving the attitude of city residents towards the future H+ development. The construction of the railway tunnel is calculated to begin in 2012 and first after the tunnel is completed the development above the ground can take place. The first stage is calculated to 2016 and the whole H+ area will be completed in year 2035.

Project organisation

For the municipality to manage this type of large-scale urban redevelopment project, a separate project organisation has been formed with the purpose of managing the whole redevelopment project, including the construction of the railway tunnel. The project organisation is directly subordinate the municipal board as an independent department. One reason for the choice of project organisation is that the municipality's permanent urban planning department can maintain focus on other development projects in the city parallel to the H+ development. Otherwise, there is a risk that the majority of their efforts will focus on the largest project, in this case the H+ development. The project organisation´s tasks are stakeholder management, time planning and cost control while the urban planning administration stands for the juridical process in consultation with the project organisation. When a project organisation is established it is important not to create parallel organisations, everyone needs to know which tasks the different organisations have responsibility for. To avoid parallel organisation, in this case, workshops are organised once a year. During these workshops the previous year will be evaluated and the coming year´s work planned for. This approach is considered to be inspiring and developing for the ones involved in the project as well as a critical success factor for the project. However, at the end of day the outcome will largely depend upon the persons involved in the project.

Visions

The survival and development of the city of Helsingborg is one of the core values in the development process of H+. The municipality sees the development of the H+ area as self-preservation. Through the development of the H+ area, important values are created for the city and its residents. The city will attract new inhabitants and businesses and improve the academic and cultural image of the city. The values for the city residents are a more attractive city to live in addition to a participative urban redevelopment process with input from a variety of stakeholders. A significant driving force for the redevelopment is to decrease social and physical barriers and thus reduce the segregation between the north and south parts of the city centre. Through the development an opportunity for city growth opened-up, and the municipal also hope to increasing the number citizens with academic degrees, which is today below the average level in Sweden.

Communications

One important task for the H+ project organisation is the communication with the city to raise the awareness among its residents and businesses. The project organisation use different channels to reach out. Everything from social networks, competitions for children and students, exhibitions and a coffee shop in the area to attract visitors is conducted. The communication goals are both to attract future contractors and residents. Communication is core task in the project, dialogue and interaction with the city created the first vision for the

development and the communication will permeate the H+ project until the last contractor leave the area in year 2035. Completed stakeholder analysis shows that 60 % of the city residents knows and are positive to the city development of the H+ area. However, in the forthcoming implementation of the development project there will be a need for further stakeholder analysis on various levels of the project, in order to achieve a good base in the decision-making process.

DISCUSSION

Helsingborg is a city where the difference between the north and the south part of the city centre is strong and clearly defined by perceived socioeconomic status; this creates a mental line that strongly affects the city resident's image of the attractiveness inherited of different parts of the city. It will not become easy to change this image, but the redevelopment of the south part will be a good beginning in this process. Helsingborg is an attractive city but to make the city to become one united city which it is not today will raise the attraction even more. Also to change the city from a worker city to a more mixed city with both contractors and academic life will attract a larger public. Replacing industrial areas by the waterfront and replacing them with attractive housing and businesses is one step in this direction.

The idea about the redevelopment of the H+ area came originally from the residents in the south part of the city. The municipality and the project organisation claims that this is a project raised from the city residents and this atmosphere should influence the project during the whole process. The H+ project is a long going process there both informal and formal ideas have elaborated and been processed with the final aim to becoming an asset for the city and its residents. In accordance with arguments from Meen and Andrew (2004) and Graaf and Dewulf (2010), redevelopment of urban areas can be used as tool for attitude change. Here is H+ an example where the municipality of Helsingborg is trying to achieve this goal.

To maximise the outcome of the H+ redevelopment the municipality use the city residents' thoughts and ideas as a relevant input. This idea is in line with the thoughts of Clark, et.al (2010) about involving the population to arise an interest by the public for their own city. Seyong-Kyu (2001) highlights the importance for people to raise their voices to achieve changes in the urban environment. In the end if the city residents' are not satisfied with the outcome of an urban redevelopment the project cannot counts as successful. Olander and Landin (2005), Bourne and Walker (2005) and Olander (2007) mention various analysis and mapping techniques which can be useful to ensure that the city residents and the city businesses interests are taken in account throughout the redevelopment process and like Ward (2003) point out a high participation from the external stakeholders is of weight to ensure a successful outcome. They are the ones who in the future will be active and enjoy the redevelopment area so by embracing their opinions it can create the future value for the H+ area.

The municipality of Helsingborg has for a long period worked out a strategy to obtain the best possible outcome of the H+ project. The project carry so much more than just a redevelopment of an earlier industrial area. This project also represents the city´s future and survival. The project organisation responsible for the H+ development was formed to create a clear focus on project outcomes by coordinating questions raised by stakeholders, time schedules and cost control. To create an independent project organisation send signals to the surrounding environment that the project is relevant and important. By creating an

independent project organisation keeps, according to Kasvi, et. al., (2003), the knowledge alive and will enable opportunities for knowledge transfer between project stages throughout the life of the project. An urban redevelopment of this scale is an ongoing process for a long period in time and the people involved may change several times during this period. However, by implementing the project with a consistent organisation the possibility of knowledge stay in the organisation and hopefully enable knowledge transfer for forthcoming urban redevelopment projects, thus increasing the value of project outcomes and experiences. Kavi et al. (2003) also argues that the project result never can be better than the project team members. This emphasise the importance for the municipality to create a leading project organisation that has the ability to create interest and involvement both among the city residents and forthcoming property developers.

Today the redevelopment of the H+ area is in an early stage. Next step in the research will become to explore the developers point of view with the project and which the confidence they have. Are they already today making planes to be a part of the development and which are their visions with the H+ area? It is up to the future to show if the project organisation produces a successful process and also if the redevelopment of the H+ area will counts as successful. Relevant factors to study in the ongoing development process are the level of transparency and how the project organisation will succeed to create an interest by different stakeholders.

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A GUIDELINE FOR PARTNERSHIP BETWEEN CLIENT AND CONTRACTOR IN INFRASTRUCTURE PROJECTS IN GERMANY

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Abstract
The major subject of this paper is the actual situation of large infrastructure projects in Germany based on a literature review of experiences in this field all over the world. The results of a field study show that many clients and contractors are dissatisfied with the current situation and wish for a change. To start with this change a guideline for partnership between clients and contractors in infrastructure projects was developed at the chair of Project Management at the University of Kassel by working groups of practitioners and scientists. This guideline contains a preamble and seven elements referring to clear project specifications, defined processes for project changes, fair risk handling, common data systems, regulations for responsibilities and decisions, contractual alternative dispute solutions and contractual incentive regulations. At present this guideline is in the testing phase to improve it, if necessary, and to collect experiences for a possible binding implementation in infrastructure projects in Germany.

Keywords: Partnering, collaboration, cooperative contracting, incentive based project optimization

INTRODUCTION

All over the world the situation in large construction projects seems to be very similar. Many projects have a cost and time overflow and the relationship between client and contractor is not cooperative. The project participants often complain about too many disputes and litigations. The typical situation in the German construction and plant market and the market in other countries has been characterized by Girmscheid (2005), Ingram and Bennet (1997) and Spang (2009) as follows:

Dissatisfied clients and distrust between client and contractor/s

- Decrease of know-how due to “lowest price-principle”
- Increasing expenses for claim and anti claim management
- A growing number of disputes and litigations between clients and their contractors

- Low rate of return and high risk of business failure for contractors.

Starting from United Kingdom, the United States and Australia in the nineties various partnering and alliancing models for the relationship between the main parties have been developed in the last years. There are for example: the early contractor involvement in the UK, the alliance contracting in Australia or the construction management in the US to enumerate the most common ones. Changes towards more partnership between client and contractor can be seen, especially in the private sector. However, the international construction market is rather different in matters of market conditions, the legal situation and public authorisations. In Germany the situation is still not satisfying at all, especially in the field of public infrastructure sector. Even though many people wish a change it is however difficult to introduce fundamental changes in the relationship between client and contractors. The current legal situation in public tendering and public financing restricts the options of a change very much. This applies as well to the strict and very citizen related provisions for the legal authorizations for infrastructure projects in Germany (”plan approval”). In spite of these very challenging preconditions, a change of the client-contractor-relationship towards more partnership is necessary and without alternatives.

THE RESEARCH WORK

Initiated by the Chair of Project Management at the University of Kassel a group of researchers, practitioners and public clients started a research project towards partnering in infrastructure projects in 2005. The research is sponsored by the German Federal Ministry of Transport, various public clients, contractor organizations and several contractors. The principal target of the project was to develop a partnering model for public infrastructure projects respecting the specific conditions of public financed road and railway projects in Germany. Following this target the detailed project objectives were defined as:

- Reduction of conflicts
- Avoiding litigations
- Optimisation of the project in sense of value engineering
- Raising the level of efficiency and finally
- Reduction of construction time and saving of money

Literature review

A global literature review should show how large and complex infrastructure projects are managed in other countries. In the beginning of the nineties the situation in the British construction market was very similar to the current situation in Germany. Hence, “Her Majesty’s Stationery Office” assigned Sir Michael Latham to analyze the reasons for the dissatisfying situation. In his report “Constructing the team” (Latham 1994) he demands for a rethinking of the tendering system, to evaluate the contractor not only by price criteria but also by quality criteria. Beyond he demands to establish preconditions to achieve a win-win situation between client and contractor, to be managed through a partnering approach. Some years later Egan (1998) recommended in his report “Rethinking Construction” that the construction industry should use best practices from other industries and implement them in their processes.

Furthermore clients and contractors should work together to achieve a common goal. To reach these goal, he also demanded for a partnership between clients and contractors. Especially in complex projects with limited budget the traditional way of project handling seems to be insufficient (Sakal 2005). The idea of a new concept was born in the early nineties with the Andrew Project of the Oil and Gas Company BP. The project had so many uncertainties that the project success was not sure. For that, a new way of contracting had to be established. Contractors were now chosen not only by price criteria and the goals of the further project handling were fixed with a fair risk sharing between all parties, better and faster solution of conflicts without court processes and a pain and gain regulation for exceeding respectively failing the project targets. The outcome was the first form of an alliance contract, which leads to a satisfactory project for the client with savings of more than 20 % (Rooney 2006).

This good result was the impulse for the Australian construction market to adapt and to develop this way of contracting. In the meantime, until today, alliance contracts are used in Australia in the private and public sector more than anywhere else in the world (Ross 2009).

Bennett and Jayes (1998) identified three levels of partnering:

- First Generation Partnering – Project Partnering
- Second Generation Partnering – Strategic Partnering
- Third Generation Partnering – System Partnering

The distinction in three different levels of partnering is due to the sometimes difficult preconditions in creating a project atmosphere which allows a collaborative way of working. To reach higher levels of partnering is even harder. Tyler and Matthews (1996) and Black et al. (2000) analyzed these preconditions. Thereby they identified the following important elements, which have to be fulfilled: Trust, common goals, communication, defined problem resolution, clear understanding of roles, commitment from senior management and incentives.

Analyzing the benefits of partnering is a big challenge, because it is hard to define how the changes contributed to the improvements (Bresnen and Marshall 2000/a). Black et al. (2000) analyzed it by a survey in the construction industry. They identified the following benefits:

- Less adversarial relationship
- Increased customer satisfaction and better understanding of each other
- Improved time-scales, quality and reduced costs (improved return on resources)
- Risk sharing

Bresnen and Marshall (2000/b) analyzed nine partnering projects in the UK contracted in different ways like long-term agreements, project alliances or construction management contracts. They found a very high level of satisfaction of the parties not least because all projects were finished in time and did not exceed the planned costs. Pakala et al. (2007) compared various innovative partnering models all over the world and found similar results, such as higher client satisfaction, reduced time of construction and a better cost control. Chan et al. (2007) compared partnering practices between Australia and Hong Kong. They found that partnering leads to a stronger teamwork with more cooperation, which results in a better overall performance. Manley (2002) conducted an international survey of eight Australian and ten international road agencies. The general feedback concerning their partnering experiences was good, and most of them would like to extend their engagement in partnering projects.

The above mentioned results should not suggest that problems do not occur in partnering projects, there are examples for problems as well. In the nine projects, analyzed by Bresnen and

Marshall (2000/b), problems were solved without claims or litigations. Lu and Yan (2007) state that partnering is not always the master key to project success. It is necessary to evaluate for each project if partnering is applicable and useful.

The positive outcome of partnering can only be achieved by contributions from both parties but the benefits of this way of working will overweigh the efforts. It is really not satisfying, that reliable methods for evaluating the effect of partnering do not exist, but it is very difficult in respect of the uniqueness of projects in general. A research work in respect to this subject is in preparation at the University of Kassel.

Field Study

Based on the results of the literature review a field study about the relationship between clients and contractors in the German construction industry was initiated (Spang et al. 2009). Half of the 130 respondents were clients respectively contractors which allows a good comparison between the answers of clients and contractors. The study showed clearly, that clients and contractors rarely feel 'partnership' in their projects, that they do not feel comfortable with the current situation and that they mostly do not see one party as a winner, which will be described more precisely below.

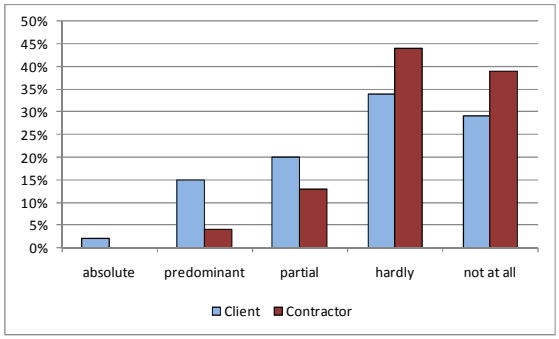


Figure 1: *Satisfaction with the current situation (Spang et al. 2009)*

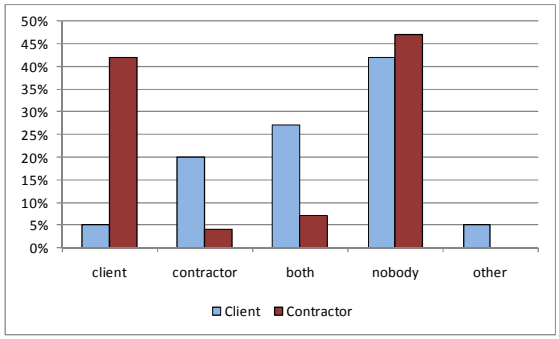


Figure 2: *Winner of the current situation (Spang et al. 2009)*

Figure 1 shows the results of the question "Are you satisfied with the current situation?" More than 80% of the contractors and more than 60% of the clients state that they are dissatisfied. Only 17% of the clients and 4% of the contractors are content with the current situation. In general the contractors are more dissatisfied with the current situation than the clients. This may be due to the strong public clients, which can impose conditions and prices to the contractors. This imbalance of power may be still amplified by the big numbers of companies in the German construction market.

The dissatisfaction of the clients may be based on the more and more intensive claim management of the contractors, which try to improve their insufficient price levels by this way. Most of the disputes and litigations are consequences of disagreements about the contract and about claims and a loss of trust.

Another reason for the dissatisfaction of both parties may be found in the answers to the question "Who is the winner of the current situation?" (Fig. 2). About 45% of all participants think that neither the client nor the contractor is the winner, whereat client and contractor have the same perception. About 42% of the contractors answered that the clients are the winners and - in contrast - just 20% of the clients see the contractors as winners. Only 7% of the contractors, but 27% of the clients see both parties as winners. But especially the benefit

for both parties, so called ‘win-win-situation’, is essential for working in partnership. Thus, a relationship, where so many participants see no winner or the other side as the winner, is not a reliable base for a successful project. The reasons for this situation may be based partly on the principle-agent-theory, but otherwise on the lack of common objectives and of accepting a win-win-situation.

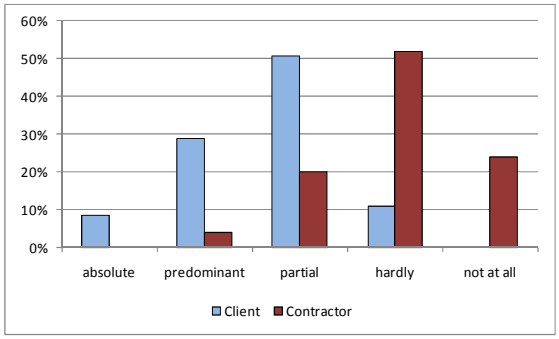


Figure 3: *Fair risk allocation (Spang et al. 2009)*

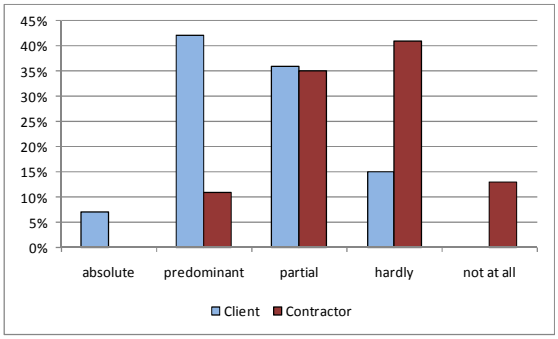


Figure 4: *Clearness of the contractually agreed scope (Spang et al. 2009)*

Further results can be seen in Figure 3 and Figure 4, where the answers of clients and contractors dispersed most, for example concerning the risk allocation. About 35% of the clients stated, that the risk allocation is at least predominantly fair. Another 50% see it partially fair. In contrast 75% of the contractors believe that the risk allocation is hardly fair or completely unfair. An explication for that might be that clients often try to shift all the risks to the contractors. This could be no problem for the contractors if they could consider the risks in their bid. But in the very competitive German construction market there is no space for the consideration of risks. Therefore contractors often are responsible for the risks without achieving a higher “risk-margin” or the risks are cached in the tender documents. The different point of view at the clients side my due to their mentioned strong position.

Concerning the clarity of the contractually agreed scope the distribution of the answers is similar. The majority of the clients believe that the contractually agreed scope is well described, while the majority of the contractors stated the opposite. The clients are convinced to have a perfect scope based on a design of high quality and the contractors see lacks and space of interpretations. There is no mutual understanding of the scope and this will be the initial point of most of the disturbances and disputes in the projects.

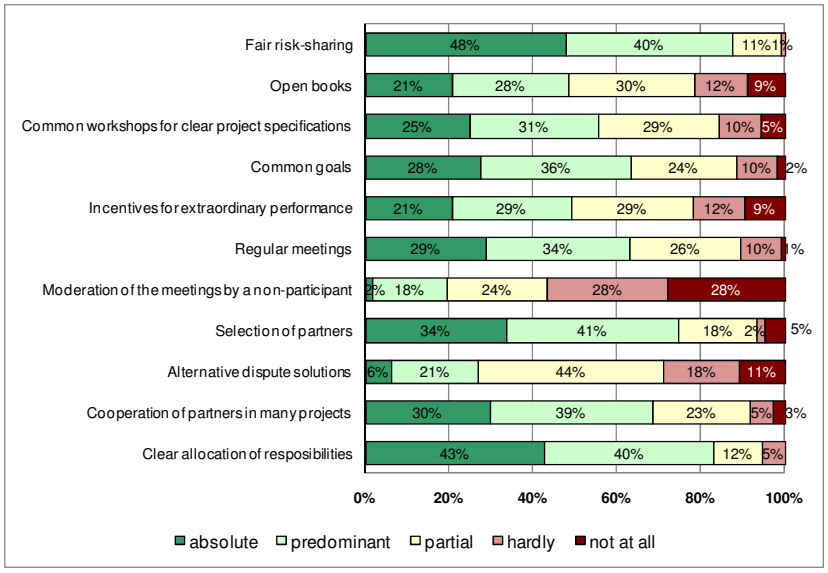


Figure 5: *Contribution to partnering (Spang et al. 2009)*

Furthermore the participants of the study were asked about possible contributions to partnering (see Figure 5). The given propositions have been deduced from the literature review. The results show that these facts are considered predominantly to be important for working collaboratively. Fair risk sharing and a clear allocation of responsibilities were mentioned to bring the most contribution to collaboration. In contrast, the participants state that moderation of the meetings by a non-participant and alternative dispute solutions are less important, but both are not really common in construction projects in Germany and so the benefits cannot be seen. Other elements, like common goals, common workshops or regular meetings contribute in a medium to high level to establish a collaborative work atmosphere. Cooperation in many projects and selection of partners seem to be well accepted, but they can not be used in public projects in Germany. In general, it must bee seen, that most of the participants did not have any experience in partnering projects.

In respect of the results of the study (more results will be found in Spang et. al., 2009) a clear wish for a change towards more fairness and partnership in construction projects ca be concluded.

The partnering guideline

The results of the field study and of the literature review were used for the development of the guideline, which will now be described.

With these results of the literature review and the filed study working groups were formed for specific topics, which are identically with the intended elements of the guideline. Each working group consisted of representatives of clients, contractors, lawyers and the chair of Project Management. Every group established one element of the guideline. The intermediate and final results have been discussed in workshops with higher representatives of the participating organizations and companies (“advisory board”). The final result of this process was the “Guideline for partnership between client and contractor in German infrastructure projects”. The guideline contains – starting with a preamble - seven elements. It contains regulations for clients and contractors for working together in partnership regarding the specific preconditions of public financed infrastructure projects in Germany.

Preamble:

The preamble aims for creating an environment that allows clients and contractors to work in partnership. To achieve this goal, basic principles like trust, willingness for cooperation and open communication are described. The preamble has to be signed by leading persons from both parties. The signatures shall be a sign for their willingness to follow the above mentioned facts and to follow the rules set in the guideline. Furthermore the companies will commit themselves to create a company culture which supports their employees to respect the guideline in their daily work. Clients and contractors should start the project with a leap of faith.

Element 1: Clear project specifications

As one result of the field study and the literature review it could be shown that a not well and comprehensively described scope is the main reason for disputes. Hence, element one provides regulations for the design-, the tendering- and the construction phase to enhance the quality of the project specifications. Special regulations for the pre qualification of the planner, exploring the subsoil and the design quality management are some examples of the suggested sub elements. Giving the contractor enough time during the tendering phase allows him to check all documents and ask questions, if necessary. Furthermore a site visit is compulsive during tendering in order to give all potential bidders the opportunity to take a look at the site and its environment, to point out possible problems and to ask questions

During the execution phase, it is advised to implement the conceptual designer in the team of the contractor to do the detailed design. If this is not possible, a minimum solution is to hire the conceptual designer as a consultant in the design-team of the constructor to guarantee a good know-how transfer from the design phase into the execution phase.

Beyond that special review workshops with representatives of the client and contractor are prescribed, which should help to learn from the project and in the project and to share knowledge not only in the own company but also between client and contractor. This knowledge can also be used to help to improve future projects, if it is introduced in a knowledge management.

Element 2: Defined processes for project changes

Even with a good scope quality, differences between the contractually scope and the necessary works will occur. Reasons may be irregularities in the underground and other site conditions, changes by the client or, which is unavoidable for complex construction projects, an incomplete design. To control this process it is necessary to have a defined model with clear and defined specifications. All stages which have to be passed in the change process are mentioned and described to specify “who has to do what in which way until when”. So, the responsible person, the action he has to do, the contents of his actions (like for example documents and its contents) and the time period are fixed in the process-model.

In the beginning of every project the time regulations have to be adjusted for the special circumstances. If these procedures are not respected by one party, the other party can relate to element six of the guideline to find a solution.

Element 3: Risk management

Infrastructure projects are, in addition to the common risks arising in every (construction-) project, fraught with many special risks like underground-uncertainties or high complexity. Hence, it is particularly necessary to identify the risks and establish a qualified risk handling process. Starting in the design phases all risks, identified and not completely cleared, have to be collected and described with their consequences in a risk register. This risk-register will be attached to the tender documents and the bidders have to complete it and implement the described risks in their offer. In the construction period client and contractor will meet in a fixed interval in a so called "risk-committee" to discuss the status of the collected risks, check if the handling of them has to be adjusted and to find out if there are any new risks. For the identified risks client and contractor together have to find ways how to handle the new risks and have to decide who is responsible for them.

Element 4: Common data

In big and complex projects many documents, drawings and information have to be used by both parties and exchanged between them. To handle this data-volume and to assure that everybody deals with the same, actual documents, a common project server with data, such as plans, documents, pictures and time schedules is installed. Moreover this data-server offers a platform for an open communication between the parties. This allows a faster and more comfortable handling of the project data. Thereby a double effort can be avoided and everybody uses the same documents and can be sure to use the newest version. There is access to the project data from everywhere. The common use of the data reduces the potential of conflicts.

Element 5: Regulations for decisions and authorizations

Many conflicts arise or grow up because of unclear responsibilities and late or wrong decisions. Sometimes staff members of the related parties do not have the entitlement to decide about a problem or the other party does not know the right contact person for their concern. For example only 40% of the participants of the above mentioned field study (Spang et al., 2009) state, that they clearly or at least predominantly know the right contact persons. That is why responsibilities and authorisations have to be clearly defined and clearly described in order to be able to take quick decisions, including client and contractor. Decision processes and standards for relevant documents are prescribed as well.

Element 6: Conflict solution

Conflicts or differing points of view are often arising in projects. If there are no quick and adequate solutions for these conflicts they may lead to a deterioration of the climate between client and contractor with a lower willingness to collaboration. Often the consequence of conflicts is a reduction of efficiency and additional works and costs. In the worst case a blockade of the project may occur as a consequence of missing decisions.

Hence conflicts should be solved as soon as possible. Especially disputes concerning money can take a long time or even end up in litigations. This is cost and time intensive and not suitable for the client contractor relationship. To handle and solve the conflicts as early as possible a stage model was created.

On the first, the operational level, the project managers of client and contractor try to find a solution for the conflict. If they don't succeed in a predefined, adequate time, every party has

the right to invoke the next level. On this strategic level, branch managers or managing directors (depends on the size of the organisation) of the two parties look for a solution of the problem. If they also do not find a solution the dispute will be given in an arbitration process. One or three arbitrators will start consultations with both parties in order to find a suitable solution. Subsequently they will formulate an arbitration award, which is binding for all parties until it is cancelled by a formal court decision. Going to court cannot be denied in Germany. Decisions by arbitrators are usually much faster and often cheaper than court decisions. Furthermore the defined process should influence the parties to find suitable solutions in the operational or the strategical level.

Element 7: Contractual incentive regulations

Generally the contractor has to realise the project as contracted. He is not motivated to find special solutions or to optimize the project with advantage for the client. But a project optimization or value engineering can often create a win-win situation for client and contractor – the client gets a better building or traffic line and the contractor gets physical advantages. In each case the chance for a common optimization creates often an atmosphere of trust.

In the first case, the contractor suggests a change or an improvement, with is equal to the contractual solution but cheaper. When he can prove the equivalency of his suggestion and the client agrees with it, he will participate in the savings in a contractual agreed proportion. This could be 50/50 but also 60/40 or 70/30. That means the contractor obtains a bonus and the client saves money for an adequate solution.

In the second case the contractor suggests an improvement with enhancing of the quality but without increasing the costs. When the suggestion is agreed between client and contractor and the target quality is reached, the contractor will get a bonus and the client gets a better work.

In the third case, the contractor finishes his work earlier than contractually agreed. In this case he will also get a bonus for the time of earlier finishing. So the contractor gets a bonus and the client finishes his project earlier.

All of these cases have to be agreed upon between the parties before execution. In each case the client must have an interest in this optimization. He must not accept the proposition; the contractor has no entitlement for the acceptance of his proposition. So, this incentive element has two effects. One is the project improvement for the client, combined with an additional revenue for the contractor, a real win-win situation. The second is the creation of an atmosphere of trust as a precondition for finding such win-win situations.

Du to the very strong boundary conditions for public financed infrastructure projects in Germany, the space for changes is restricted, so a “revolutionary step forward” was not possible. Some of the formulated specifications in the guideline are not new and do already exist in Germany. Others are new, at least for public financed infrastructure projects, as the common project reviews (element one), the common risk handling (element three), the common database (element four), the arbitration process (element six) and the incentive arrangement (element seven). Even when it is no revolution and the model goes not so far than models in other countries, this guideline may be the first step for a collaborative project management in large infrastructure project in Germany.

TESTING THE GUIDELINE

At present the research project is in its second phase – the testing phase of the guideline. During this phase the research results, fixed in the guideline shall be validated and the guideline is to be tested on its practicability. Thus the guideline is actually applied in two pilot projects. The first project is an upgrading of a highway from one lane in each direction to two lanes in central Germany. The whole site is 1 km long and has total investment costs of about 4m €. The project is just terminated. The second project is a construction of a new motorway in eastern Germany. It is about 8km long with total investment costs of ca. 45 mio €. The contractor consists of a consortium of three companies for the subsoil, bridge and pavement works, so there are more possible interactions between client and contractor. The project started in autumn 2009 and will be terminated in spring of 2012 due to a very hard and long winter period in 2010/2011. Further projects are in preparation.

To collect many information and experiences in applying the guideline, the chair of Project Management is strongly involved in these pilot projects. Thus the clients are strongly supported in terms of the guideline and all observations, results and particularities of the project are to be collected for the evaluation of the pilot phase.

The first findings of these two pilot projects are mostly positive and can be described as follows:

- More collaborative way of working together
- Open communication between client and contractor
- Fair risk allocation, no hidden risks
- Fast solving of problems without litigations
- Optimisation of the whole project (not only monetary, but also qualitative)
- Higher satisfaction of the participants, but also
- Backslides towards confrontative working from time to time,
- Upcoming mistrust because of violation of agreements
- "Bad prices" and "old" organisational structures obstruct the success of partnering.

The review workshops, which have been conducted in both projects, showed a big step towards partnering, because client and contractors participated commonly. The workshops showed as well, that there have been significant changes in the communication and in problem solving as well as in proactively risk handling towards partnering.

After finishing the research project, there will to be discussed, if the public authorities will prescribe this guideline as binding for specific infrastructure projects.

CONCLUSIONS

As shown above, the current situation in the German construction market is affected by dissatisfaction on both sides – client and contractor. Neither both, nor one of the parties is the 'winner' of the current situation. With the guideline a first step to a more collaborative way of working is achieved. The results of the testing phase with the adoption of the guideline in pilot projects has shown big progresses, but structural problems as well. As a result of the different workshops in both pilot projects, it could be seen that all elements of the guideline

act together in a way that the communication between client and contractor became more open and the atmosphere changed for the better. So far all problems could be solved either on the operational level or, in just a few cases, on the strategical level. Till today, the arbitrators have not been contacted. Element seven of the guideline contributed to savings of money for the client. Simultaneously the contractor got some extra money for his ideas. Another step forward to start working in a collaborative way.

Further pilot projects will show if this positive impact will continue. In this case there will be a good chance that the guideline will become a fixed standard for infrastructure projects in Germany.

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INNOVATION IN COLLABORATION FOR BELGIAN BUILDING PROCESSES

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Abstract
Today in many of our neighbouring countries 'working together in integrated project teams', using groupware and BIM, is the future way of process thinking in the building practice. Everyone is convinced that 'teams outperform individuals'! Especially when diverse skills, judgement and experiences can enhance the project's outcome.
This paper contains the first phase of a comparative study of IPD processes, ways of enhanced collaboration and communication between the different stakeholders in the supply chain of projects abroad, to solve the problems occurring in traditional construction processes used in Belgium. Before the search for solutions can start several questions need an answer first. 'Which types of building processes are being applied in Belgium today? From which problems do stakeholders suffer? Do all stakeholders understand the problems? Why do Belgians keep following these traditional processes? Are they already aware of the progress in innovative processes made in our neighbouring countries? Is there economical, professional, legal or political support for them?'

Keywords: innovation, collaboration, integration, comparative, Belgium

INTRODUCTION

This paper is written as a part of a PhD research. The first phase of this research contains an exploratory study to be able to clearly define the problems occurring in the traditional Belgian building processes. The aim of the PhD research is making a comparative study of diverse integrated building processes, ways of enhanced collaboration and communication between the different stakeholders in the supply chain of projects abroad, to solve the problems of the traditional construction processes at home.

RESEARCH QUESTION

Integration

Today in many of our neighbouring countries 'working together in integrated project teams', using groupware and BIM, is the future way of process thinking to achieve best practice in building. Everyone is convinced that 'teams outperform individuals'! (Wright, 2009) Especially when diverse skills, judgement and experiences can enhance the project's outcome. (Katzenbach, 1993) In the process of integrated project delivery (IPD) people, systems, business structures and practices are integrated into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication and construction. (AIA, 2007) The integrated team has to be formed at the inception of the project. Next to the owner and the advising architect, the contractor is also involved from the first draft of the design on. He is often individually invited from the architect's former experiences. The contractor contributes through his knowledge of materials, details,

managing and timing the execution phase, and he advises the project team concerning technical and financial feasibility. This results in the best quality/cost combination for the project. There exists a continuous communication between all the team members, which will lead to improved learning, more informed decision making and increased effectiveness. The building information is non-stop shared through new ICT tools. Working intensively together will result in a lower cost, earlier delivery and higher quality within the scope agreed at the outset of the project. All team members will probably need to sacrifice a part of their own interests, they will have to make trade-offs to reach the overall goal of the project (Bovens, 2009a). Everyone has to share in the risks, through intensive meetings the uncertainties are defined and the best owner will be selected. At the same time they share in the profits as well, the better they work together, the more risks they can avoid or transfer, the greater the shared potential profits will be at the end. This is the ultimate way of stimulating ownership and commitment of all the stakeholders. Transparency among the partners involved is the key to success.

Tradition

Nevertheless building partners in Belgium stick to the traditional design-bid-build method, in which the responsibilities of assigning, designing and executing are strictly divided and follow each other chronologically (Bruggeman et al., 2010). In this way of procuring, lots of problems occur. Experience learns that every day, projects suffer from overruns in time and costs and perform under quality. The stakeholders can't cope with the new prescriptions in terms of sustainability, energy-efficiency and whole life performance. Poor communication between the stakeholders makes it all even worse. The more parties involved in the building process, the more information that gets lost during design and execution, the more risks occur. Mistrust is growing. Incentives to create involvement and ownership and to perform more efficiently are lacking.

A belief

All the positive elements of integration in construction processes cited above can never be part of exact science, it's more a belief. However it is interesting to examine whether this belief in integration could bring solutions for the problems encountered in the Belgian building processes. Before this search for solutions can start several questions need an answer first. 'Which types of building processes are being applied in Belgium today? From which problems do stakeholders suffer? Do all stakeholders understand the problems? Why do Belgians keep following these traditional processes? Are they already aware of the progress made in our neighbouring countries? Do they plan any action in the future? Is there economical, professional, legal or political support for the stakeholders involved in projects?' Subsequent to the questions concerning the Belgian situation being answered, this belief in integration abroad enquires for a critical view. What is stated in literature, 'Working in integrated project teams is necessary to achieve best practice!' (see paragraph 1) will need further investigation in a second phase of the PhD research to verify whether integration is already implemented in building practice abroad or is still only theory.

EXPLORATORY STUDY

To be able to clearly define the problems occurring in the Belgian building processes, two methodologies were applied. With the questions listed in the previous paragraph a questionnaire was drawn up to base interviews on among the different stakeholders in the construction process. Together with an analysis of the existing literature in Belgium on the

implemented processes today in construction, a clear picture of the organisation of building projects in Belgium is established.

Implemented processes

Traditional

The traditional building process of design, bid, build is still the overall used process in Belgium. In this building process the owner (customer or developer as representative of the end-users) has thoughts, needs and requirements concerning a project that he/she would like to execute on a certain site (Bruggeman et al., 2010). In Belgium an owner will begin by searching for an architect, to discuss his plans with, to get the brief of the project clear. Important in choosing an architect is selecting and appointing one, whose ideas or maybe already his/her first design meets in a substantial way with the outcomes the owner has in mind, this to spare time. When owner and architect have reached an agreement on the design, the architect can finish the drawings and prepares all the documents to acquire the building permission from the authorities. While waiting for the building permission to return the architect starts making a bill of quantities together with a description of the building specifications of the project. With these documents the procurement can start. General contractors can bid for the whole job or subcontractors are bidding for separate packages. After a certain period the bidding procedure will be finished and the offers can be compared (Van der Heyden, 2010). During the design phase the architect made several estimations of the building cost, based on studies he made or asked for, to assure the project is designed within the owner's budget. The contractor with the best quality/cost combination will be assigned for the project. When the building permission is delivered by the authorities, the execution on site can start. The architect will plan, manage and inspect the construction phase, because he will be partly responsible for the outcomes to be achieved within time, cost, quality and scope.

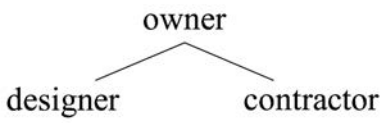


Figure 1: *contractual relations in traditional process as well as in building team in Belgium*

Building team

Working together in building team avoids the chronological fragmented organisation of the traditional building process and replaces it by a multidisciplinary coordination of design and execution (Breesch and Versele, 2009). All building professionals are involved from the very early beginning and contribute through sharing their knowledge on construction, this increases the buildability of the project. Risks and problems are detected by the multi professional team during the design phase, to avoid complications in execution It is a more integrated way of organising the building process, although abroad this building team model is still categorised as a variant of the traditional method (Wamelink et al. 2010). This because the sharing of risks and responsibilities, costs and profits of IPD, which generates optimal involvement, ownership and stimulates whole life cycle thinking is not incorporated in this model. The contractual relationships remain unchanged (fig.1), caused by the legal incompatibility in the relationship between architect and contractor and the deontological requirement of total independence of the architect at all times. (Art. 6 Architectenwet, 1939) All stakeholders are involved from the very beginning, the rest of the process remains equal

to the traditional process. Nevertheless using building teams proved their use already in several projects in Belgium, mainly in industrial and office buildings and residential projects.

Traditional versus building team
Verheyen (2009) states: 'traditional building is everything except a sustainable building process, after the project is executed we have to confess that every party's concern was achieving as much as possible its own interests, being the budget for the owner, the creative concept for the architect and the profit to be made for the contractor'. This is everything but what the integration thought requires. (see paragraph 1) Timing, costs, quality and scope should be shared interests! 'An ethical charter should be signed by all parties to outline the common goal of this temporary cooperation.'

From the chart Ceyssens (2008) drafted, it can be deduced that a 20% profit can be achieved in timing as well as in cost by working intensively together in building team compared to the traditional design-bid-build method.

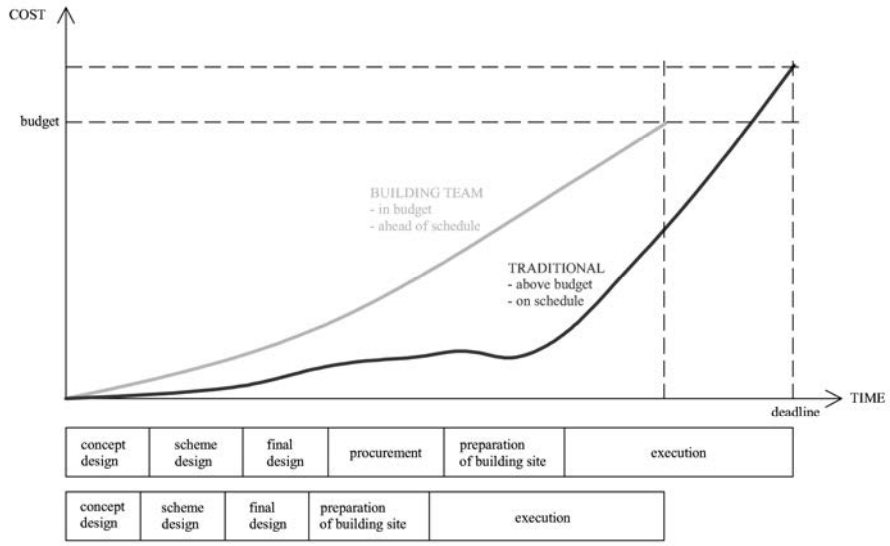


Figure 2: *traditional versus building team (Ceyssens,2008)*

Breesch and Versele (2009) argue that Belgium continues to work traditionally cause the building sector doesn't obtain any administrative or legal support for working in building team. There's an urgent need for a structured procedure together with a well thought through planning of this process. Parties continue working with unsuitable contracts of traditional building process, which of course creates disputes along the process. Bellens (2009) confirms that today parties apply the building team model by trial and error, there is a great deficiency of clearly formulated rules, manuals, standard contracts, documents, …

Knowing that this is only a small step into integration compared to what our neighbouring countries intend to implement, Belgium should be able to systematize this better.

Interviews to define the problem
The three main building partners included in the interviews will be the clients, the advising architects and the contractors. The group of clients can be divided in public authorities and institutions, private institutions, companies, developers and private owners. For the advising architects the attention can be drawn to all individual architects or architects offices. Together

with the Board of Architects (a legal authority in charge of defining the statement of ethics for architects and guarding whether Belgian architects comply with this code) and the two major professional organizations for architects, NAV and BVA, it's possible to get a entire view on how the problems of traditional building is encountered on the architects' side. On the contractors' side, two main federations the Confederatie Bouw (federation of Belgian contractors) and more specific the FABA (federation of Belgian general contractors) could be a guide to find interesting co-operators for the interviews. Knowing that this target group is to vast, aiming for a more narrow scope is a must, a selection need to be made to continue the research.

The target group was narrowed down from an architect's point of view. As an architect I experienced the traditional building process in practice myself, therefore a focus on the architects first seemed a reasonable next step. The purpose of the first interview with the chairman and director of the NAV (largest professional organization for architects) was to get a clear picture on which type of architects offices suffer from which problems in the Belgian building sector. And subsequently analysing whether these problems were caused by the traditional way of building. The list of problems was long, going from never been able to deliver a project within the budget or on schedule to the unfair obligation for the architect to take a ten year professional liability insurance for each project, compared to the contractors who don't have any legal obligation in this matter.

Size matters

NAV statistics show that the type of problem suffered depends on the size of the office. Offices of 1 to 3 people struggle the most with the fact that in small scale projects in Belgium there is ascertained that the owner's search for an architect is not because he needs his advice but because of the legal obligation to work with an architect to get a building permission from the authorities. Those owners are only looking for a signature for the least payment. This attitude decreases the value of the architect's profession (Bellens, 2009a), but was shaped by the Belgian architects' act of 1939 and still in use, that protects the title and profession of architects. This act describes the compulsory services of the architect, containing: making the design, delivering the plans and documents for the building permission and periodically inspecting the execution phase on site, what created a monopoly status for the architect in Belgium. These offices apply the traditional building process cause it still suits well for small scale projects. According to Van der Heyden (2010) working in building team is an investment in time and energy, this need to be in balance to the benefit possible to make. For offices between 5 and 10 people the major concern is that they are not big enough to be able to invest in retraining their staff into a multi professional team, they have difficulties in coping with all the new regulation that is written according to sustainability and whole life cycle costing, energy efficiency, safety, … The work package of the Belgian architect grew to a great velocity the last ten years. Creative designing only takes a small piece in the daily agenda of the architect, 52% of the architect's work package exists of administration. This, together with the increasing responsibilities and being the only building professional who is legally obliged to have a professional liability insurance, with the deep pocket approach as a consequence (owners will always try to involve the architect in construction disputes), leads to the following disturbing figures: 36,2% of Belgian architects consider a change of profession in 2009, compared to 25% in 2008! (NAV survey, 2009). The 'Wet Laruelle' (2006) encountered the heavy liability of a Belgian architect, what was called an explosive cocktail by Mrs. Body (2004), to some extent by offering architects the opportunity to practice their profession in a corporation with limited liability. But what still remains is that the owners are not aware of the overwhelmed work package of the architect, resulting in

difficulties in asking for extra remuneration. Informing the clients should be everyone's primary concern.

The search for the right focus group continued within the G30 (an association that represents recognized architects' offices in Belgium). The members of this association are the top of the Belgian building market, their portfolios comprise a great percentage of the major projects executed the last 15 years in Belgium. The main ideas that drive the G30 are: 'bringing together leading architecture firms in Belgium and represent them, promoting best practice in the field of architecture and urbanism towards clients and contributing to improve the conditions of practice of the profession in Belgium and Europe. Through the interviews within the G30 it became clear that these offices are ready to question the overall used traditional building process and are interested in the challenges of integration. Analysing their projects in the future will enable finding the right people on the clients' and contractors' side to meet.

Problem listing
As a result of the interviews a list of the most frequently occurring problems in construction projects according to the Belgian architect was drawn up. A division is made in problems caused by the fact projects appear through implementing a traditional building process and problems that don't have their roots in the traditional way of building but sure do have their influence on it.

Caused by traditional process
- Overruns in time and budget, underperformance in quality
- Low document quality for the bidding procedure
- Division in too many work packages > many bidding procedures > time consuming
- No transparency in cost/quality balance > fixed price
- No whole life cycle thinking
- Poor communication, no team work
- Low involvement > low ownership
- Risk averse attitude of everyone, no sharing in the risks
- Lack of trust and mistrust

Caused by other factors, but have consequences for the traditional process
- New regulations on sustainability, energy-efficiency, whole life cycle costing
- Heavy work package > lack in delegating
- Job hopping > project management changes > no relations of trust
- Unfair obligation of the professional liability insurance
- No ICT tools available at decent prices

The problems that returned in all interviews were the quality of the documents for the bidding procedure in traditional building processes. The scope and specifications of the project should be described enormously detailed for the contractor to understand every part of the construction, because he never saw the design before, this is time consuming. Alongside this the legislation concerning energy-efficiency and preserving the environment, and according to that the work package of the architect, is changing very quickly in Belgium. As a result the architect can almost not assure the owner that the documents delivered are complete. Secondly the architect often tries to shift some of the risks and responsibilities to the contractor by ordering special studies or research in the bidding, together with the construction contract becoming frequently fixed price, transparency in the prices disappears.

The contractor from his side is searching for the blanks or errors in the bidding documents, the selling unit of the different articles will go up and down depending on the commercial judgement of each contesting contractor, cause they can make profit out of it. They try to anticipate on the uncertainties of the studies made and the changes they expect the owner will ask for, e.g. articles which are likely to disappear will get a negative margin resulting in achieving a lower bidding price (Bovens, 2011). This created an enormous mistrust in the past up till now between clients and contractors. Clients experience the use of competition in the bidding procedure as the only way to ensure cost control. When it comes to choose between contractors, the client repeatedly decides to work with the cheapest one instead of the one with the best quality/cost combination. Finally a project is often divided in several work packages as: foundations, main construction, windows and doors, roof, finishing,… which means a bidding procedure for each individual package will be necessary. This takes much time in collecting and comparing prices, also in communication and managing during the building process. The more parties involved, the more information that can get lost during the execution, the more risks can occur. To conclude, there's often no existence of collaboration between the building partners. Which comprise the poor communication, the low involvement, the risk averse attitude, … This unhealthy building environment has to be taken on!

Heard from IPD?
The interviewees that had foreign projects before knew of the existence of integrated project delivery, but none of them ever implemented it. This isn't too strange knowing that for instance in the Netherlands and the UK the majority of projects are still constructed through the use of traditional building processes as well.

When considering public assignments in Belgium like PPP-projects, what should represent that all building partners work together in a temporary venture to design, build, finance and maintain a project, partnerships are never established, it is only of a structured way of collaborating. The public CBO-procedure (Constructieve Benadering Overheidsopdrachten) resembles the design & build method, but again doesn't mean that designer and contractor share the responsibility and risks of these projects. These models are restricted in use because of the monopoly status of the architect in Belgium and together with that, the prohibition of a cooperation between architect and contractor because of the potential conflict of interests that would occur. Meaning that the Belgian architect, as an adviser and representative of the owner, at all times has to preserve his incompatible relation with the contractor, cause he can't control and work together with the contractor at the same time.

Support?
To the question whether architects felt supported in their search for solutions to the problems they experience in their profession, the answer was disappointing. Although all Belgian architects are obliged to register at the Board of Architects to provide their services, you would think they will be represented by them, like in many other European countries. Unfortunately none of the interviewees could enumerate a positive experience. Nevertheless the Board of architects should have an important role in promoting the profession and informing the sector for instance on new, more integrated building processes.

CONCLUSIONS

From the search for the applied processes in Belgian construction projects, the problems of the traditional building process and the little progress made through implementing building teams, the following can be deduced: 'Belgian architects aren't aware of the positive elements of integration yet.' What they do realize is that the loads of problems in construction today, make it impossible to guarantee a project being delivered within time, budget, quality and scope. Through the interviews a clear checklist of the problems arising was made, some relate to the traditional building process, some have an influence on it. Although Verheyen (2009) stated that time, budget, quality and scope should be shared interest, new enhanced ways of collaborating will be necessary to achieve this goal.

FUTURE CHALLENGES

After this exploratory phase, where the problems of the traditional building process from an architects' point of view has been analysed and how those problems emerge in the Belgian construction market, time has come to go through some case studies on G30 projects, to get into contact with the other building partners. Once the picture on how everyone involved in construction encounters the problems of the traditional building process is tangible, looking for solutions in building processes applied in our neighbouring countries can commence. Figure 3 illustrates the future steps, where the research is heading for in the coming years.

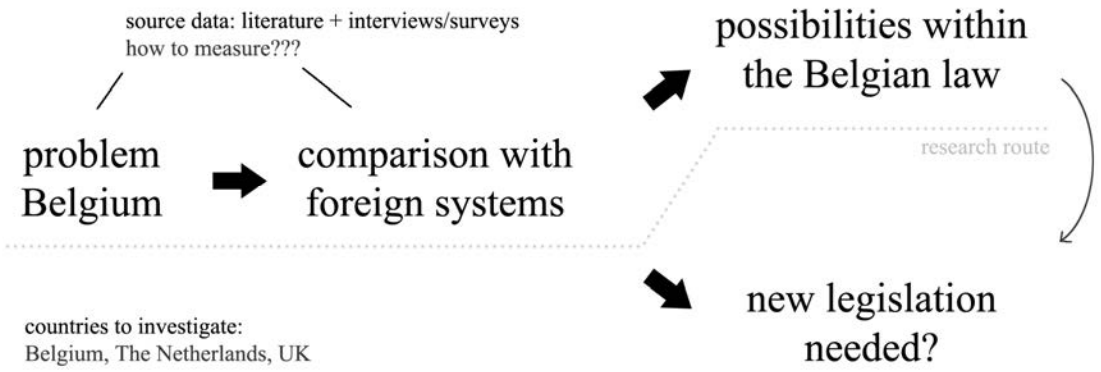


Figure 3: *Research route*

Comparison with foreign systems & possibilities within the Belgian law
Today integrated project delivery methods are used together with adjusted contracts to enhance the building processes in the Netherlands and the UK. They intensively use building teams, integrated contracts like design & build and turn-key, public private partnerships, alliances, SPE's, … The restriction of the monopoly status of the architect in Belgium together with preserving at all times his incompatible relation with the contractor will be considered first. The following questions will guide the research in the future: 'Which future perspectives can Belgium have? What kind of integrated methods are successful in our neighbouring countries? Are there any possibilities to implement them within the Belgian legislation or is a profound revision inevitable? Will an evolution be enough or is a real revolution to be expected? …'

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STANDARDIZING KNOWLEDGE: A DIALECTIC VIEW ON ARCHITECTURAL KNOWLEDGE AND ITS MANAGERS

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ABSTRACT
Many organizations within the construction industry are currently developing standardized practices. Increased standardization involves new ways of organizing construction projects, changing interrelations between professional groups, setting a new culture, i.e. challenging the institutionalized way of being. It, for instance, leads to a concentration of key knowledge into specific knowledge networks and artifacts. This in turn creates new and/or strengthened roles of expertise within the organizations leading to a reallocation of knowledge, as well as power, from the project setting to centrally organized functions, specialist consultancies and knowledge networks. Based on a case study of one Architect Company, this paper examines the tensions and paradoxes inherent in these 'new' roles. In the study, 13 persons were interviewed; actors responsible for changing practices, developing tools and ensuring learning among employees. The study contributes to theory building within a research field that examines the emergence of new roles and practices in construction and the contradictions which arise leading to tensions and possible conflict. Many of the assumptions that underlie these new practices run counter to the established norms and local practices as well as to construction practitioners' 'intuitions'.

Keywords: social practices, roles, knowledge management, standardization, construction process, architect company

INTRODUCTION

Many companies within the construction industry have today adopted strategies and procedures in order to operate in a more standardized and industrialized way. Knowledge Management related to standardized and industrialized building has been the focus of several recent studies. Most studies have focused on the procedural processes (eg. Höök and Stehn 2008, Koskela 2000) or ICT tools (eg. Persson et al 2009, Ekholm and Wiberg 2009). A few studies have had a more organization oriented perspective focusing on supply-chain relationships (Engström et al 2009a), quality control (Johnsson and Meiling 2009) and business barriers (Pan et al 2007). Conclusions are made that the industry's interest to adopt these new ways of building is still limited and suggestions are that to make it happen the project culture must change (Höök and Stehn 2008, Roy et al 2003), the client's power need to be strengthened (Engström et al 2009b) or peoples' perceptions on industrialized building need to change (Pan et al 2007). However, few have thoroughly studied these aspects. So far, much research has been 'trapped' within the theoretical frame of 'rational selection' and/or 'tool production' and thus not addressing on-going social processes related to standardization.

Increased standardization implies that strategic long-term decisions are embedded in the products and processes. This involves new ways of organizing a project, changing

interrelations between professional groups, setting a new culture, i.e. challenging the institutionalized way of being (Styhre 2009). It, for instance, leads to a concentration of key knowledge and expertise into specific knowledge networks and artifacts, such as technical platforms (Styhre and Gluch 2010) and ICT models. This in turn create new and/or strengthened professional roles of expertise within the organizations, such as production specialists, technical specialists, and BIM experts who possess knowledge that previously was to a great degree part of the professional role of an experienced project manager. This change leads to a reallocation of knowledge, as well as power, from the project setting and project manager to centrally organized functions, specialist consultancies and knowledge networks. However, results from a study of knowledge management in the construction industry (Johansson 2010) reveal that this change is not easily made. In fact it shows that individuals often mistrust the validity of the knowledge provided by experts and other professional groups. Consequently, if experts wield their power through their knowledge advantage it is perceived by practitioners as a possible threat towards the project manager's traditional role as site leader and as a disruption of institutionalized order within project practice and met with resistance (Gluch 2009).

Based on evidence from a case study of one architect company, and by taking on a dialectical perspective, on knowledge and its management (Benson, 1977; Zeitz, 1980; Seo and Creed, 2002; Omanović, 2009), this paper make an attempt to uncover paradoxes and contradictions that arise due to the ongoing change towards a higher degree of standardization in the construction industry.

THEORETICHAL APPROACH: A DIALECTICAL PERSPECTIVE ON KNOWLEDGE AND ITS MANAGEMENT

A dialectical perspective on organization views it as a multileveled phenomenon connected with contradictions that continuously challenge its existence (Benson, 1977). A dialectical perspective is thus strongly connected to the concept of on-going organizing processes, where organizations are constantly subject to change and where people continuously construct their social world. This means that the way an organization develops depends on the interests of actors and upon their ability to shape and maintain a social form. As such a dialectical model of an organization involves power and resource relations in organizational networks (Zeitz, 1980). A dialectical analysis therefore entails a search for accountants for the emergence of specific social situations. For management studies this means placing the process through which organisational arrangements are produced and maintained in the centre of analysis. It also aims at discovering ideas that are contradictory. Benson (1977) proposes four principles for a dialectical analysis: social construction, totality (context), contradictions, and praxis. It has been suggested that none of the four principles can be understood separately since they are intertwined and provide an overall perspective on social arrangements (Seo and Creed, 2002).

In this paper the first principle concerns how professional knowledge is *socially constructed* in the construction industry. This construction is influenced by actors involved in the social process of developing various ideas (Omanović, 2009). Here, human interaction, social patterns and a set of institutional arrangements are built, modified and eventually replaced. More, relationships are formed, roles are created and institutions are built (Benson, 1977). Human interaction is directed by people's interests and power (Seo and Creed, 2002) which makes these interesting to uncover in a study of knowledge and its management.

Knowledge is embedded in specific social contexts shaped by individuals taking part in this context (Fernie et al, 2003). The second principle in this paper therefore concerns how knowledge and its management are shaped by the *social context* where it occurs. Examining social context related to knowledge and its management entails linking structural networks of involved actors in their individual setting as they relate to one another and to a larger social environment. Seeing standardized knowledge and its management as part of a whole rather than an isolated phenomenon, includes studying not only new and emerging social arrangements, such as a more standardized way to manage knowledge, but also relating it to established and institutionalized social arrangements.

The third principle, *contradictions*, refers to various inconsistencies both among and within established social arrangements (Seo and Creed, 2002). Causing tensions and conflict within and across social systems, contradictions are in theory seen as possible forces of organizational change (Benson, 1977; Ceo and Creed, 2002). The direction is however dependent on human action and practice where contradictions and inconsistencies may be used to facilitate new thinking (Foldy, 2006). Thus, identifying tensions in the process of standardizing knowledge in construction may uncover change agents as well as identifying actions for change.

The forth principle of *praxis* incorporates aspects related to agency and structure in organizations. Benson (1977) uses the word praxis in the sense of a collective human action and mediating mechanism between contradictions and change. The perspective helps understand how interaction between actors, structures and artifacts forms identities and roles in a specific organizational setting (Lindgren and Packendorf 2007, Gerhardi and Nicolini 2002, Orlikowski 2002). Here this means exploring roles, interrelations and power positions of various actors in the context of increased standardization and knowledge management in construction projects.

METHOD AND CASE DESCRIPTION

The present study is based on a case study methodology of one Swedish company within the construction industry; *Alpha*. One of the principal interests of the study was to understand which instituted arenas and practices for knowledge sharing were used in the studied companies. The centre of analysis has been the process through which knowledge management practices are produced and maintained in an organisation.

Alpha, a major Scandinavian architect firm, is a nationally renowned and a prestigious firm attracting some of the most skilled and creative architects, interior designers, lighting designers, designers, and engineers in Scandinavia. Alpha works in a wide variety of areas, including housing, health care buildings, schools, landscape design and architecture, furniture design, and interior design. The company was founded in the early 1950s and has grown both organically and through mergers and acquisitions, today being one of the largest architectural firms in Scandinavia. The firm employs 500 co-workers in 10 offices. In the spring of 2008, thirteen interviews were carried out with relevant actors; such as practicing architects, interior designers, and designers.

The interviews were conducted by two senior researchers and structured in accordance with a semi-structured interview guide, lasting for about one hour and being tape-recorded. All the

interviews were conducted at the company office. During the interviews, the interviewees were asked to tell about their day-to-day work, what they were working on at present, how they regarded their profession, what kind of media they were using, and what they thought was most rewarding in their day-to-day work. In general, the interview guide was structured so as to pave the way for detailed discussion about the day-to-day practices of their professional work. The interviewees were asked about the their own professional biographies and careers, their work procedures, their preferences and beliefs regarding a range of work practices, and were encouraged to critically reflect upon their own work procedures and experiences.

All interviews were transcribed verbatim. The transcribed interview material was examined and analyzed by the two researchers individually. The analysis of the interview transcripts focused on the ways in which the different actors constructed their social world in their narratives. Key words, phrases and concepts were extracted, compared and contrasted. Representative extracts were then selected to construct the narratives represented in quotes used to illustrate specific phenomenon related to knowledge management practice. All the interviews were conducted in Swedish and thus translated into English.

STANDARDIZING KNOWLEDGE: A STORY OF BUILT-IN CONTRADICTIONS

Alpha has established a medium which they refer to as *The Knowledge Construction* (KC). KC consists of extensive networks active throughout the whole company. KC is supposed to work as a meeting place with no geographical boundaries. One major aim with KC is to make use of, bring together and promote all knowledge, skills and wealth of ideas possessed by Alpha's employees. Although open for all employees KC is govern by a set of employees assigned as *knowledge masters*. Besides leading an assigned field of expertise within KC, the *masters* are also responsible to maintain the corporate intranet. The master's are assigned this function as a side-task to their regular consultancy work. Although it varies between different masters and over time, they spent about half-a-day per week working within KC.

KC is divided into various expertise areas, for example sustainable building, ICT, public buildings, landscape, and interior design. Each master is responsible for the activities within each field of expertise. Based on personal and/or professional interest the employees can freely choose which network(s) they like to join. They can also decide to not participate in any. Although the utilization may vary there is a standardized set of activities that should be carried out within each field of expertise. These activities may be conducted internally or together with clients and partners in order to highlight relevant topics. KC has a system to arrange various activities, such as seminars, workshops and study trips. More, internal education and network meetings are arranged within the frame of the network as well as an online discussion forum. KC also supports the organization with reference documents and other 'inspirational artifacts' (checklists, texts, photos, presentations, links etc). The interviews showed that KC has a general support from the employees and, which is exemplified by the following quote:

> *KC is very important for Alpha, one of this company's strengths is that top management allocates resources on a more systematized sharing of knowledge. The industry is rather changeable and being involved in the early phases you have to sense which direction it may take.*

Contradiction 1: Masculine individualism versus a collective interest

That knowledge and knowledge sharing is an important resource for an architect company is thus evident but the interviewees had difficulties in framing what 'architectural' knowledge actually is. As professional group architects are traditionally generally located between the artistic and aesthetic fields and the engineering sciences, described as a hybrid by the following architect.

> *The role as architect is a bit peculiar; it combines the technical with the artistic, the technical side of this role possesses a more verified knowledge while the artistic side possesses a more intuitive knowledge.*

So besides their distinct architect skills and competences they are also expected to understand technical aspects as well as taking account of the demands and expectations of a wide range of stakeholders including clients and end-users. This scattered competence makes it difficult to know what should be systematized in the KC, or as one of the knowledge masters expresses it:

> *It is difficult to systematize architectural knowledge: what is it exactly? As architects we still struggle to define it, what kind of expertise knowledge do we possess actually? It is difficult to tie individuals' tacit knowledge and articulate this in seminars and discussions.*

Here, the KC network was partly working as a mean in the process of constructing what architectural knowledge is. One of the interviewees said that within the KC "we become conscious about what we do and what we see, placing wordings on our aesthetic preferences". Another said that "during these discussions I get ideas that I normally do not have time to think of. These I can 'save' for later use' ". And one of the masters said that taking an active part in the KC network forces her to "step outside my regular role and think: 'What do we want to do?' Where are we going?' ".

What complicates the framing process of architectural knowledge is the existence of a dominant view of what 'good architecture' is and what the 'right' architectural vocabulary is. The right architecture is today, according to the interviewees, a masculine view that is "taught the very first semester in architecture school, and thereafter becomes habitudinal". Considering that the world are changing we can here see a tension between two social processes that influences the role of architects, the drive towards a collective ability to handle holistic societal demands through a more systematized sharing of knowledge and the individual and masculine force to build 'good' architecture according to institutionalized norms. As a consequence some employees feel uncertain of his/her architectural preferences "when you no longer know what you believe in anymore" and/or become sidestepped due to conflicting professional interests which the following quote by a master within the environmental knowledge network illustrates:

> *They [the architects and building engineers] lack genuine interest in my expertise area; ... Therefore it is very difficult for me to learn them anything.*

The above reasoning illustrates how 'standardizing' of knowledge in this company is a social construct influenced by self-interest and traditional preconceptions of the social world. For Alpha it was clearly important to maintain the opportunities to engage their employees in the process of constructing architectural knowledge.

Contradiction 2: Stereotyped copycats opposing conformity

Within the social world, the context, there are contradictions related to the architect role. The interviewees revealed a frustration of being torn between the idealistic innovative and creative person and the stereotypical copycat. Or as expressed by the following two architects:

> *We need to stretch the boundaries a bit more, learn from other countries, in some offices in Europe it is not unusual to have about 20 nationalities in one office, here we think alike, come from the same school, has similar ideas, belong to the same networks, reads the same magazines, like the same things…*

On the same topic another architect with 22 years of experience says:

> *Over time I have become the weary architect which I mocked when I was 25.*

Although aware of this autonomous stereotyping of their role and the outcome from their work, or maybe in spite of it, there seem to be an self-assumed attitude among the interviewed architects to oppose conformity in other contexts, for example when adopting management systems and work routines. One of the more experienced architects says:

> *Creating a collective stock of knowledge is a linchpin in our office. We are convinced that we perform better together than each one individually…. [however] we have a hard time keeping up routines… we are a typical kind of organization that has difficulties in maintaining things… We lash out if it becomes too squared and institutionalized… we have to balance between a more standardized knowledge available in systems and databases and our curiosity. Otherwise we will dig our own grave and become deadly boring.*

The more standardized and systematically way to work, as prescribed by KC, is conforming to the way the employees believe is the most efficient way to work with regard to the product to be delivered, but is simultaneously conflicting with the attitude regarding the 'curious' architect.

Contradiction 3: Cross-fertilization of like-minded

To maintain business Alpha has, according to one interviewed head manager, chosen to strategically market the company as "a company that possess expertise knowledge within a range of areas". As such Alpha offer a broader but also a more specialized service, encompassing architects with focused expertise areas, such as school buildings, infrastructure, lighting, hospitals etc, as well as experts from other professional expertise areas, such as energy experts, project managers, ICT engineers. The interviews reveal that this change causes a professional identity conflict among the architects, moving away from the traditional role as the generalist that "knows everything when it comes to building a house". This strategic change involves, with KC as an intended motor, making people with various professional background but common expertise interest, meet in a more systematic way. This idea is met differently by the employees. One team manager supports the idea although the outcome from it may, according to him, be disputed. He says:

> *Top management has an outspoken strategy to cross-fertilize between different professional groupings… I encourage that my team members also work in other teams*

than my… Sometimes it gets nowhere but you have put something to stake to go beyond the predictable.

Another senior architect is of a similar view and addresses a challenge of un-locking professional barriers within the organization. She says:

One challenge is to get to that different professional groupings benefit and spur each other, and not locking-in each other in predefined boxes.

However, a contradiction to this determination to cooperate and exchange over professional and organisational boarders is that many of the interviewed also emphasise the effectiveness inherent in teams that share a long common history. Talking about a shared and intuitive collective knowledge and reference frame and the necessity of "having a professional home base" contradicts to the idea of KC. More, educational background was found to serve as basis for a very distinct grouping of employees within the company. The development of KC as a mean to share knowledge more systematically is in Alpha also obstructed by an existing and dominating culture of 'learn-by-doing and seeing'. Listening and reading, which are cornerstones in the KC framework, is not considered as ways to learn. One of the interviewed architects says: "...the most important knowledge sharing happen when you work together, not when you just listen... I learn by confronting people face to face." More, a strong individualism and prestige-mindedness were forwarded by the interviewees as a hinder for knowledge sharing. The interviews indicate that this attitude is nurtured and driven by the project based organising, where a strict economical project frame only "cover 'you' and your personal interest".

This final remark from one of the interviewees is summing up the main essence of KC and standardized knowledge sharing in Alpha illustrating the paradox of 'no matter how 'good' a system is, it is never better than the user':

KC is a great initiative; not very many architectural companies' have such an organized knowledge network to rely on. But I am quit bad using the opportunities given within it.

DISCUSSION AND CONCLUSIONS

By adopting a dialectical perspective on knowledge and its management focus of this paper has been to create a wider understanding of how architectural work practice, knowledge and context relate to the ongoing change towards a more standardized way of knowing what to do in the company. By focusing on these aspects a number of paradoxes and contradictions have been uncovered. The following discussion will be out of the perspective of contradictions as a possible force of change.

The KC idea of a more systematic knowledge sharing and the creation of a collective knowledge base and mind, were found to conflict with the institutionalized embedded perception of 'good' architecture and practice among the employees. The characteristic of 'good' architecture, as well as practice, was: *individualistic* with a practice where curious and independent creativity is favored, *masculine* with a practice inspired by male 'star' architects as role models and, *competitive and prestigious* with a culture where winning architect competitions and large contracts give credibility leading to a successful career. This

individualistic view on architect practice was further nurtured by the temporary 'bracketing' (Kreiner, 1995) of construction projects, which frame the individuals' performance in relation to short-term project goals and not the long-term objectives of the company. The collectively standardized and systematically way to work, as prescribed by KC, was nevertheless found to have support within the organisation as it conformed with the way the employees believed was the way forward towards a more efficient way to work. Simultaneously it conflicted with this attitude regarding the 'successful' architect and 'good architectural practice. In addition, the company's strategy to provide broader but more specialized service lead to shifting roles, from the traditional generalist to specialist within a targeted expertise area. In Alpha today this conflict between perceptions of architectural preferences and 'good' practices creates an identity crisis among the employees, with employees not knowing what they are and what they stand for. They wished to be innovative and creative but found them self as adaptable copycats. A stressful awareness of a present on-going process leading to a more stereotyped architect role and architecture with the risk of losing professional authority, led to that many chose to oppose conformity in situations where they were in control of their decisions, for example to not fully adopt management systems and standardized work routines.

The standardization of knowledge sharing in Alpha, by the means of the KC network, did however facilitate a continuous process of constructing what architectural knowledge is. Thus, various and sometimes conflicting views became more evident when people met leading to a reconsideration regarding one's habitual architectural practice. Participating in KC activities also permitted stepping out of their regular role which allowed them time to reflect, time seldom available in a time pressed consultancy life. However, the main basis for entering to a specific KC group was personal and/or professional interest. This might lead to that the group will consist of like-minded and even like-minded already belonging to previously established personal networks. Consequently there is a risk that KC fails creating the cross-fertilization of various professional groupings as hoped for, and instead creates sub-groupings of like-minded with a previous common history. It is therefore very important to maintain, and even enhance, the opportunities to engage within the KC network, so that a viable process of constructing modern architectural knowledge and practice is stimulated. Thus, provide a place where employees can reflect upon aspects that lie outside the every-day work. Preconceptions will be challenged, eventually leading to change. So, if the company wishes to change into the multi-professional company they constantly need to confront the reigning institutional norms of 'good' architecture and architectural practice. The KC framework show good potential in serving as mean for this change process.

In conclusion, the attempt to standardize knowledge and knowledge exchange within the KC frame in Alpha together with an attempt to broaden their market share could mean shifting from being a specialist company with hybrid employees to a hybrid company with specialized employees. Rightly used the KC could provide an opportunity to cross-fertilize professional knowledge within the organisation and also un-lock professional barriers. However, more standardized practices as well as more defined and specialized roles contradict with the current perception of what an architect is and know which resulted in that KC only existed on the periphery of regular work.

From this study it can be concluded that 'standardizing' of knowledge is a social construct influenced by self-interest and traditional preconceptions of the social world. In line with conclusions made by Fernie et al (2003) it is therefore important to consider that for a more systematic, 'standardized', knowledge sharing between organizational entities, professional groupings and individual professionals, it is necessary to facilitate a dialectic debate within

the organizations. By uncovering dominant ideas and interests in the process of standardizing knowledge the results from present study can serve as a starting point for such a discussion.

This paper should be seen as a setup for a continuing research project ending in 2013. The objective of the research is to stimulate and support development in the studied organizations (one construction company, one architect company and one prefabrication manufacturer) but also to visualise and raise knowledge and understanding concerning biases and consequences from changes made in each organisation. This means identifying opportunities and arenas where parties can share and adjust beliefs and values so that mutual knowledge sharing can take place. I also mean bridging different interrelating theoretical and practical perspectives of technology, ICT, organizational theory and psychology.

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A METHOD TO STUDY THE MANAGEMENT OF URBAN DEVELOPMENT PROJECTS

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Abstract
The management of urban development projects in the Netherlands has changed significantly in recent years. These projects have become mainly 'led' by developers as they manage the entire life cycle of development projects, while public actors mainly facilitate development projects. This changes the way projects are organized and managed and might resolve in different outcomes. Therefore, this research aims at understanding the roles of public and private actors in private sector-led urban development projects and aims at determining the effects of their cooperation by conducting empirical research in different contexts. This paper provides a method for academic scholars to study the management of urban development projects, as management has been underestimated in theory as a way to influence project outcomes. A conceptual steering model is introduced which provides opportunities to describe, analyze and compare complex urban development cases. Furthermore, empirical findings from case studies in the Netherlands and England are presented and compared with each other to indicate how the conceptual model can be used.

Keywords: Conceptual Steering Model, Management, Urban Development, Method, Cases

INTRODUCTION

The way public and private actors influence the outcome of urban development projects has changed fundamentally in the last decade. By adopting more neoliberal principles throughout the European continent and subsequently Dutch society and spatial planning, the private sector gradually gained more influence over development projects. Daamen (2010) argues that 'governments have found themselves not above but between the other actors concerned, signifying a definite shift in their power to enforce and regulate particular land-uses and planning activities.' Thus, private actors, civic groups and public bodies have all become participants in the process of improving the way land is being used and developed.

It is increasingly acknowledged that this shift also affects the roles, relationships and management opportunities of public and private actors in urban projects. These projects have increasingly become 'private sector-led' as developers apply all sorts of management activities in the entire life cycle of development projects. Public actors mainly facilitate these projects by using public management tools to influence project outcomes. In this regard, Adams & Tiesdell (2010) argue that planners could be more conscious about their role as they already operate in the interest of market actors. In their view public bodies heavily rely on market investment, with the result that planners should effectively use tools at their disposal to implement public planning policies through projects. Thus, boundaries between what is 'state' and what is 'market' evaporate as both actors have become dependent on each other to develop cities and urban areas. It doesn't really matter who is who, but how planning can be implemented, or projects can be influenced.

In addition to this trend, many authors (De Zeeuw, 2007; Van Rooy, 2009) argue that Dutch urban development practice is characterized by a growing sense of ineffectiveness and inefficiency. They argue that legal and organizational arrangements could assist in solving the implementation problem. However, Van Aken (2004) and Klijn (2008) argue that it is often the actors' management of projects which makes a difference in achieving successful outcomes of projects. Nevertheless, the management of urban projects often has been overlooked in academic literature as a way to realize public and private objectives. Therefore, we focus our research on how actors can influence the outcomes of private sector-led urban development projects. Here, we use the steering paradigm applied by De Leeuw (2002) to the business management domain, which sees management as 'any form of influencing'. This is further explained in the conceptual model section.

Thus, the problem of the research is that there is limited scientific and practical understanding about how public and private actors cooperate within private sector-led urban development projects. Therefore, the research objective is to analyze organizational and managerial roles of public and private actors on a project level with the aim to design conceptual roles of public and private actors in Dutch urban development practice. Than, the main question the research tries to answer is: *what are the preferable roles of public and private actors cooperating in private sector-led urban development projects in the Netherlands?* In this paper a conceptual model is introduced that enables us to analyze these development projects, followed by the empirical findings from Dutch and English private sector-led projects. Finally, we compare and draw lessons from these practices.

THEORETICAL BACKGROUND

In order to answer the research question above, we need a conceptual model. For this research we developed a *conceptual steering model based upon the systems approach*. According to Arbnor & Bjerke (1997) the systems approach is characterized by a way to view (part of) reality as being a system. We use the systems approach to understand the mechanisms underlying the cooperation of public and private actors in order to design roles for public and private actors cooperating in private sector-led urban development projects.

Management based on the Systems Approach

De Leeuw (2002) has applied the systems approach to the field of business administration. This approach is suitable for studying urban development projects as well as this is also a goal-oriented interaction-driven discipline where actors intend to achieve individual and common goals by collaborating in urban development projects. Here we emphasize that the model is used at a project level which forms the subject of study. Hence, we are not interested in describing the complex and dynamic nature of urban development. We aim at understanding the cooperative mechanisms that take place on a project level but recognize that this is influenced by a complicated set of factors and conditions. Furthermore, by using such a structured device we are able to systematically analyze and design actor's roles within urban development projects. Thus, the model provides opportunities to prescribe solutions for problems as insight is given into relevant mechanisms underlying these problems.

Here, we must explain our view of management within the systems approach which builds upon a *steering paradigm*. Steering according to De Leeuw (2002) is defined as 'any form of direct influencing'. A steering paradigm than is a 'collection of concepts of thought about

steering and the way these can be used to make representations and models for analysis and design.' This view on steering is based on some key principles. First of all, De Leeuw distinguishes three important dimensions in steering projects; uncertainty, unpredictability and ambiguity. These dimensions are also present in urban development projects and need to be dealt with in an accurate way which depends on the changing conditions and aims of projects in specific contexts. Secondly, De Leeuw (2002) supports the contingency theory as he states that: 'There is no universally effective way of managing, the appropriate way to manage is dependent on the circumstances'. Van Aken (2002) also argues that the actual management of projects is not the objective of academic management research as this is the domain of practitioners. Academic research should try to develop useful products and models to analyze and design conceptual 'exemplars for implementation'. Finally, steering is based on three dominant aspects of managing projects; achieving objectives with people, steering a course, and problem solving and designing solutions. This is in line with our research aim.

Conceptual Steering Model

For this research we use a *conceptual steering model* based upon the *systems approach* which is represented in Figure 1. In order to understand this model some key principles need to be elaborated. First, the project *context* represents the different levels of surroundings a certain empirical object of study is part of, a context that is often subject to change. Applied to the domain of urban development the project's context for example exists of spatial policies or economical circumstances which are viewed as conditions for the way urban development projects can be organized. Second, the *organizational system* represents different aggregation levels of organizational structures, formal and informal partnerships, relationships and roles. Applied to the domain of urban development this organizational system consists of actors and the way they organize the public-private cooperation of a project. Third, the *processing system* is the subject of study. In our case this is an urban development process that needs to be managed by actors who organized themselves in an organizational system.

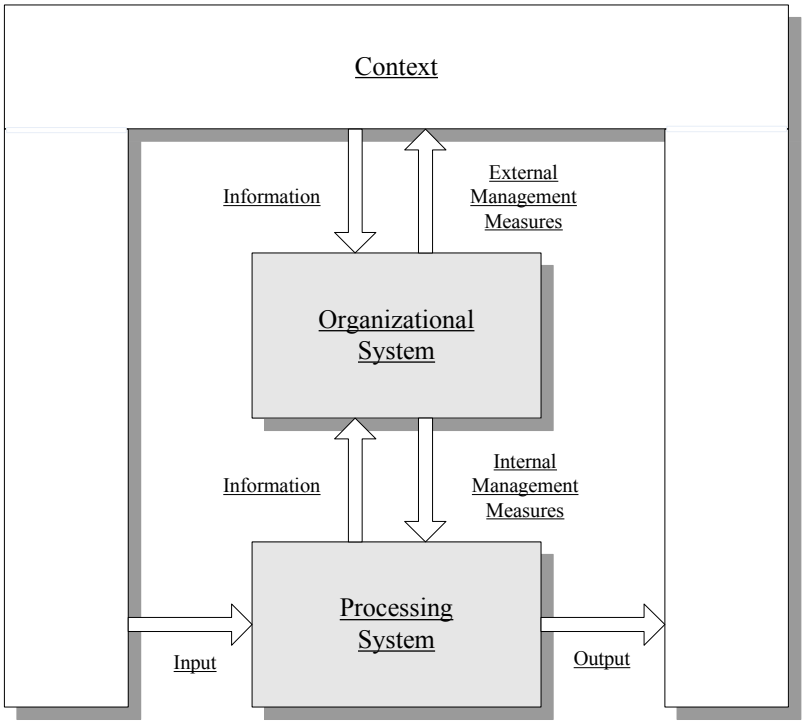


Figure 1: *Conceptual Steering Model based on the Systems Approach (De Leeuw, 2002)*

Furthermore, there are relationships between these three major components, which reflect the dynamics that exist in projects. For instance, a changing context has an impact on planning and development processes, which than is considered as *input*. For instance, changes in economical circumstances changes the way processes can be managed; i.e. the planning for delivering houses will be adjusted according to a changed customer demand. *Information* on changing processes than is 'send' to project organizations, who sometimes adjust their organizational arrangement to cope with the changes. This adjustment can be effectuated by different *management measures*, which are categorized as internal and external management measures. Internal management measures are aimed at influencing the objectives of the project itself, while external management measures are used to influence the project surroundings. For instance, internal management measures eventually are used by actors to realize an *output* or effect of the project. In urban development projects this can be the adaptation of a functional program that is more in line with contextual demands. External management measures can be used by public and private actors for instance to persuade political leaders to politically support the project. Despite the fact that some contextual characteristics are hard to manage, this research analyzes both management measures in order to see how actors are capable of influencing private sector-led urban development projects.

Analysis Aspects & Variables

Thus, this steering model is not a static representation of reality; it rather provides the ability to explain all sorts of mechanisms occurring in projects. In order to analyze and compare cases, however, a choice is made about which aspects are included in the analysis. Here, a brief description of the main analysis aspects is given based on several theoretical insights and categorized into the project's context, organization, management and effects.

In terms of context, three different contextual aspects are analyzed: *economy & politics*; *urban governance*; and *planning system & policies*. Several authors like DiGaetano & Klemanski (1999), Nadin & Stead (2008), and Adams & Tiesdell (2010) amongst others, have in our perspective indicated the importance of several contextual circumstances for actual planning implementation. In this research the economy and politics are described as a way to understand how economic situations and political landscape influences the public-private project cooperation. The urban governance situation is described as a way to understand the relationship between and roles of public, private and civic institutions that influence the project. Planning systems and subsequent policies are described as a way to understand the influence of legal rules and instruments on the project.

In terms of organization, three different institutional aspects are analyzed: *organizational*; *financial*; and *legal*. Bult-Spiering & Dewulf (2002) and Bailey et al. (1995) argue that these institutional aspects are in place in public-private cooperation and determine the inter-organizational roles of actors within different development stages of projects. In this research, organizational aspects that are analyzed are tasks and responsibilities, the financial aspects that are risks and revenues, the legal aspects are requirements and rules. Hence, all these aspects can influence actor's management opportunities in projects.

In terms of management, four different types of management measures are analyzed: *project management* activities; *process management* activities; *management tools*; and *management resources*. Here, we follow scholars like Black & Porter (2000) who indicate that management is 'getting things done with people', and De Leeuw (2002) who refers to different management measures which actors can apply to reach objectives. In this research,

project management activities are related to development stages through which influencing takes place, which are initiating, designing, planning and operating. Process management activities are related to the interaction between actors necessary to develop projects, which are negotiating, decision-making and communicating. Management tools are related to planning tools (see Adams et al., 2005) used by public bodies to influence developments, which are shaping, regulating, stimulate and building capacity. And management resources are related to the necessary assets for development, which are land, capital, and knowledge. All these management functions can be used by actors to influence the outcome of projects.

In terms of effects, three different project aspects are analyzed: *effectiveness*; *efficiency*; and s*patial quality*. These effects are important for determining the output of private sector-led urban development projects in relation to the stated ineffectiveness and inefficiency of Dutch urban development. Effects are measured qualitatively by asking interviewees to indicate whether or not these effects are realized. Effectiveness is the degree to which public and private actor's intended objectives are met. Efficiency is the extent to which public and private actors' cooperation takes place against a minimum use of time and costs. And spatial quality is the degree to which the development project satisfies user, experience and future values of the public and private actors involved.

METHODOLOGY

Hence, this research is a combination of descriptive and prescriptive research. Within the descriptive part, we use qualitative *case study methodology* to collect, analyze, and compare research data. Here we follow Yin (2003) who argues that a case study is 'an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident.' Hence, this is very suitable for the purposes of our research: a case study provide opportunities for management research as it is interested in the comprehension of the 'meaning of action' and data refers to the 'essences of people, objects or situations' (see Miles & Huberman, 1994).

Therefore, to create an understanding of private sector-led urban development projects Dutch and English cases are *described*, *analyzed* and *compared*. In the Netherlands, twelve cases of the concession model, which can be seen as the Dutch form of private sector-led projects, have been conducted. In England, two inner city mixed-use development projects 'led' by developers have been analyzed. The methods used to collect the data are literature reviews, document reviews, interviews and field work, which enables us to triangulate the data as different sources are used to collect them. The analysis of data has been structured by the conceptual steering model, which enables us to compare cases nationally and internationally.

In order to carry out the prescriptive part of this research *lesson-drawing* will be used. Janssen-Jansen et al. (2008) argue that there are three levels of transfer of lessons: inspiration, learning, and transplantation. As the objective of this research is to draw lessons from development projects in different countries and to use these lessons to create a design, our level of transfer will focus on inspiration and learning and not transplantation. Attempts have to be made to formulate context-dependent and context-independent lessons. In order to design the preferable roles, we follow the *engineering design methodology* presented by Dym & Little (2008) which consists of making a conceptual design, testing a design, and making a final design. The design is tested in an expert meeting to validate the design parameters.

DUTCH CASE STUDY FINDINGS

This section contains the case study findings from twelve Dutch private sector-led (concession) urban development projects. The main question we answer is: *How do public and private actors manage Dutch private sector-led urban development projects?*

Empirical Findings

Table 1 gives an overview of the twelve Dutch cases that have been analyzed in this research, which shows the variety of characteristics. These cases have been described and (cross-) analyzed on the basis of the components of the conceptual steering model: organization, management and effects. Hence, in this paper we focus on describing and analyzing the management component of projects.

Table 1: *Case Overview the Netherlands*

City	Project	Location	Scale (ha/acres)	Program (on April 2009)
Amsterdam	Park de Meer	Inner City	14 / 34.6	700 houses facilities
Den Haag	Ypenburg Deelplan 20	Greenfield	5 / 12.4	470 houses
Enschede	De Laares	Inner City	30 / 74.1	450 houses 2.500 m2 retail / 5.000 m2 office
Maassluis	Het Balkon	Greenfield	22 / 54.4	1.000 houses facilities
Middelburg	Mortiere	Greenfield	100 / 247.1	1.500 houses 3.000 m2 office / golf course
Naaldwijk	Woerdblok	Greenfield	30 / 74.1	900 houses
Rotterdam	Nieuw Crooswijk	Inner City	30 / 74.1	500 houses
Tilburg	Koolhoven	Greenfield	100 / 247.1	2.000 houses facilities
	Stappegoor	Inner City	50 / 123.6	1.100 houses / sport facilities / cinema 5.000 m2 retail / 20.000 m2 office
	Wagnerplein	Inner City	10 / 24.7	600 houses / parking 9.000 m2 retail / 60.000 m2 office
Utrecht	De Woerd	Greenfield	17 / 42	500 houses
Velsen	Oud IJmuiden	Inner City	12 / 29.7	350-650 houses

Management

The management of private sector-led urban development by both actors has not been mentioned in literature. Already we indicated that several management measures can be used to influence the outcome of development. Table 3 gives an overview of how these management measures are divided among or between the actors in the Dutch empirical cases.

Table 2: *Empirical Management of Public & Private Actors in Dutch cases*

Management Measures	**Management Functions**			
Project Management	Initiating	Designing	Planning	Operating
	Both	*Private / Both*	*Private*	*Public*
Process Management	Negotiating	Decision-making		Communicating
	Both	*Both*		*Both*
Management Tools	Shaping	Regulating	Stimulating	Capacity Building
	Public	*Public*	*N/a*	*N/a*
Management Resources	Land	Capital	Knowledge	
	Private	*Private*	*Private*	

In terms of *project management* activities, the cases show that local authorities in majority initiate the projects. Thereby, they establish spatial requirements for development and thus are able to influence the project characteristics. Designing plans as mentioned primarily is a private task but in more than half of the cases this management activity is carried out by both actors. Planning as management activity is a way for private actors to influence the profit margins and speed of development. Hence, the operation and maintenance of the project after delivery in all cases becomes a public task. Therefore, at the start of projects they can influence public space characteristics as they become the owner.

In terms of *process management* activities, the cases show that negotiating, decision-making and communicating are management measures that are carried out by both actors. Thus, both actors have opportunities to negotiate the incorporation of public and private objectives into the project at the initiative, design and realization stages. Furthermore, both actors influence developments based on internal or inter-organizational decision-making processes. Communicating as a management activity often is structured by different meetings and legal approvals of plans during the process. However, communication processes have influenced the development progress negatively. Public project leaders do not all have the competencies to align different municipal departments. Furthermore, developers not all seem to be aware of how to communicate with other stakeholders like local communities. Hence, housing associations in some inner cities played a key role in creating support from local residents.

In terms of *management tools*, the cases show that shaping and regulating are the main management measures used by public actors to influence development. They use indicative spatial plans and public briefs as management tools to shape developments. Furthermore, public actors use land-use plans, quality and visual conditions, and other contractual agreements to regulate development. Sometimes these briefs, plans, and conditions are highly detailed and inflexible, which results in minimum freedom for private actors to design and innovate. Hence, Dutch public actors do barely use stimulating or capacity building

management tools to influence the outcome of development. Some local authorities used subsidies to financially stimulate development, but building capacity by involving relevant stakeholders to create social or political support does not occur in the cases.

In terms of *management resources*, the cases show that land, capital and knowledge are mainly used by developers to influence development outcomes. Private land ownership on some of the greenfield sites was used a powerful resource for development. However, brownfield sites were hardly characterized by private land ownership. But as most of the developers performed the land acquisition they were able to influence development at their own interest. Hence, some of the local authorities performed the land acquisition and development in stead of developers. Thereby they managed the time and price of the land sale to developers, but at the same time created an unclear role division between the actors, undermining the principle of concessions. Capital for development was primarily managed by developers, however, their influence was limited as most of them depended heavily on bank loans. Knowledge about local market demand and project marketing mainly were a management measure used by private actors.

Conclusions

On the basis of the Dutch cases, it seems that both actors still encounter difficulties to cooperate in accordance to private sector-led urban development principles. Local authorities in some cases are not completely aware that this type of cooperating implies that they have to management projects differently. Also private actors in some cases are not completely aware that their role also imply that they take on more risks and other responsibilities than they are used to. Therefore, one of the main conclusions is that the private sector-led urban development practice in the Netherlands is not (yet) characterized as a mature way of public-private cooperation, as several problems and misconceptions still exist. In order to design future public and private roles, we need to create a better understanding of the phenomenon of private sector-led urban development by broadening our view towards foreign practices.

ENGLISH CASE STUDY FINDINGS

This section contains the main case study findings from two English private sector-led urban development projects (see Figure 3). The main question we answer here is: *How do public and private actors manage English private sector-led urban development projects?*



Figure 3: *Aerial views Bristol Harbourside and Liverpool One*

Empirical Findings

Table 4 gives an overview of two English private sector-led urban development projects that have been analyzed in this research on the basis of the components of the conceptual steering model: organization, management, effects. Hence, in this paper we focus on describing and analyzing the management component of projects.

Table 4: *Case Overview England*

City	Project	Location	Scale (ha/acres)	Program	
Bristol	Harbourside	Inner City	8 / 20	Total space	119,000 m2
				Office	45,000 m2
				Housing	44,000 m2
				Leisure/hotel	30,000 m2
Liverpool	One	Inner City	17 / 42	Total space	234,000 m2
				Office	3,250 m2
				Housing	500 units
				Leisure/hotel	ca 30,000 m2
				Retail	130,000 m2

Management

In terms of *project management* activities, the cases show that both public actors initiated the project as they were part land owner of sites; no unsolicited development proposals of private actors were handed in. Thereby local authorities were able to influence development at the merits of the projects as they set the ambition. However, developers were able to influence the project outcome by designing and planning activities, as development schemes and project planning are private matters. Hence, by operating development the developer in Liverpool was able to set 'private' requirements for the project at earlier development stages. In conclusion, project management activities in both cases mainly are private sector-led.

In terms of *process management* activities, the cases show that a lot of interaction between the actors takes place. Influencing mainly takes place in negotiations in the pre-realization phase, where public and private objectives are defined and final scheme decisions are made. At a later stage, public influence on project is limited to planning applications for separate buildings or plots which require public planning permission. Hence, communicating to key stakeholders is mainly conducted by developers. Several community involvement and public meetings were organized in which several wishes were incorporated into final schemes. In conclusion, both cases show that process management activities are used by both actors. Public and private actors negotiate and make joint decisions, while private actors in both cases use communicating as a way to incorporate other objectives.

In terms of *management tools*, the cases show that public actors use local plans, area visions and public briefs as tools to shape developments. Regulating development takes place through public instruments like planning briefs, development frameworks, development agreements, section 106 agreements, design guidelines, and even planning permission. In Bristol, the local authority stimulated development by securing public grants for cultural functions which kick-started development. In Liverpool this was not the case. Capacity building was also used by the public actor in Bristol as they facilitated a partnership between

the public and private landowners (the Harbourside Sponsor Group). In Liverpool no such network building relationship activity was used. Thus, the cases show that management tools are mainly used by public actors to influence development.

In terms of *management resources*, the cases show that private actors take the lead and influence development by using land, capital and knowledge. Although local authorities in both cases had substantial landownership, they did not use it as a resource to influence development, as land development was carried out by developers once they acquired it. Capital in both projects was almost solely private investment secured by the developers. In Liverpool, the developer also has an interest as a real estate financer. Also knowledge about market demand and development concepts was a private management resource. Developers had a variety of in-house specialists or hired specific consultants to give advice about different subjects. Thus, resources were private sector-led ways of influencing development.

Table 5 shows which empirical management measures have been used by public and private actors to influence English private sector-led urban development projects.

Table 5: *Empirical Management of Public & Private Actors in English cases*

Management Measures	**Management Functions**			
Project Management	Initiating	Designing	Planning	Operating
	Public	*Private*	*Private*	*Private / Public*
Process Management	Negotiating	Decision-making		Communicating
	Both	*Both*		*Private*
Management Tools	Shaping	Regulating	Stimulating	Capacity building
	Public	*Public*	*Public / n/a*	*Public / n/a*
Management Resources	Land	Capital	Knowledge	
	Private	*Private*	*Private*	

Conclusions

Some general conclusions from these cases are that in terms of context, urban regeneration in England can be considered as politically complex. Both cases show that the changeable nature of urban policies under different political powers also can change conditions for development, which are hard to influence by the actors themselves. In terms of organization the cases have shown that local authorities do not develop themselves, but encourage or establish all kinds of inter-organizational partnerships with other public, private or civic stakeholders in order to create support and raise funds for development. Hence, despite being mostly private sector-led at first sight, the English cases show that local authorities have different and sufficient management measures to influence development, and are aware of how to use them.

INTERNATIONAL COMPARISON

The aim of this research is also to systematically compare development projects in different international contexts. Here, we compare all findings from both empirical private sector-led urban development cases by showing some similarities and differences between all the conceptual model analysis components, presented in Table 7. Hence, we must highlight that this comparison is made on the basis of this research. These cases are not exemplary for áll private sector-led urban development projects in the Netherlands and England. Nevertheless, the table reveals some interesting points from the Dutch and English cases. The influence of the project's context in England seems to be higher than in the Netherlands; especially the political power and changeable policies influence development. Project actors have difficulties to manage these environmental aspects. The organizational role division of private sector-led projects in England seems to be stricter than in the Dutch projects, where public requirements sometimes are formulated in more detail. Management in the Dutch cases are slightly less private sector-led than in England, were local authorities and developers are more aware of how to use management measures at their disposal. The effects show quite some resemblance; effectiveness and spatial quality can be achieved, while efficiency remains difficult as time and budget overruns occur frequently.

Table 7: *Comparison of Dutch and English private sector-led urban development projects*

Aspect	Netherlands	England
Context	Moderate political influence on project	High political influence on project
	Public-private-civic project relations blurry	Public-private-civic project relations clear
	Policies stable, certainty for project	Changing policies, uncertainty for project
Organization	Blurred task & responsibility division	Strict task & responsibility division
	Risks & revenues mainly private	Risk & revenues always private
	Detailed requirements & rules	General requirements / detailed rules
Management	Project management by both actors	Project management by private actors
	Process management by both actors	Process management by both actors
	Public man. tools used unconsciously	Public man. tools used consciously
	Management tools by private actors	Management tools by private actors
Effects	Cooperation generally effective	Cooperation generally effective
	Process hardly efficient	Process hardly efficient
	Spatial quality mostly satisfying	Spatial quality mostly satisfying

CONCLUSIONS: MANAGEMENT LESSONS LEARNED

This paper showed that it is possible to systematically study urban development projects. Here, we explore what management lessons can be learned from both case study findings.

Important to notice is that despite the local authorities taking less risks and responsibilities they are well able to influence or manage development projects. Thus, private sector-led urban development involves a whole set of managing opportunities for local authorities, and not necessarily less management. Hence, they also have the awareness of how to apply these management measures more consistently then is the case in the Netherlands. Furthermore, developers in England, at least in the cases, tend to be more aware of their managerial tasks and opportunities. First, they create more civic support for development by involving local communities and businesses in the design process. Second, they are open for long term commitment to their projects as they, at least in the Liverpool case, apply long term business models in operating the project after delivery, to secure financial returns and minimize risks. Another main conclusion is that, when viewed from a management perspective, both practices do not differ that much in opportunities for both actors to influence projects.

Therefore, one of the main conclusions is that private sector-led urban developments in England can be characterized as a more mature way of public-private cooperation. In summary, we argue that in order to cooperate on the basis of a private sector-led urban development approach, other public and private management attitudes and competencies should be applied to make this type of projects successful in the Netherlands. With these lessons, conditions for designing preferable public and private roles for Dutch private sector-led projects have been established for what will be the focus of the following research stages. However, as the context for urban development has changed dramatically in recent years, we have to take this into account as well when we design these roles. These are some of the challenges that remain in the last stage of this research.

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SUSTAINABLE CONSTRUCTION FOR INDUSTRIALIZED DETACHED HOUSE ROLE OF RESOURCE RECYCLE FACILITY

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Abstract
The objective of this research is to analyze the function and effects of resource recycle facility in a Japanese industrialized detached house manufacturer. First, this paper analyzes the actual condition of waste disposal before the establishment of resource recycle facility. Secondly, this describes the logistics of the facility, and surveys the actual condition of waste separation with the facility. Thirdly this makes clear of the site fabrication of plaster board, and shows the trial calculation of material flow cost accounting for plaster board. Finally, this discusses the effectiveness of the facility established by house manufacturer itself.

Keywords: detached house, industrialized house, resource recycle, industrial waste disposal, waste separation

INTRODUCTION

The industrialized house is a house which applied an advanced industrial technology to the production. In Japan, the effectiveness of the applied technology has been demonstrated. However, the difference of productivity among construction projects is pointed out (Wu et al., 2008). Construction sites in the central area of Tokyo are small. There are no stock yards at construction sites. A general contractor is starting to adopt a little collection of industrial wastes from small projects (Hamada et al., 2004). The comprehensive logistics for detached house projects is necessary. Moreover, global environment problem has been more important. Some industrialized detached house manufacturers have set up resource recycle facilities for the establishment of resource recycle system.

Objectives

The main objective of this research is to analyze the actual function and effect of resource recycle facility in a Japanese industrialized detached house manufacturer, and to propose the comprehensive and efficient resource recycle system from the standpoint of economic and environmental assessment. This research surveys the kinds of waste separation and their quantities at construction sites to make clear the effort at sites for industrial waste disposal. Then, this surveys the waste separation and the recycle system at resource recycle facility and analyzes the effectiveness of the facility established by house manufacturer itself.

Research Method

This research compares the former industrial waste disposal system and the current industrial waste disposal system with resource recycle facility of house manufacturer M. First, this surveys 4 construction projects as the former system, and makes clear the kinds of waste separation and their quantities at construction site. How to dispose industrial waste outside construction sites is also surveyed. Secondly, this analyzes the operation results of the resource recycle facility built in 2009 as the current system, and makes clear the relation between site fabrication and waste quantity of plaster board. Finally this discusses the role and function of resource recycle facility established by the house manufacturer itself.

WOOD PANEL BONDING STRUCTURE AND CONSTRUCTION METHODS

Wood panel bonding structure

The house manufacturer M in Japan has built the industrialized houses on the basis of Japanese industrialized system. Figure 1 shows the structure of wood panel bonding method by house manufacture M. The structure of house is mainly composed of floor panels, wall panels and roof panels. The panels are manufactured in the factory beforehand, and are joined with glue at construction sites. Nailing and screwing is necessary as a finishing operation. After the shell of the building with the panels is erected, the desired finishes are applied to both inside and outside. On the outside, the plywood is often covered with the siding. On the inside, the fabric is often applied.

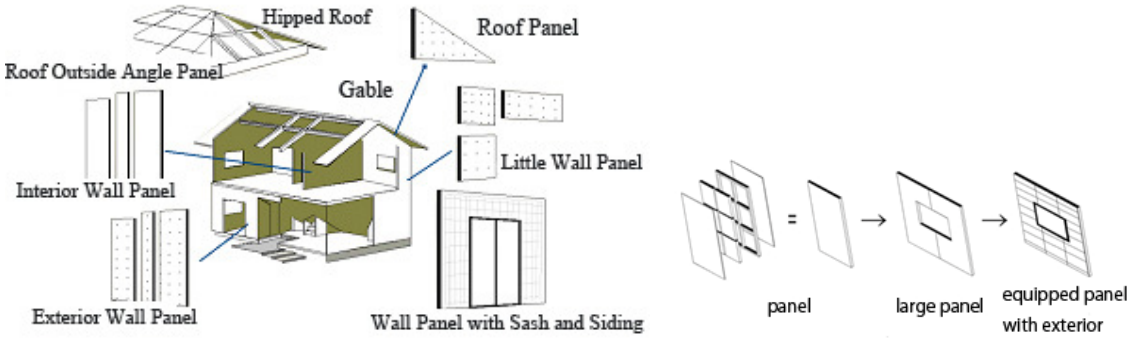


Figure 1: *Wood panel bonding structure*

Factories for wood panels and components manufacturing in Japan

The left in the figure 2 shows the location of factories of house manufacturer M in Japan. They are scattered and covers the whole area of Japan. The survey of delivery of materials from the factories investigates the distance and packing methodology of building components (Kimoto, 2009). The standard number of times of delivery by the house manufacture is 3. The objects in the first delivery are wood panels of main frame. Those in other deliveries are interior and exterior finishing building components.

The right in Figure 2 shows the location of resource recycle facility. It is established in the center of Kanto area which is comprised of 8 prefectures including Tokyo in 2009.

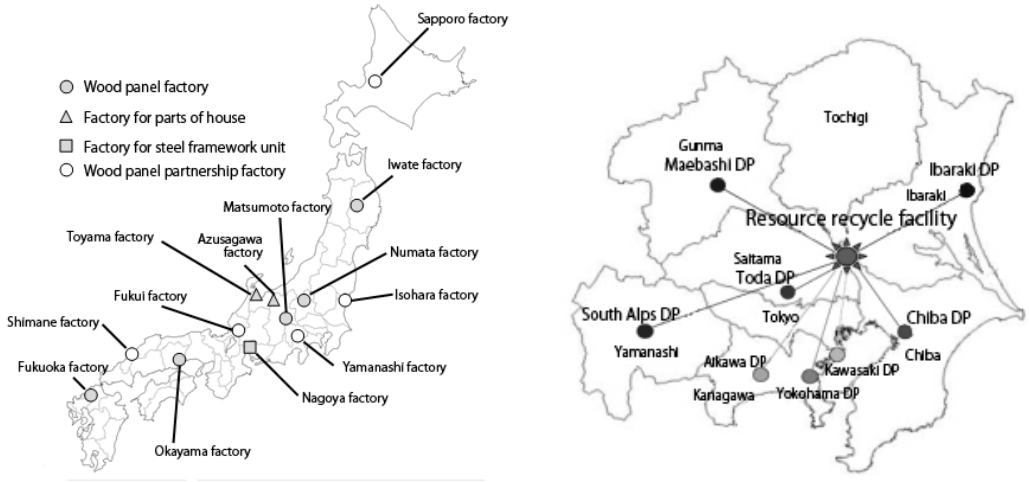


Figure 2: *Location of factories (left) and resource recycle facility (right) in Japan*

Various kinds of construction methods from the standpoint of prefabrication

In the delivery of wood panels, the adoption of pre-assembly at factory is a matter for study. Some projects adopt the pre-assembly of wood panels with the siding at factory. The left in figure 3 shows the pre-assembly of wood panels. The other projects can not adopt the pre-assembly because of small construction sites and narrow access roads. The right in figure 3 shows the delivery of wood panels. They assembled wood panels at construction sites. The adoption mainly depends on the condition of access roads. A big truck cannot run on narrow roads. A crane cannot work on narrow roads. The pre-assembly can reduce the workload at site. The supplies from the house manufacturer are relatively long-distance migration. On the other hand, the elective components by clients are relatively short-distance migration.



Figure 3: *Pre-assembly at Factory (left) and Assembly at Construction Site (Right)*

WASTE DISPOSAL WITHOUT RESOURCE RECYCLE FACILITY

Waste separation at construction sites

The survey of the collection of industrial wastes from construction sites to waste disposal facilities investigates the waste separation and the waste quantity. The survey, based on questionnaire with 25 dealers beyond the scope of resource recycle facility, makes clear the

actual condition of waste disposal. Figure 4 shows the main number of waste separation. They are different. There is one dealer that separates 10 kinds of waste. There are three dealers that don't separate waste at construction sites. There are six dealers that separate 2 kinds of waste. Figure 5 shows the main items of waste separation. Over 70 percent of dealers adopt the separation of plaster board. Nearly half of dealers adopt the separation of chips and shavings, and cardboard.

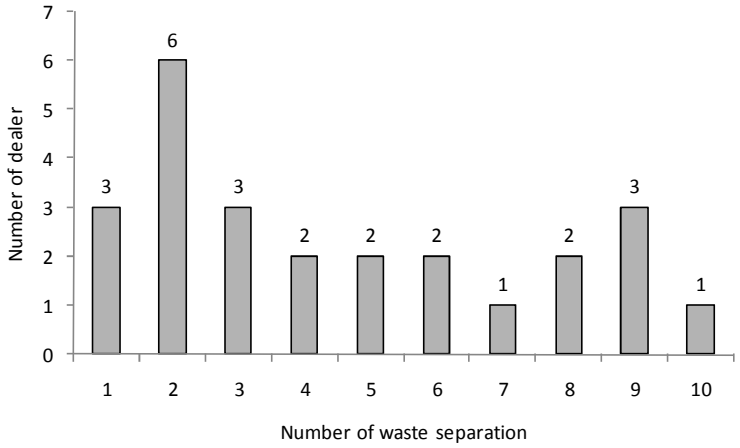


Figure 4: *Number of waste separation*

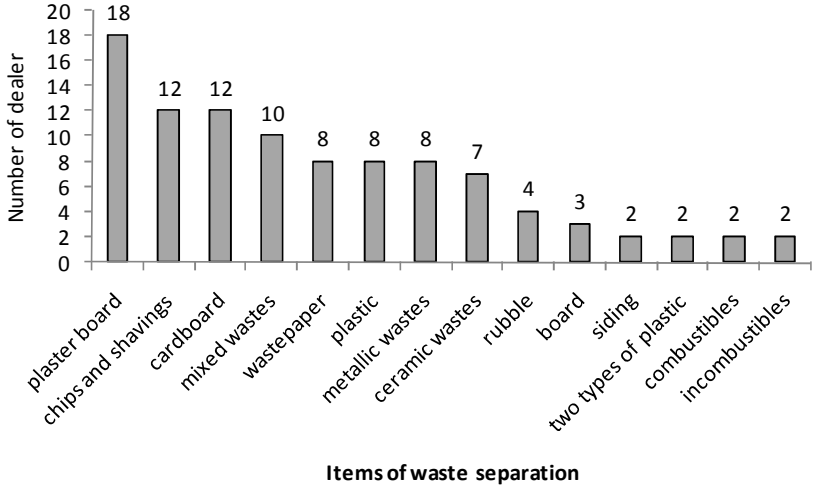


Figure 5: *Items of waste separation*

Volume of industrial waste from construction sites

Table 1 shows the construction projects for survey of industrial waste disposal before the establishment of resource recycle facility. They are located at Tokyo and the neighboring prefecture in Japan. They are detached houses, and wood panel build 2-storied structure. The size of houses is similar. S1 and S2 adopt the pre-assembly construction method of wood panels. M1 and M2 adopt the site-assembly construction method of wood panels. They carry industrial waste to intermediate process facilities. Their function is mainly the separation of wastes and the disposal of some parts.

Table 1: *Construction projects for survey*

Project	S1	S2	M1	M2
Location	Kashiwa City, Chiba, JAPAN	Kashiwa City, Chiba, JAPAN	Kita Ward, Tokyo, JAPAN	Itabashi Ward, Tokyo, JAPAN
Number of Stories	2	2	2	2
Site Area	260 ㎡	150 ㎡	100 ㎡	80 ㎡
Total Floor Area	115 ㎡	120 ㎡	105 ㎡	85 ㎡
Entresol Area	-	-	30 ㎡	20 ㎡
Construction Period	August, 2007 - September, 2007	July, 2008 - September, 2008	October, 2007 - December, 2007	May, 2008 - July, 2008
Structure	Wood Panel Bonding Method			
Site Condition	Good for Construction		Bad for Construction	
Assembly of Wood Panels	Pre-assembly of Wood Panels with Siding at Factory		Assembly of Wood Panels at Construction Site	
Number of Delivery	3	3	3 (Every Day)	5

Table 2: *Waste disposal at construction sites before the settlement of resource recycle facility*

	Number of Separation	Item									Total
		Plastic	Chips and Shavings	WastePaper	Cardboard	Fiber Waste	Plaster Board	Metallic Wastes	Concrete	Ceramic and Glass	
S1	4	-	○ 2.00㎥	○ 5.00㎥	-	-	○ 1.00㎥	-	-	○ 0.20㎥	8.20㎥
S2	5	○ 0.50㎥	○ 6.50㎥	○ 3.50㎥	-	-	○ 0.50㎥	-	-	○ 0.50㎥	11.50㎥
M1	9	○ 0.20 t	○ 0.86 t	○ 0.15 t	○ 0.27 t	○ 0.30 t	○ 1.52 t	○ 0.07 t	○ 0.15 t	○ 0.09 t	3.61 t
M2	6	○ 0.55 t	○ 0.80 t	○ 0.41 t	-	-	○ 1.40 t	○ (Metal) 0.06 t	-	○ (Glass) 1.78 t	5.00 t

Table 2 shows the actual waste separation and waste quantity of 4 projects at intermediate process facilities. The numbers of waste separation are different: 4 in S1 project, 5 in S2 project, 9 in M1 project, and 6 in M2 project. The intermediate process facilities in S1 and S2 measure the volume of industrial waste. The ones in M1 and M2 measure the weight of industrial waste. It depends on their systems. House manufacturers had not made effective use of the results.

RESOURCE RECYCLE FACILITY

Role of Resource recycle facility

In 2009, house manufacturer M established the resource recycle facility by itself. The expected role of the facility is to grasp the actual condition of industrial waste disposal and improve the environmental management system including the logistics and the effective utilization system of resource. It is important to grasp the actual condition of returned goods. The establishment of feedback mechanism about the above information is also important.
The facility adopts the QR code system to grasp the waste separation and waste quantity accurately and quickly. Figure 6 shows an example of QR code attached at construction site for industrial waste. It has the project information. The industrial waste at construction sites are separated to 10 kinds shown in figure 6.

M Co.,Ltd. Wastes Collection System

M Co.,Ltd. branch in ○ ○ ○

Contract number

○ ○ ○ ○ ○ 's house

□ chips and shavings	□ metallic wastes
□ wastepaper	□ ceramic wastes
□ cardboard	□ rubble
□ plastic	□ mixed wastes
□ plaster board	□ unused material

Seal affixed / /

Figure 6: *QR code system at resource recycle facility*

Advantageous effect of logistics by resource recycle facility

Figure 7 shows the before and after comparison of logistics of house manufacturer M. After the establishment of resource recycle facility, 10 ton trucks go around among the distribution center, the deposit center and resource recycle center. 2 ton trucks go around among the deposit center and construction sites. Special common pallets for both the delivery of materials and the collection of industrial waste are used over and over again. As a result, the material flow has rationalized.

Figure 8 shows the ratio of industrial waste collected to the resource recycle facility from May 2009 to September 2010. The ratio of plaster board and ceramic wastes is 26 % and is the highest. That of chips and shavings is 16 %. That of cardboard is 11 %. The ratio depends on the structure and specifications of houses.

Figure 9 shows the time series data of quantity of industrial waste brought from construction sites from May 2009 to September 2010. It also shows the number of commencement of construction. Roughly, the industrial waste is produced a month behind the commencement. Fiscal year of house manufacturer M is from April to March. Therefore, the number of completion of construction increases in September and March.

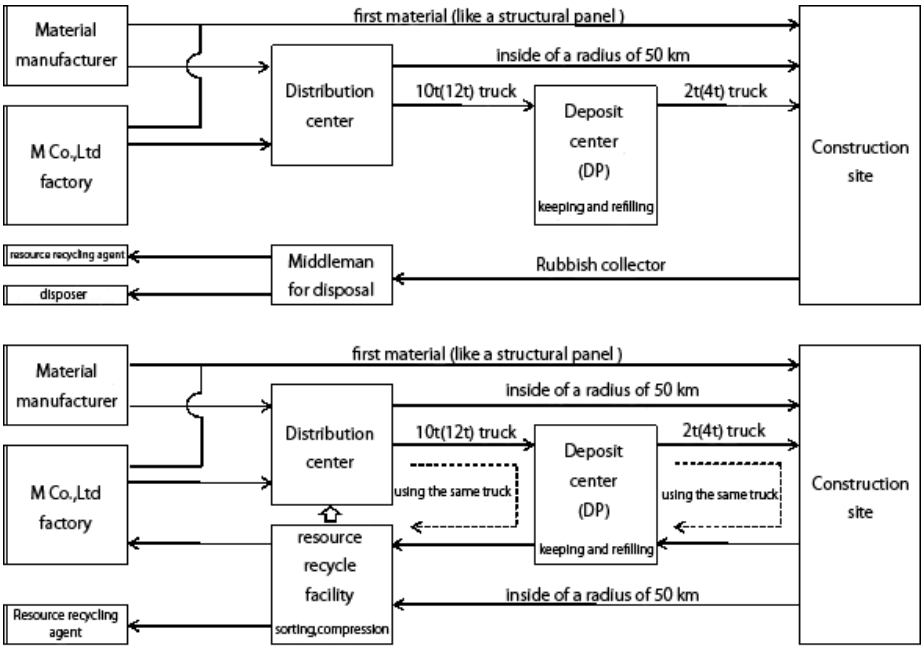


Figure 7: *Change of distribution by resource recycle facility*

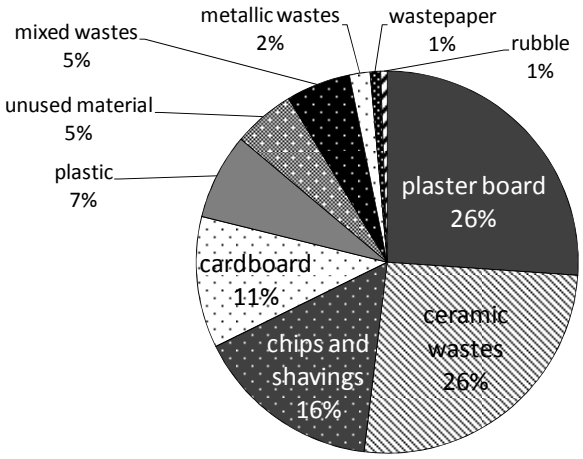


Figure 8: *Ratio of industrial waste from May 2009 to September 2010*

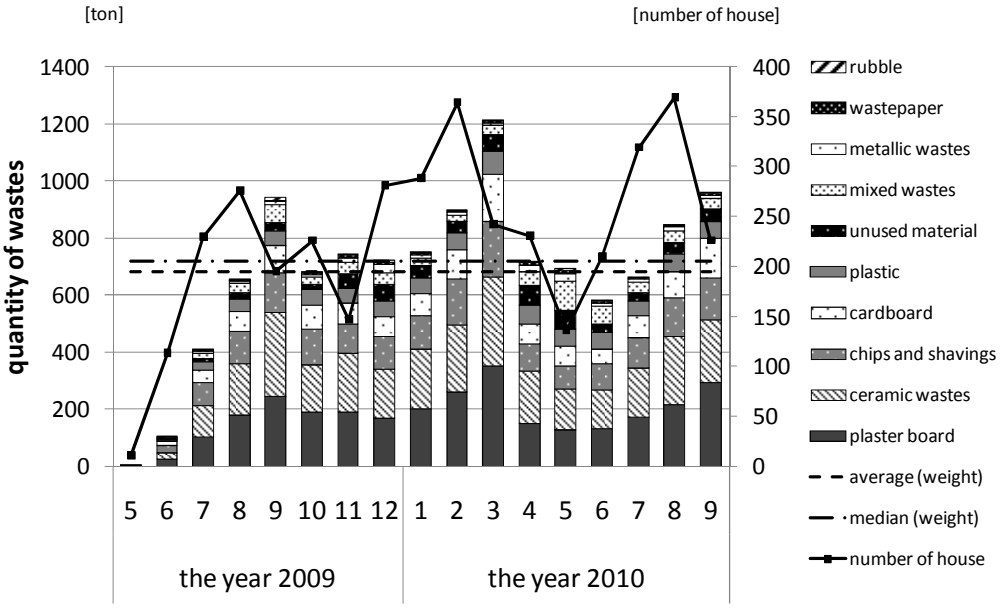


Figure 9: *Time series data of industrial waste brought from construction sites*

Figure 10 shows the industrial waste comparison among construction methods: the assembly of wood panels at site, the pre-assembly of wood panels with sash at factory, and the pre-assembly of wood panels with sash and siding at factory. The higher the ratio of prefabrication is, the less the quantity of industrial waste produced at construction site is. Of course, the quantity of industrial waste produced at factory shows countertrend.

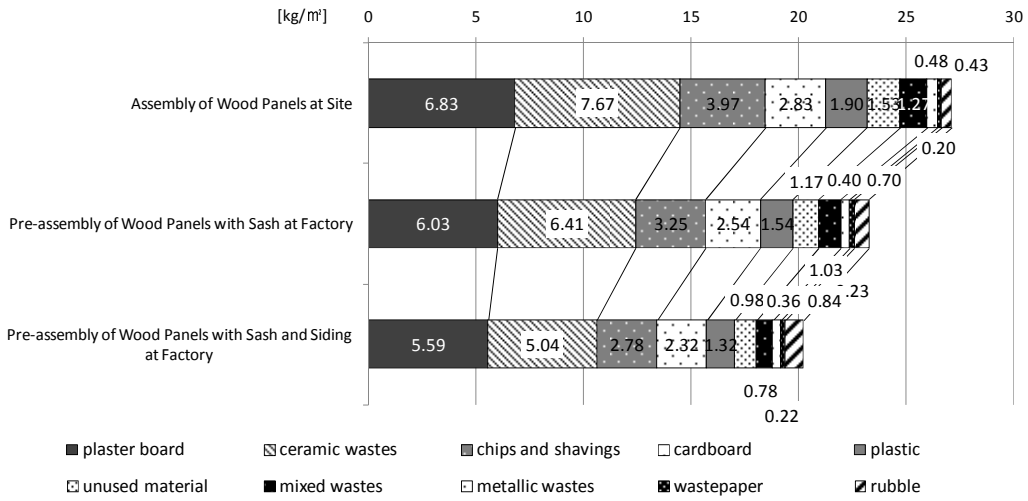


Figure 10: *Comparison of industrial waste brought from construction sites*

WASTE DISPOSAL OF PLASTER BOARD

Plaster board is the highest waste ratio in house manufacturer M. Table 3 shows the outline of construction projects for waste disposal survey. All of them adopt the pre-assembly of wood panels at factory. They are located at Tokyo and the neighboring prefecture in Japan. They are detached houses, and wood panel build 2-storied structure. The size of houses is similar.

Table 3: *Construction projects for waste disposal survey*

Project	S2	S3	S4
Location	Kashiwa City, Chiba, JAPAN	Yotsukaido City, Chiba, JAPAN	Hatogaya City, Saitama, JAPAN
Number of Stories	2	2	2
Site Area	150 ㎡	151 ㎡	152 ㎡
Total Floor Area	120 ㎡	127 ㎡	124 ㎡
Entresol Area	-	-	-
Construction Period	July, 2008 - September, 2008	December, 2009 - February, 2010	November, 2010 - December, 2010
Structure	Wood Panel Bonding Method		
Site Condition	Good for Construction		
Assembly of Wood Panels	Pre-assembly of Wood Panels with Siding at Factory		Pre-assembly of Wood Panels at Factory
Number of Delivery	3	3	3

Cutting of plaster board

The detail of cutting plaster board at construction site in projects is shown: S2 project in Figure 11 and S3 project in Figure 12. The number of cutting plaster board whose waste is the most in S2 project is 4. The average of quantity of waste is 3.15 kg. That in S3 project is 3. The average of quantity of waste is 2.18 kg. The manpower at construction site such as the cutting of plaster board is related to the adoption of precut. Less than 5 times cutting plaster board has a possibility of precut.

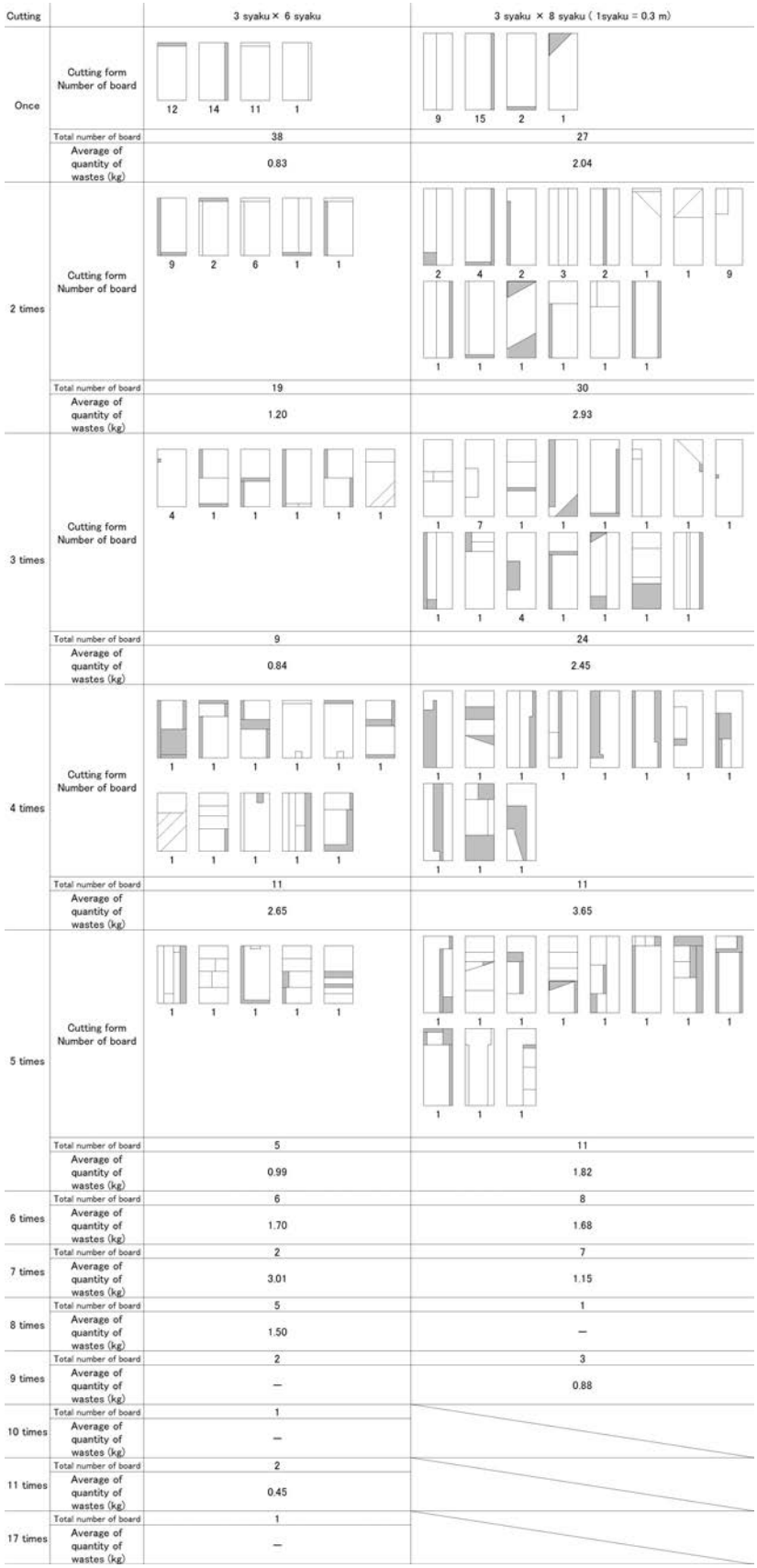


Figure 11: *Detail of cutting plaster board at construction site in S2 project*

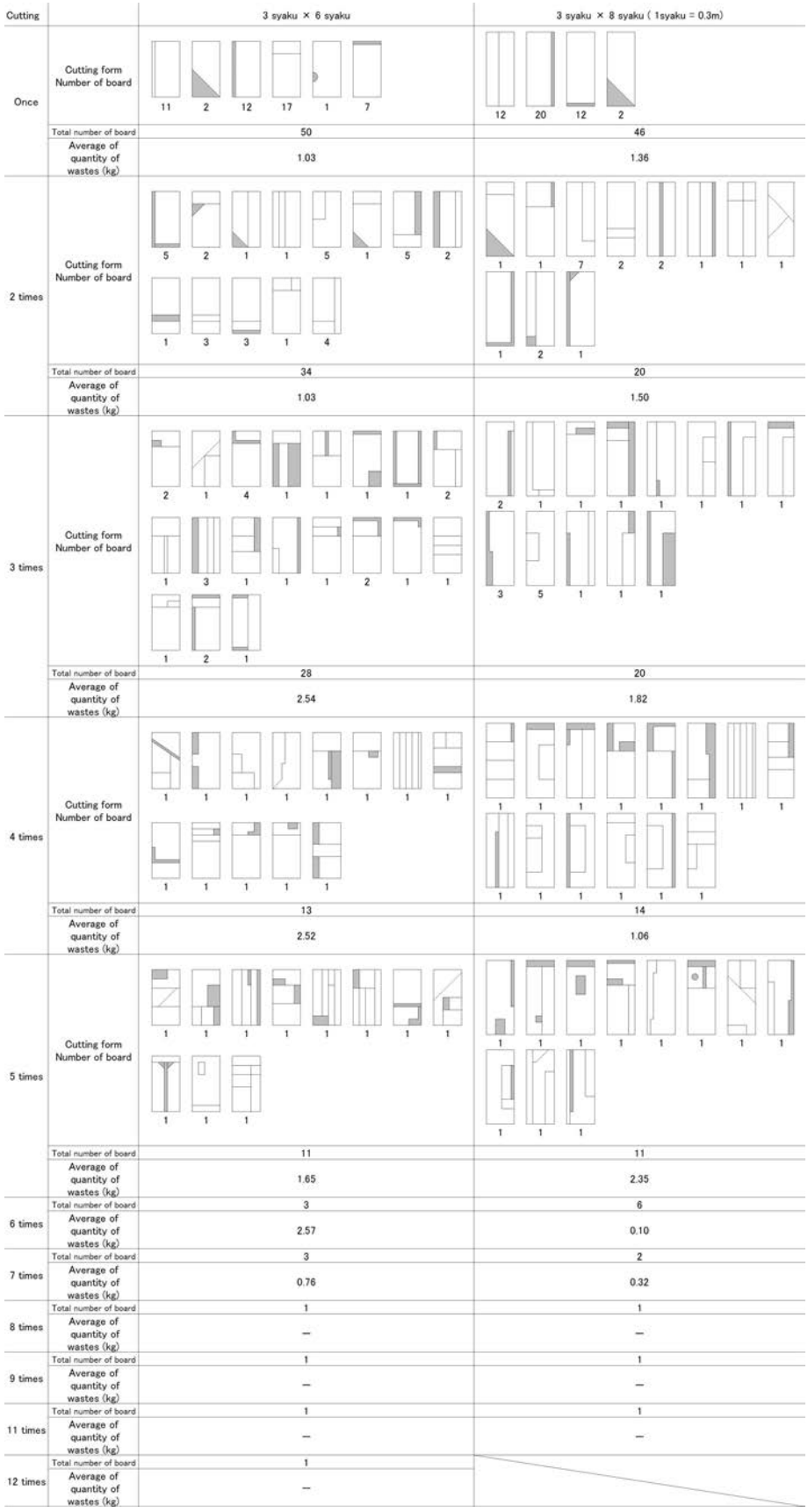


Figure 12: *Detail of cutting plaster board at construction site in S3 project*

Carry-in and carry-out plaster board

The survey weighs the plaster board in projects at the time of both the carry-in and the carry-out. Table 4 shows the result of carry-in and carry-out in S2 project. The weight of carry-in plaster board is converted with the number of sheets. That of carry-out plaster board is weighed directly with a spring scale. The number of carry-in is limited. That of carry-out is scattered. Actually they are stocked at the edge of construction site and carried out at weekly intervals.

Table 4: *Weight of Carry-in (left) and Carry-out (right) Plaster Board in S2 Project*

Month	Day	910mm × 1,820mm (Number of Sheets)	910mm × 2,420mm (Number of Sheets)
8	25	70	0
9	3	40	80
9	8	0	61
9	13	6	0
Total Number of Sheets		116	141
Weight per Sheet (kg)		13.4	17.8
Sub-total Weight (kg)		1,554.4	2,509.8
Total Weight (kg)		4,064.2	

Month	Day	Plaster Board (kg)	Number of Carpenters	Work Area
8	25	74.0	2	Lathing
9	5	18.0	1	1F Wall
9	8	152.0	1	1F Wall
9	9	38.0	1	2F Wall
9	10	123.5	2	1F and 2F Ceiling
9	11	48.0	1	2F Wall
9	12	95.2	2	1F and 2F Ceiling
9	13	51.2	1	2F Ceiling
9	14	13.2	1	1F and 2F Partition
Total Weight (kg)		634.1	12	

Trial calculation with Material Flow Cost Accounting

The cost of plaster board is cheep. The reduction of material cost doesn't become incentive motivation. Material Flow Cost Accounting (MFCA) is an environmental accounting method originally developed in Germany. In addition to the cost of materials, labor cost, and other processing cost are allocated under loss cost, and waste cost is calculated by the same means as production cost. Therefore, waste is called "negative product" in MFCA.

Figure 13 is a trial calculation of plaster board work in project S4 with MFCA. The ratio of negative product is 19.8 %. The cost is 76,630 yen. It is more than three times material cost.

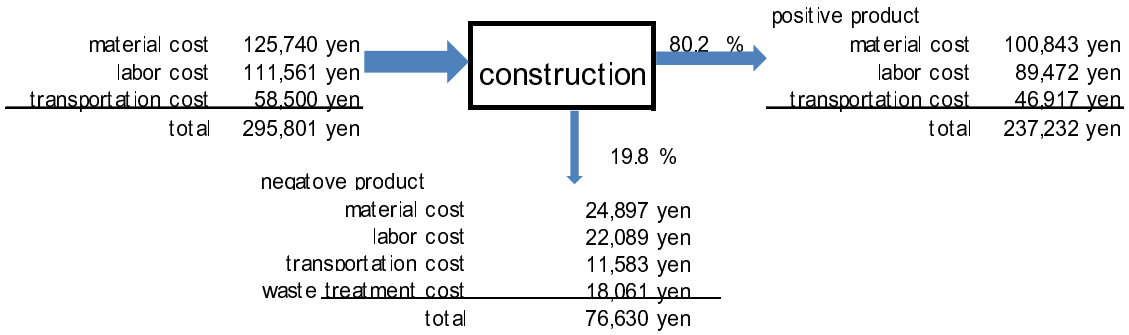


Figure 13: *Trial calculation of plaster board with MFCA*

CONCLUSIONS

The objective of this research is to analyze the function and effects of resource recycle facility in a Japanese industrialized detached house manufacturer.

First, the survey, based on questionnaire with 25 dealers beyond the scope of resource recycle facility, makes clear the actual condition of waste disposal. They are different. There is one dealer that separates 10 kinds of waste. There are three dealers that don't separate waste at construction sites. Over 70 percent of dealers adopt the separation of plaster board. Nearly half of dealers adopt the separation of chips and shavings, and cardboard. There are no systematic methodologies such as the waste disposal data analysis.

Secondly, this survey makes clear the before and after comparison of logistics with resource recycle facility. After the establishment of the facility, 10 ton trucks go around among the distribution center, the deposit center and the resource recycle center. 2 ton trucks go around among the deposit center and construction sites. Special common pallets for both the delivery of materials and the collection of industrial waste are used over and over again. This survey verifies that the material flow has been streamlined.

This survey analyzes the ratio of industrial waste collected to the resource recycle facility from May 2009 to September 2010. The ratio of plaster board and ceramic wastes is 26 % and is the highest. That of chips and shavings is 16 %. That of cardboard is 11 %. Moreover, the higher the ratio of prefabrication is, the less the quantity of industrial waste produced at construction site is. This analysis shows the difference of construction methods.

This survey also shows the time series data of quantity of industrial waste brought from construction sites from May 2009 to September 2010. Roughly, the industrial waste is produced a month behind the commencement. Fiscal year of house manufacturer M is from April to March. Therefore, the number of completion of construction increases in September and March. Moreover, the higher the ratio of prefabrication is, the less the quantity of industrial waste produced at construction site is. This time series data analysis of quantity of industrial waste shows the task of load leveling of resource recycle facility.

Thirdly, this survey makes clear of the site fabrication of plaster board. Four times and five times cutting plaster board produces more waste. The most of waste quantity is 3.65 kg. The manpower at construction site such as the cutting of plaster board is related to the adoption of prefabrication. Less than 5 times cutting plaster board has a possibility of precut. This survey also shows a trial calculation of plaster board work with MFCA (Material Flow Cost Accounting). The ratio of negative product is 19.8 %. The cost is 76,630 yen. It is more than three times material cost. This indicates the importance of rationalization of waste disposal. There is a room for improvement of waste disposal system.

Finally, this paper makes clear the before and after comparison of the establishment of the resource recycle facility by house manufacturer itself. This survey indicates that the load leveling of resource recycle facility and the adoption of construction methods such as prefabrication and precut are worthy of consideration from the standpoint of environment management. After this, the research will survey the detail of waster separation and disposal in the resource recycle facility.

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ANALYSING THE TRANSMISSION PATTERN WITHIN THE FRAMEWORK OF HOUSING SUPPLY AND MONETARY POLICY IN AUSTRALIA

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Abstract

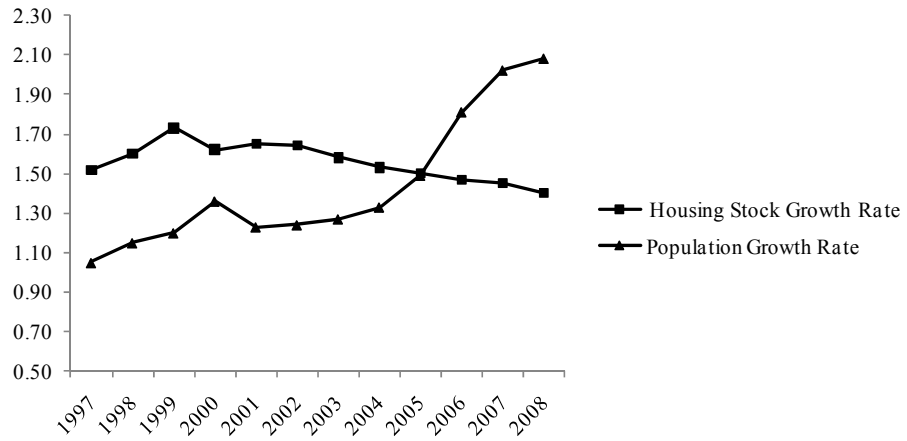
Housing supply is one of important components of the housing sector. Compared with an increasingly strong housing demand, the growth rates of total housing stock in Australia have exhibited a downward trend since the end of the 1990s whilst the significant adjustments in the Australian monetary policy were being implemented. This research aims to estimate the nature of the relationship between housing supply and monetary policy by a vector error correction model. According to the empirical results, a transmission pattern comprised of the indicators associated with housing supply and monetary policy can be identified, which suggests that there is a significant interrelationship between monetary policy and the supply side of the housing sector in Australia.

Keywords: housing supply, monetary policy, transmission pattern, vector error correction model

INTRODUCTION

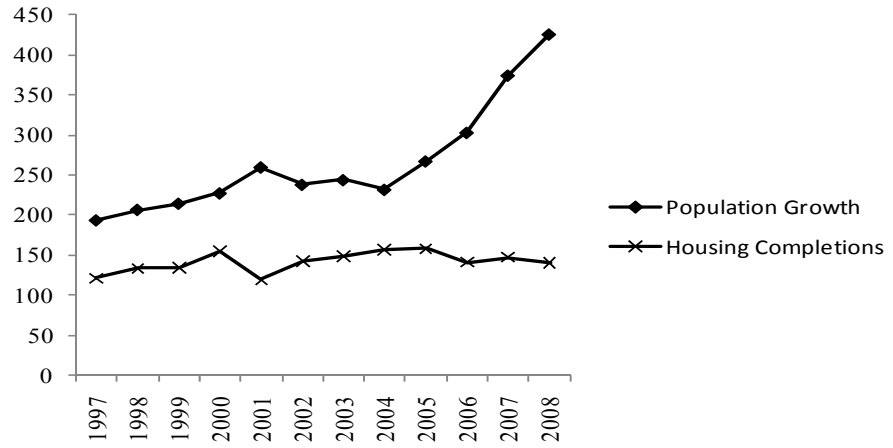
Housing supply is an essential component of the housing sector. However, Australia has been facing a challenge from inadequate housing supply since the 1990s while the demand for housing across Australia was extremely strong. The statistics from the Australian Bureau of Statistics (ABS) indicate that the growth rates of total housing stock have exhibited a downward trend accompanying a dramatic urban population growth in Australia since the 1990s. The movements in the growth rates of housing stock and urban population in Australia are illustrated by Figure 1. Urban economic theory claims that the growth of urban population is an indicator of the increase in housing demand and there should be a steady equilibrium (convergence) relationship between total housing stock and urban population (DiPasquale, 1999).

The housing literature demonstrates that the construction of new housing is a leading source of the increase of total housing stock. In Figure 2, compared with dramatic population growth, the number of new housing completion in Australia were highly stable over the past decade. It is able to be inferred from both Figure 1 and Figure 2 that a divergence between housing supply and urban population has gradually occurred in Australia. In simple terms, currently, the supply of housing can not keep pace with the demand for housing across Australia.



Source: ABS, 2009a

Figure 1: Growth rates of urban population and housing stock in Australia



Source: ABS, 2009a; 2009b
Figure 2: Population growth and new housing completions in Australia

Another statistic data regarding housing finance also indicates that the annual number of the housing mortgage for the purchases of owner-occupied dwelling in Australia increased from 412,032 to 598,566 with the increase rates of 45.3% during the period of 1997-2008 (ABS, 2009e). These data further explicitly reveal that the demand for housing in Australia is increasing. Owing to the strong housing demand and the inadequate housing supply, the annual report of the Housing Industry Association (HIA) argued that a housing shortage of approximately 110,000 had emerged in Australia in 2008 and this problem would be exacerbated in the future (HIA, 2009).

Based on the reports of the Reserve Bank of Australia (RBA), from 1997 to 2008, the growth rates of the money supply in Australia had decreased and there had been a corresponding rise in the interest rates (RBA, 2009a; 2009b). The increase in the interest rates as well as a decrease in the money supply growth rates implies that the Australian monetary policy was adjusted significantly during the period of 1997-2008. RBA's (1999) announcement supported this perspective and stated that the expansionary monetary policy that had been implemented in Australia for a couple of years would be gradually slowed down.

Monetary policy is generally defined as a process by which the central bank or national monetary authority of a country adjusts the interest rates to a target level in economy (McTaggart *et al.*, 2003; RBA, 2007a). It is a key tool for government to regulate economic activities. In housing literature, many researchers have investigated how monetary policy affects housing demand while few empirical studies were concerned with the relationship between the supply of housing and monetary policy. Thus, a research question, 'What is the interrelationship between housing supply and monetary policy?', has emerged. This paper aims to contribute to the literature by developing a conceptual model as well as a methodology to estimate the relationship between housing supply and monetary policy.

The rest of this paper is laid out as follows. Next section will review the relevant literature with respect to the relationship between monetary policy and the housing sector. Then, the *Conceptual Model* followed by the *Methodology and Data* will be described. Finally, the empirical results yielded by the econometric model will be used to analyse the linkage between housing supply and monetary policy.

LITERATURE REVIEW

Monetary policy plays an active role in the governmental interventions on economy. It is considered to be an important tool that bridges policy makers to realistic economic system. Theoretically, monetary policy can affect both the supply of and the demand for housing (Elbourne, 2008).

The response of the housing sector to the shock of monetary policy has been well considered in numerous studies since the 1990s. The econometric technique employed for these studies is either the reduced-form vector autoregression (VAR) model or the sophisticated VAR [e.g. structural VAR (SVAR) and vector error correction model (VECM)]. The early research relevant to the effect of monetary policy on the housing sector in the 1990s is the study by Baffoe-Bonnie (1998), in which a reduced-form VAR was used to analyse the dynamic effects of monetary policy and macroeconomic aggregates on the house prices and the number of houses sold on a national and regional level in the US. The quarterly data on money supply, mortgage rates, house prices and the number of houses sold were selected for modelling. The estimates suggested that monetary policy had a strong impact on the mortgage rates, which in turn triggered immediate responses of the house prices and the number of houses sold in the national and regional housing markets in the US (Baffoe-Bonnie, 1998).

Likewise, in 2004, Edelstein and Sau (2004) studied the relationships among monetary policy, house prices, wealth effect and macroeconomic situations in Singapore by a reduced-form VAR. Using the data on disposable income, interbank rates, real private and public house prices, transaction volume and real public housing wealth measure, the empirical evidence indicated that the shock of the interbank rates negatively affected the disposable income, private and public house prices and public housing wealth in Singapore (Edelstein & Sau, 2004).

Some prior VAR research demonstrated that the model misspecification is more easily triggered in the reduced-from VAR (Bernanke & Blinder, 1992; Sims, 1992). To avoid this problem, more and more studies in the recent decade identified the shock of monetary policy on the housing sector by the SVAR or the VECM. Take the research by Lastrape (2002) as an example, this study examined the impact of monetary policy on the housing market applying the SVAR. The primary interest of Lastrape (2002) was to interpret the response of the prices of owner-occupied housing to the shock of money supply across the metropolitan regions in the US. The results suggested that

both real house prices and house sales were driven up within a short-run period in response to the positive shock of money supply (Lastrape, 2002).

It is noted that Lastrape's (2002) work focused on the influence of monetary policy on house prices on a regional level. However, Aoki *et al.* (2002) investigated this issue within a national context utilising the SVAR as well. The research by Aoki *et al.* (2002) sought to explore the relationship among monetary policy, house prices and consumption level in the UK. It was identified that 0.8% decrease in the house prices in the UK was triggered after the 50 basis point shock of the interest rates within five quarters (Aoki *et al.*, 2002).

In addition to Aoki *et al.* (2002), Iacoviello (2002; 2005) and Iacoviello and Minetti (2008) explored the linkage between monetary policy and housing sector on a national level by means of the SVAR and VECM respectively. In Iacoviello's (2002; 2005) research, six European countries, involving France, Germany, Italy, Spain, Sweden and UK, were considered as an integrated entity to estimate the role of monetary policy in the inflation of house prices. Under the identification scheme of King *et al.* (1991), the results yielded by the SVAR indicated that the house prices would decrease by 1.5% following a tightening of monetary policy. On the other hand, the study conducted by Iacoviello and Minetti (2008) contributed to the literature by uncovering the credit channels of the monetary policies of such four European countries as Germany, Finland, Norway and UK. The results of the VECM suggested that an approximately 0.25% fall of economic output [Gross Domestic Product (GDP)] and 1% drop in house prices were produced by a shock of interest rates.

Recently, a research by Elbourne (2008) emerged to clarify the relationships between house prices and the transmission mechanisms of monetary policy, which include commodity prices, interbank rates, retail sales, price level, money supply and nominal market exchange rates. Empirical evidence from the SVAR suggested that the retail sales in the UK fell by 0.4% after receiving a positive 100 basis point shock of the interbank rates while house prices decreased up to 0.75% in response to 15% of the consumption drop caused by a monetary contraction.

In Australia, the research on the effect of monetary policy on the housing sector is sparse. The empirical study by Liu and Liu (2010) examined the linkage between monetary policy and housing affordability across eight state capital cities in Australia using the SVAR. In this study, the shock of monetary policy was measured by the interbank rates and the money supply (M1), and the housing affordability was associated with the house prices. The results show that the interbank rates triggered -1.28% effects on the house prices across Australia's eight state capital cities while the M1 positively affected the house prices by 1.08%.

It is able to be identified from this literature review that the past studies on the interrelationship between housing sector and monetary policy are primarily concerned

with the impact of monetary policy on house prices, GDP and disposable incomes. These variables are the components of the housing demand function (Quigley, 1999; Hui & Yue, 2006). Summarily, while there is extensive empirical literature on the relationship between monetary policy and the demand for housing, far less has been written about housing supply.

Although the literature in terms of the impact of monetary policy on housing supply is sparse, the history of this type of research can be dated back to the 1950s. An early study is that undertaken by Wolff (1957), which sought to examine the effects of the variation caused by economic characteristics of different regions on the post-war housing market in the US. The focus of this study was on economic disparities rather than monetary policy, however it briefly mentioned that the new housing construction activities in the South and West regions of the US were more sensitive to monetary policy changes than the remaining US regions (Wolff, 1957). In the 1970s, the study by Bebee (1972) divided Canadian housing markets into five regional markets and analysed the effects of economic disparity (measured by inter-regional population flows, interest rate and the household number) on the volume of dwelling unit started for construction by a simple multivariate regression model. The results indicated that monetary policy and population growth had significant influenced the housing starts in all regional markets in Canada.

In summary, the literature review in this section suggests that a number of empirical studies investigated the relationship between monetary policy and the housing sector in the framework of VAR models. Nevertheless, the majority of them concentrated more on housing demand than housing supply. In addition, the previous research by Wolff (1957) and Bebee (1972) did not explore the linkage between housing supply and monetary policy in a comprehensive context, but just discussed this issue in a simple way. The limited research scope in regard to the housing sector and monetary policy provides this paper with an opportunity for further study.

CONCEPTUAL MODEL

To empirically estimate the impact of monetary policy on Australia's housing supply, the first step in this study is to develop a conceptual model comprised of the monetary policy function and the housing supply function. These two functions will allow monetary policy and housing supply to be investigated through a series of relevant economic variables. Figure 3 illustrates the master plan of this empirical research in a simplified manner.

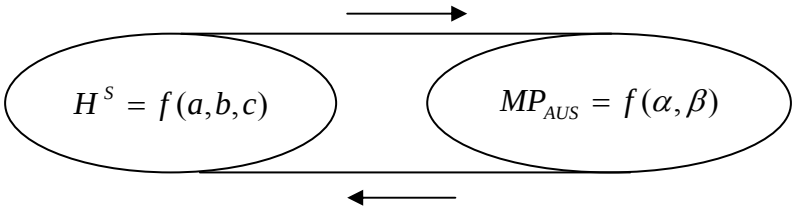


Figure 3: Simplified master plan of this research

Monetary Policy Indicators

In Australia, monetary policy is determined by the Reserve Bank of Australia in accordance with the *Reserve Bank Act 1959*, aiming to control inflation, stable currency, improve full employment and then maintain economic prosperity and people's welfare (RBA, 2007b). The RBA (2007a) stated that an inflation target is the centrepiece of Australian monetary policy.

As a country where the inflation-targeting monetary policy is implemented, the adjustment in interest rates is a key instrument (McTaggart *et al.*, 2003). Thus, interest rate is an indicator of the Australian monetary policy. However, in this research, money supply will be introduced as a variable for modelling because the interest rates and the money supply are inextricably interrelated. In Australia, a single tool left for the RBA after the removal of all direct controls on financial markets in the 1980s to achieve its objective is an open market operation (OMO). The OMO is a method used to adjust interest rates by changing money supply. Hence, employing 'money supply' for the analysis relevant to the Australian monetary policy is rational (Liu & Liu, 2010). The function of the Australian monetary policy can be written as Eq. (1).

$$MP_{AUS} = f(INT, MS) \tag{1}$$

where *INT* denotes the interest rates; and *MS* represents money supply.

Housing Supply Indicators

Quigley (1999) summarised that the supply of housing depends upon the prices of houses and new housing construction activities, thus housing supply is a function of house prices and new housing construction. Hui and Yue (2006) adopted Quigley's (1999) perspectives to study the house price bubbles in China and their empirical results supported Quigley's (1999) housing supply function.

Although the reliability of Quigley's (1999) conceptual model has been validated by Hui and Yue (2006), this function does not include the variable of construction costs. Somerville (1999) argued that construction costs are the endogenous variables of the housing supply function. Liu and London (2011) further proved that residential construction costs and housing supply in Australia are significantly interconnected. Thereby, construction costs should be incorporated in the housing supply function. In some western countries, such as Australia, UK and US, new housing construction should involve the completely new dwelling construction and the addition as well as conversion to established housing. As claimed by Baer (1986), the addition and

conversion to existing housing stock are also essential dynamics on the supply side of the housing sector in a lot of western countries. Therefore, a new housing supply function based on Quigley's (1999) perspective is developed as Eq. (2).

$$H^S = f(HP, Cost, Const^T) \tag{2}$$

where *HP* represents the house prices; *Cost* denotes the residential construction costs; and $Const^T$ stands for the construction of completely new dwelling and the addition as well as conversion to established housing.

Based on the research strategy illustrated as Figure 3, the analysis on the interactions between the endogenous variables in Eq. (1) and Eq. (2) can assist in identifying the interrelationship between housing supply and monetary policy. The interrelationship defined in this study is the causal and dynamic linkages.

METHODOLOGY AND DATA

Methodology

The econometric model used in this study for estimating the causal and dynamic relationships between housing supply and monetary policy is a vector error correction model. The VECM is useful for identifying the causal and dynamic links between the variables (Dinda & Coondoo, 2006; Liu & London, 2010).

The VECM was proposed by Engle and Granger (1987) through integrating the autoregressive and error correction representations into co-integrated systems. It is a vector autoregressive model with co-integrated restriction and error correction term. One of the most purported advantages of recognising co-integration in the VAR system is the improvement in forecasting performance (Engle & Yoo, 1987). The form of the VECM (*p*) is able to be represented as Eq. (3) and (4).

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{3}$$

$$\Delta Y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{4}$$

where ΔY_t is a *k*-dimensional vector in difference; $ecm_{t-1} = \beta' Y_{t-1}$ denotes the error correction term; Γ_i is the coefficient matrices; and ε_t is a vector of error term.

The causal and dynamic relationships between the variables can be detected by the Granger causality test and the generalized impulse response function under the VECM. The Granger causality is a concept proposed by Granger (1969) in the 1960s and Sims (1972) developed the test for this causality depending upon the VAR model. The Granger causality test is utilised to examine whether or not the lagged values of a

time-series variable *X* have explanatory power for the other time-series variable *Y*. If the changes in the *Y* can be explained by the lagged information of the *X*, it is concluded that *X* Granger-cause *Y*.

The impulse response function (IRF), on the other hand, is a technique used to trace the dynamic effect of a shock of the error term of an endogenous variable to other endogenous variables in the VAR or VECM. Koop *et al.* (1996) developed the traditional IRF and devised a unified method to impulse response analysis which is applicable to both linear and nonlinear models. This is the generalized impulse response function.

Data Collection and Description

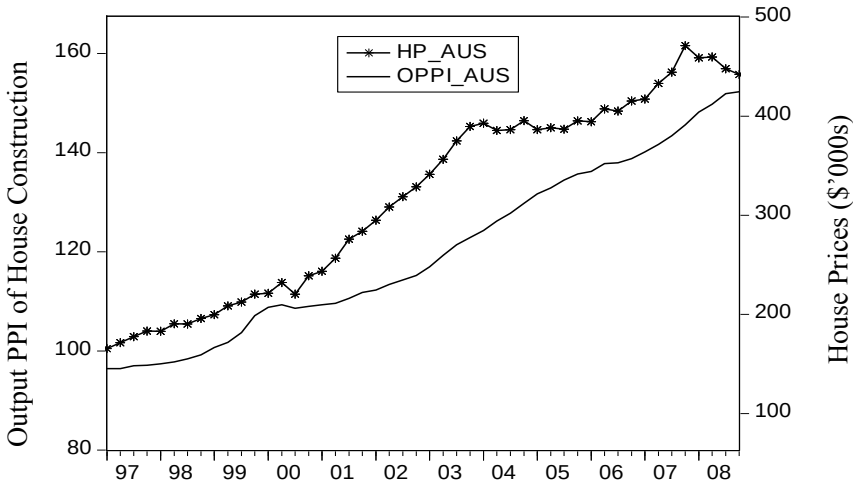
For the purpose of estimating model, the data were extracted from several reliable sources. Firstly, the house prices selected in this study are the median house prices (HP), which are published by the Real Estate Institute of Australia (REIA).

Secondly, the output producer price indexes (OPPIs) of housing construction will be employed as the proxy for residential construction costs. The output PPIs of housing construction are issued by the ABS. It is an index measuring the rates of changes in the costs (labour input costs, plant and material input costs) throughout the procedure of housing production (ABS, 2005; 2010a). In addition, new housing construction will be measured by the housing approvals (HA) published by the ABS as well. Housing approvals reflect the total number of dwelling (house and other residential buildings) approved for construction in given periods. The data on the output PPIs and the housing approvals include the information about the construction of new dwelling and the addition and conversion to established housing (ABS, 2009d; 2010a).

Finally, in the monetary policy function [Eq. (1)], interest rates and money supply are two endogenous variables. Therefore, the interbank rates (INT) and the M1 are the ideal data for measuring these two variables (Elbourne, 2008; Liu and Liu, 2010). The interbank rate is the rate of interest charged on the loan made between banks and it is the operation target of RBA's monetary policy adjustments (RBA, 2001). Moreover, the M1 is the total amount of currency and current deposits of private non-bank sector (RBA, 2009b). Both the interbank rates and the M1 are provided by the RBA.

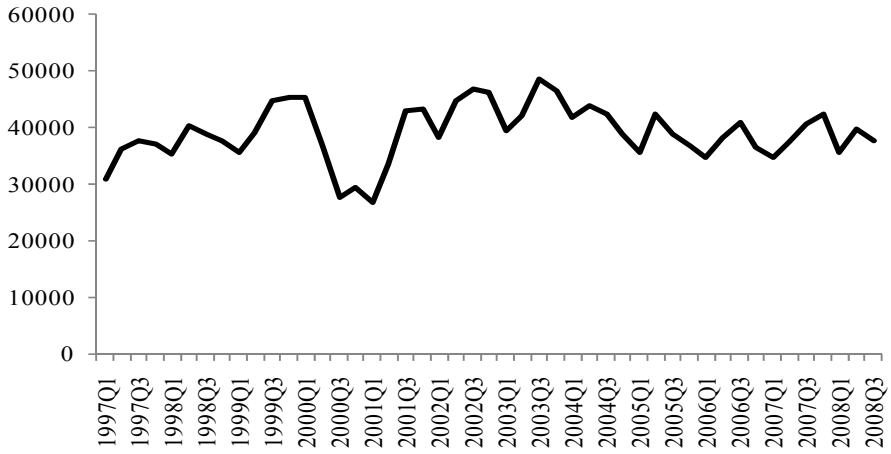
According to the statistics from the REIA (2009) and the ABS (2009a), the house prices and the output PPIs in Australia had dramatic movements during the period under study. Figure 4 illustrates the changes in the house prices and the output PPIs between the January quarter of 1997 (1997Q1) and the December quarter of 2008 (2008Q4) in the Australian housing and construction markets. It is discovered that the output PPIs of housing construction increased from 96.4 to 152.3 with the increase rates of 58% from 1997Q1 to 2008Q4. Meanwhile, the house prices also maintained an upward trend and achieved a peak of AUD 471,200 in 2007Q4. Then the median house prices began to move down and decreased to AUD 442,000 in 2008Q4. In

addition, Figure 5 indicates that the moving trend of the housing approval in Australia was stable. The average quarterly number of new housing (completely new dwellings and the units produced by the addition and conversion to established housing) approved for construction in the sample period was approximately 38,000.



Source: ABS, 2010b; REIA, 2009

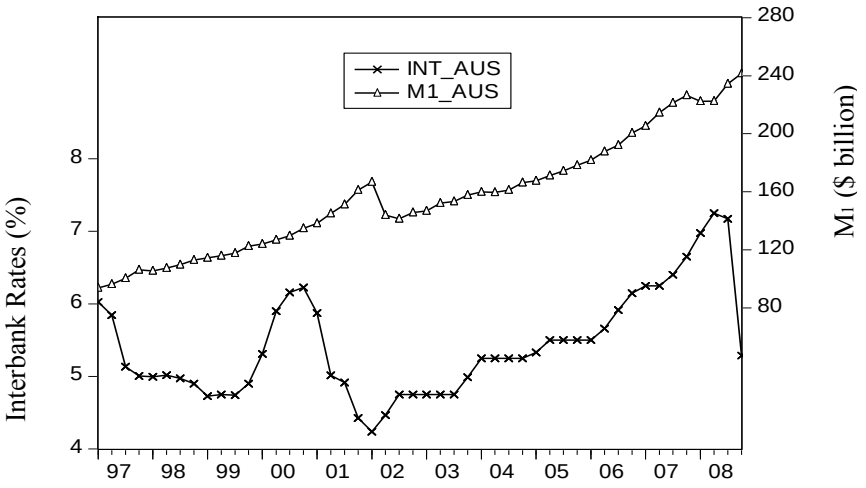
Figure 4: House prices and output PPIs of housing construction in Australia



Source: ABS, 2009c

Figure 5: Number of housing approvals in Australia

Apart from the house prices, output PPIs and housing approvals, Australia's interbank rates and money supply had also changed significantly over the past decade. Figure 6 illustrates that the interbank rates fluctuated upwards within a long-run context and climbed to 7.25% in 2008Q2, from which the interbank rates then suddenly declined to 5.29% in 2008Q4. Conversely, the movement in the M1 exhibited a smooth trend, rising from 93.8 to 241.5 billion dollars in twelve years.



Source: RBA, 2009a; 2009b

Figure 6: Interbank rates and money supply (M1) in Australia

The data description reflects that the supply side of the housing sector in Australia between 1997Q1 and 2008Q4 was exposed to the slowdown of an expansionary monetary policy. Therefore, the research question described previously is addressed again and it will be answered in accordance with the empirical results in next section.

ANALYSIS AND DISCUSSION

Unit Root Tests and Cointegration Tests

In time-series econometric modelling, the data imported must be stationary. Otherwise, a spurious regression would be triggered (Granger & Newbold, 1974). Therefore, the unit root tests will be the first test undertaken in this study. Table 1 reports the results of the PP tests of the selected variables [house price (HP), output PPIs (OPPI), housing approvals (HA), interbank rates (INT) and M1]. Based on this table, all data utilised are integrated of the order one, i.e. *I* (1).

Variables	**Level**		**First Difference**		**Results**
	Model specification (lags)	PP Test Statistics (5%, 1% sig. level)	Model specification (lags)	PP Test Statistics (5%, 1% sig. level)	
ln(HP)	Trend &Intercept (2)	-0.24 (-4.17, -3.51)	None (2)	-4.66 (-2.62, -1.95)	*I* (1)***
ln(OPPI)	Trend & Intercept (2)	-2.67 (-4.17, -3.51)	None (2)	-3.65 (-2.62, -1.95)	*I* (1)***
ln(HA)	Trend & Intercept (2)	-3.32 (-4.17, -3.51)	None (2)	-6.24 (-2.62, -1.95)	*I* (1)***
ln(INT)	Trend & Intercept (2)	-2.76 (-4.17, -3.51)	None (2)	-2.59 (-2.62, -1.95)	*I* (1)**
ln(M1)	Trend & Intercept (2)	-2.49 (-4.17, -3.51)	None (2)	-4.29 (-2.62, -1.95)	*I* (1)***

Notes: The PP Test, which is the unit root test similar to the ADF Test, contains three kinds of model specification: only intercept, trend and intercept, and no trend and no intercept. ** and *** denote the 95% and 99% significance level.

Table 1: Summary of the PP test results

The co-integration test is the second necessary step for constructing the VECM. The approach proposed by Johansen and Juselius (1990) (known as the JJ test) will be conducted after the PP unit root tests. As suggested by the Akaike Information Criterion and the Schwarz Information Criterion, one lagged term has been selected for the co-integration test. Although there are five models in the JJ test, this study is concerned with Model 3 and Model 4 (Model 3 has a linear data trend but no trend in the co-integration equation; and Model 4 has a linear data trend with both an intercept and a trend in co-integration equation) as the description on the data has confirmed that the majority of the data used in this research appears to be trending series. Table 2 summarises the results of the JJ tests, which suggest that a long-run equilibrium relationship exists among the observed variables.

Variables	Lagged difference	Model specification	Results (Trace test)	Results (Max-eigenvalue test)
ln(HP), ln(OPPI), ln(HA), ln(INT), ln(M1)	1	Model 3	1	1
		Model 4	1	1

Table 2: Summary of the JJ co-integration test results

In Table 2, one co-integration vector has been identified by both Model 3 and Model 4 under the Trace test and the Max-eigenvalue test. However, Krol and Ohanian (1990) claimed that there is a stationary deterministic trend in money supply. As a result, one co-integration vector of Model 4 will be selected because Model 4 is suitable for the situation that some of the series are trend stationary.

Causal Relationships between the Selected Variables

As the co-integration was found among the variables, the VECM can be formulated to carry out the Granger causality and the generalized impulse response function. Applying the Wald tests and joint *F*-tests, the null hypothesis that the independent variables do not Granger-cause the dependent variables is rejected at the 95% and 99% significance level. Table 3 indicates the results of the Granger causality tests. According to Table 3, a transmission pattern illustrated as Figure 7 can be identified. This transmission pattern not only confirms the interrelationship between housing supply and monetary policy, but also depicts how the monetary policy and the supply side of the housing sector interact with each other. In summary, there is a significant relationship existing between monetary policy and the supply of housing in Australia.

Dependent Variables	Directions	Chi-square	*P* values	Results
ln(INT)	ln(M1) → ln(INT)	5.63	0.02	Y
	ln(HP) → ln(INT)	0.24	0.62	N
	ln(OPPI) → ln(INT)	0.21	0.65	N
	ln(HA) → ln(INT)	2.28	0.13	N
ln(M1)	ln(INT) → ln(M1)	1.23	0.27	N
	ln(HP) → ln(M1)	5.39	0.02	Y
	ln(OPPI) → ln(M1)	0.29	0.59	N
	ln(HA)→ ln(M1)	8.83	0.00	Y
ln(HP)	ln(INT) → ln(HP)	3.91	0.05	Y
	ln(M1) → ln(HP)	0.33	0.56	N
	ln(OPPI) → ln(HP)	0.22	0.64	N
	ln(HA) → ln(HP)	1.35	0.24	N
ln(OPPI)	ln(INT) → ln(OPPI)	4.11	0.04	Y
	ln(M1) → ln(OPPI)	0.33	0.56	N
	ln(HP) → ln(OPPI)	1.90	0.17	N
	ln(HA) → ln(OPPI)	0.29	0.59	N
ln(HA)	ln(INT) → ln(HA)	2.52	0.11	N
	ln(M1) → ln(HA)	0.78	0.38	N
	ln(HP) → ln(HA)	9.22	0.00	Y
	ln(OPPI) → ln(HA)	13.09	0.00	Y

Table 3: Summary of the Granger causality test results

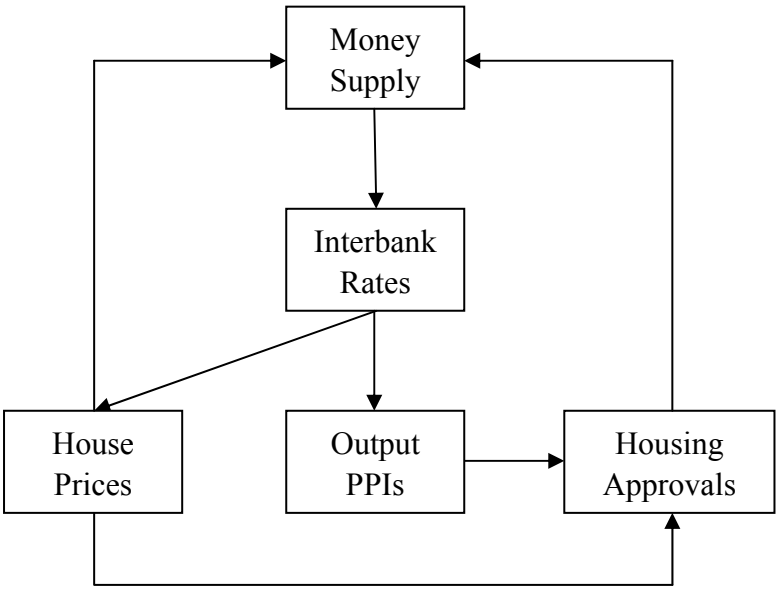


Figure 7: Transmission pattern between housing supply and monetary policy

The transmission pattern first suggests a one-way causality relationship between the money supply and the interbank rates. This finding is consistent with the reality that the RBA adjusts the interbank rates by changing the supply of money in realistic economic system. Furthermore, Figure 7 illustrates that the interbank rates Granger-cause the house prices and the output PPIs, both of which Granger-cause the housing approvals. Nevertheless, no causal relationship was identified from the

interbank rates and the money supply to the housing approvals, implying that house prices and construction costs perform as two transmission mechanisms of the shock of the monetary policy on new housing construction activities. In short, a ripple effect exists among the observed variables, and monetary policy influences new housing construction activities via house prices and residential construction costs.

The discussion previously mentioned focused on the causal links within the direction from monetary policy to housings supply. However, the empirical results also indicate that the house prices and the housing approvals Granger-cause the money supply without a feedback. Macroeconomic theory argues that the development of important economic sectors has been an essential factor in today's monetary policy decisions (McTaggart *et al.*, 2003). Hence, the changes in the housing sector can induce the monetary regime shifts.

Dynamic Relationships between the Selected Variables

The Granger causality test has identified the causal links between the observed variables, however it is not able to explore the dynamic linkages among the endogenous variable. Thus, the generalized impulse response function (GIRF) will be adopted in the following analysis and Figure 8 illustrates the results.

Firstly, there are dramatic effects produced by the interbank rates on the house prices. It is noted that the maximum values of the response of the house prices to the standard deviation of the interbank rates achieve -1.10%. The 'negative' values here indicate that the increasing trend of the house prices in Australia had been dramatically depressed by the increases in the interbank rates during the period under study. On the contrary, the response of the output PPIs to the interbank rates is positive. Specifically, a total of 0.43% dynamics on the output PPIs is yielded by the interbank rate disturbances, suggesting that an increase in construction costs was strengthened by a rise in the interbank rates. It is knowledge that an inflation of the interbank rates increases the payments on interests, which represent a major part of the costs of the construction projects financed by the loans of banks or other financial institutions. The ABS (2009d) reports that an approximately 50% of housing construction projects in Australia is under the loans. As a result, the construction costs in Australia can be easily affected by the changes in interest rates.

Compared with the interbank rates, the house prices and the output PPIs are less sensitive to the movement in money supply. The results indicate that the standard deviation of the M1 produces less effect on the house prices as well as the output PPIs than that of the interbank rates, 1.07% and -0.21% respectively in five quarters. These two values suggest that the house prices are positively related to the M1 and there is an inverse relationship between output producer prices and money supply.

It has been described in *Introduction* that the growth rates of the money supply in Australia from 1997 to 2008 exhibited a downward trend in conjunction with a rise in

the interest rates. Thereby, the empirical results associated with the responses of the house prices and the output PPIs imply that the slowdown of an expansionary monetary policy had weakened the upward trend of the house prices but increased the residential construction costs in Australia.

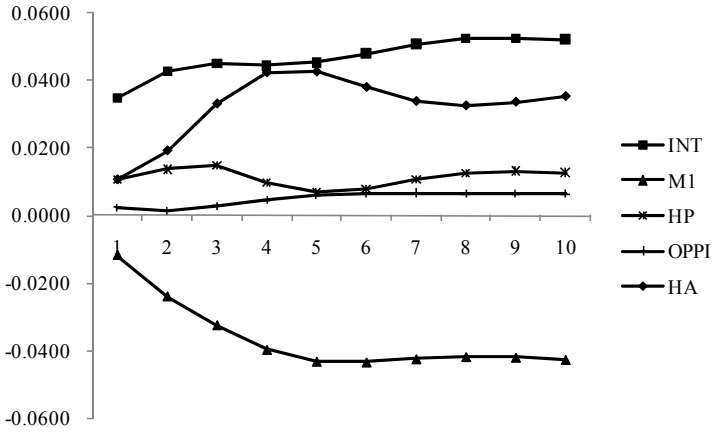
Secondly, new housing construction activities measured by the housing approvals are sensitive to the changes in the house prices and the construction costs. Overall, the house prices have a positive effect on new housing construction while an increase in the output PPIs reduces the construction for new housing. According to Figure 8, the responsive values of the housing approvals to the standard deviations of the house prices and the output PPIs reach 1.41% and -3.87% respectively in five quarters.

As discussed previously, the adjustments in monetary policy between 1997 and 2008 in Australia had depressed the house prices but driven up the residential construction costs. Due to the strong linkage between new housing construction and the changes in house prices and construction costs, the slowdown of monetary expansion surely can reduce new housing construction level across Australia. This conclusion can be supported by the results of the GIRF, which indicate that the housing approvals are decreased up to 1.65% in three quarters by the shock of the monetary policy.

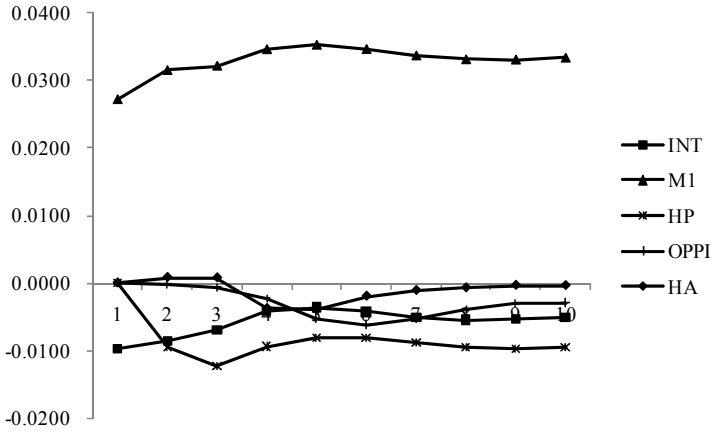
Finally, the influence of the supply side of the housing sector on monetary policy decisions can not be ignored. The empirical results indicate that the responses of the interbank rates and the M1 to the impulses of the house prices, output PPIs and housing approvals are: 1.25% and -0.85%, 1.17% and -0.65%, and 5.11% and -1.16% respectively. It is inferred from these values that Australia's central bank will decrease the money supply to increase the interbank rates when facing overheating investments in the housing sector. Conversely, if a recession occurred in the supply side of the housing sector, the central bank will lower the interbank rates to stimulate the investments on housing development. These findings comply with the conventional macroeconomic theory, thus the conceptual model and the VECM developed in this study are reliable.

Based on the empirical evidence displayed in Figure 7 and Figure 8, an overall outcome of this research is able to be summarised as Figure 9. In summary, the slowdown of an expansionary monetary policy had weakened the increasing trend of the house prices and raised the residential construction costs in Australia. Consequently, the level of new housing construction had been depressed by the price and cost changes triggered by the shock of monetary policy. In conclusion, the development of the supply side of the housing sector had been negatively affected by the monetary regime shifts during the recent decade in Australia.

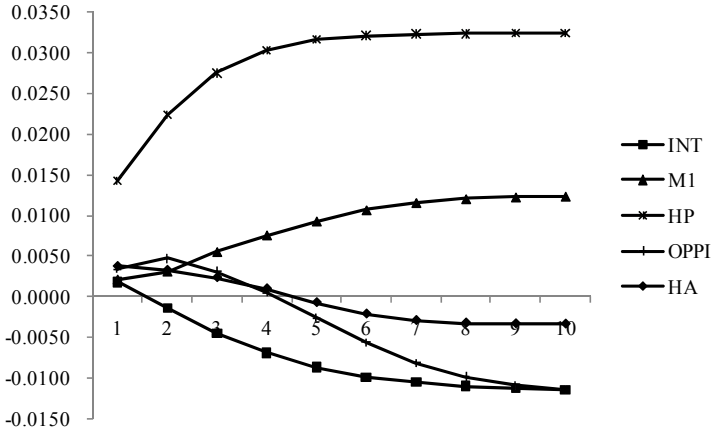
Responses of the interbank rates



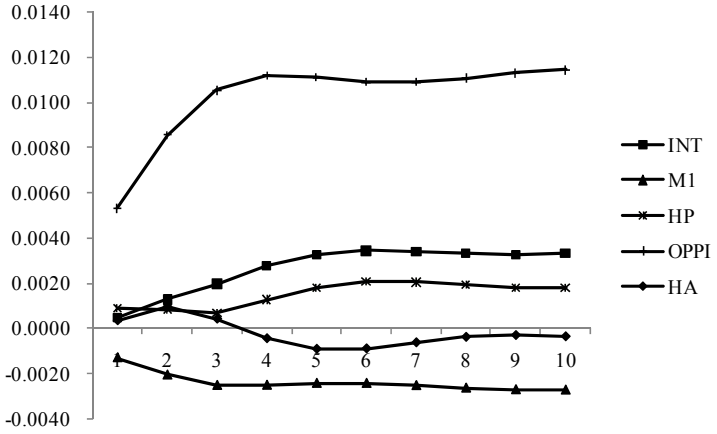
Responses of the M1



Responses of the house prices



Responses of the output PPIs of housing constructions



Responses of the housing approvals

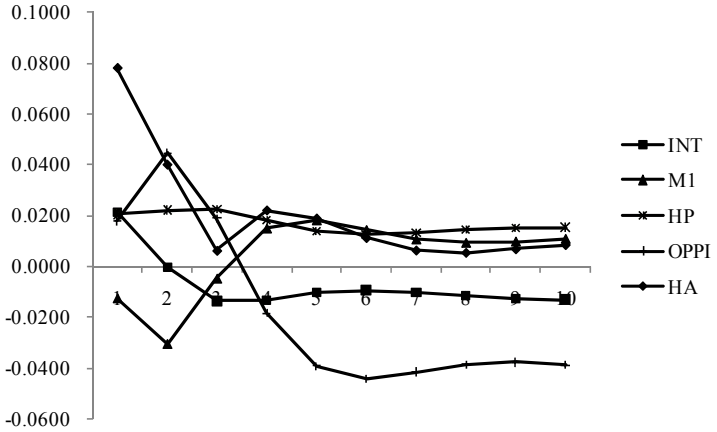


Figure 8: Results of the generalized impulse response function

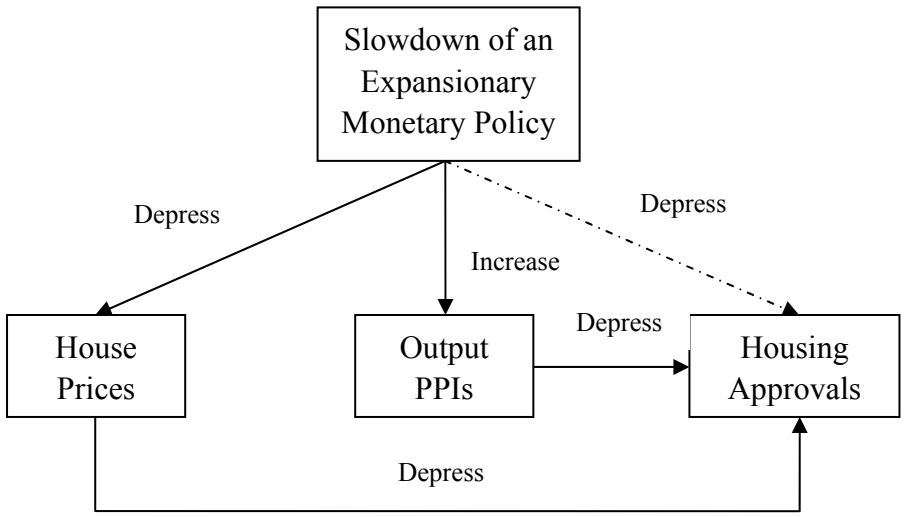


Figure 9: Impact of the slowdown of an expansionary monetary policy on the supply side of the housing sector in Australia

CONCLUSION

This empirical study has investigated the interrelationship between housing supply and monetary policy in Australia by a vector error correction model. Depending upon the Granger causality test, a transmission pattern within the framework of monetary policy and housing supply has been identified. This pattern illustrates that the interbank rates perform as an activator that transfers monetary policy makers' interventions to the supply side of the housing sector, and house prices and residential construction costs are two transmission mechanisms of the shock of monetary policy on new housing construction activities. According to results of the generalized impulse response function, it can be concluded that the slowdown of an expansionary monetary policy has significantly depressed housing supply in Australia.

This paper uncovers the negative effect of the slowdown of an expansionary monetary policy on housing supply. The models developed in this research is useful for policy makers to estimate the influence of monetary policy on the supply side of the housing sector and provides them with valuable insight to improve the housing supply across Australia. Furthermore, as suggested by the perspective of policy collaboration, some other policies (e.g. construction policies or taxation policies) in relation to residential construction can be enacted for construction industry by the Australian governments to reduce the negative impact from current monetary policy and then stimulate the investments on new housing developments. In reality, the construction policies for the supply side of the housing sector are a promising field for future study.

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VISUALIZATIONS OF SOCIAL NETWORKS AS SUPPORT FOR STAKEHOLDER MANAGEMENT WITHIN CONSTRUCTION PROJECTS

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Abstract
Engaging the right stakeholders at the right time is a key factor to successfully complete a construction project. However, the decision which stakeholders to engage within a project can often be difficult. This research looks into the applicability of visualizations of Social Networks as a tool to support project managers to decide which stakeholders to engage and with consecutively engaging these chosen stakeholders. To provide empirical evidence for the utility of Social Network Analysis, we conducted a case study on a public-private redevelopment project in the Netherlands. The findings from this case study show that representations of social networks give project managers a quick overview of the cliques, key players, and the general position of stakeholders in the social project network. This overview helped the project managers to identify which stakeholders to engage. At the same time, our findings show that visual representations of social networks help to engage stakeholders by giving them clear insights into their respective position in the social project network. Overall, the study illustrates the utility of social network visualizations to understand and engage stakeholders on public-private construction and design projects.
Keywords: Social Network Analysis; stakeholder engagement; public-private construction

INTRODUCTION

Stakeholders are all the people, groups of people, or organizations, such as neighborhoods, institutes, or societies, with a concern for the outcomes of a certain construction project (Mitchell et al., 1997).
The influence of stakeholders on public project outcomes is traditionally high. Stakeholders can for example often rely on legal procedures to slow down or stop a project that is against their will and interests. Another option stakeholders often use to gain influence on project outcomes are political lobbies. Hence, project managers need to manage stakeholders well to achieve desired project outcomes (Achterkamp & Vos, 2007). Goals of such stakeholder management efforts are, among others, to increase support and reduce project costs and durations (Zhong et al., 2007). If stakeholders support a plan, this will prevent that time and money is spent on legal procedures and objection procedures. Another goal might be

community learning or better and more sustainable project acceptance (Innes & Booher, 1999).
As a first step in stakeholder management, project managers should start with mapping all those people and organizations with an interest in a project. This will provide project managers with a complete overview of the project's stakeholder environment. Ideally, project managers should do that early on in the project because At the very outset of a project, stakeholders have the most chance to get actively involved in the planning activities.
After identifying stakeholders, project managers have then to decide which stakeholders they like to engage in the planning process and how they like to engage them. Stakeholder engagement focuses on the participation of stakeholders, or enabling stakeholders to exert an influence on a project and its outcomes. Project managers should engage stakeholders, to reach project outcomes that are more likely to be successful in the implementation and maintenance phase. This greater success is a consequence of incorporating the ideas and opinion of a broad set of stakeholders in the eventual plans.

However, identifying and engaging stakeholders is not an easy task. Stakeholders form a complex social network that project managers need to understand to be able to engage the right stakeholders at the right moment. Further, if the stakeholders understand the social network too, this will probably grant them better understanding of the decisions project managers make regarding the engagement process. In any case, to successfully identify and engage stakeholders, project managers have to understand the social interdependencies between stakeholders within a project's social stakeholder network. The visualization of such a social stakeholder network in the form of a graph seems to be a good tool to support project managers in their stakeholder identification and engagement efforts. To explore empirically how such social network visualizations can support stakeholder management activities, we conducted a case study on a public private partnership project in the Netherlands during which we introduced social network graphs in the planning process. This paper reports the results of this case study.
The paper is structured as follows: in the next section, we will discuss the theory we used as basic knowledge for our research. In the subsequent section, we will discuss the research method we applied during the twelve weeks of research. After that, we will describe the data we collected during this research, and the results of the analysis of this data. The report will conclude with the conclusions and the limitations of the research.

VISUALIZATIONS OF SOCIAL NETWORKS IN STAKEHOLDER MANAGEMENT

If project managers set up well managed participation processes for stakeholders, this can lead to better project outcomes, reduce of costs (Zhong et al., 2007), and lead to broader support of the project. That is why it is important for project managers to identify the important stakeholders within a project. One important step during such identification efforts is to analyze the interdependencies between stakeholders in a social network. Current models for stakeholder management (Mitchell et al.,1997; Achterkamp & Vos, 2007; Bakens et al., 2005) do not provide insight in those interdependencies. Visualizations of social networks do.
To theoretically underline our work, this section offers an overview about current available models in stakeholder management and briefly discusses their advantages and shortcomings. Afterwards, this section then introduces methods to visualize social networks, and derives a number of theoretical benefits of such visualizations during the stakeholder management process.

Currently applied stakeholder management methods focus on the same basic principles to support project managers in their decisions on stakeholder engagement: identifying and categorizing the stakeholders. Identification is often done by brainstorming sessions. This is a good way to stimulate out-of-the-box thinking and produce an as complete as possible list of (potential) stakeholders of a project.
Based on the list of identified stakeholders, current methods then suggest that project managers categorize stakeholders. This categorization can be done in several ways. For example by categorizing stakeholders based on attributes they possess, such as power, legitimacy and urgency (Mitchell et al., 1997), or based on the role a stakeholder has in a project, like a client or a representative stakeholder (Achterkamp & Vos, 2007). For their own purposes, these are useful techniques. Nevertheless, the techniques do not give project managers and external stakeholders insight in the interdependencies between stakeholders in the social (project) network.

These interdependencies between stakeholders can be visualized by a social network graph that shows the stakeholders as nodes and their mutual relations as edges between these nodes. This presentation can grant project managers and external stakeholders insight in the key characteristics of stakeholders within the network: their centrality, their prestige, whether they form cliques with other stakeholders, and their relative position. Further, the graph representation can show missing ties between stakeholders. The following subsections will elaborate on how social network graphs can help to identify the above listed characteristics.

Prominence: Centrality & Prestige

Prominence of a stakeholder in a network exists in two forms: centrality and prestige. Centrality reflects the involvement of a stakeholder within many relations in the network. The centrality of a stakeholder can easily be determined by the number of relations they have within the network. Take for example a non-directed network with six stakeholders (figure 1).

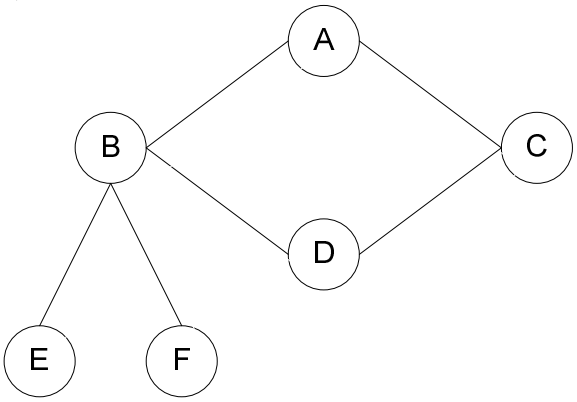


Figure 1: *Example of a non-directed social network (Knoke & Yang, 2008)*

In this network, stakeholder B is the most central stakeholder with four relations. Through this, B is the most visible to the other stakeholders and can be considered a key stakeholder. Stakeholders with many relations are likely to have a high influence on a project, as they can reach many other stakeholders in the network to convince those stakeholders of their view on a project and the desired project outcomes.
The other form of prominence in a social network is prestige. Prestigious stakeholders are receivers of many relations; i.e. they don't initiate many relations within the network, but

receive many ties from other stakeholders. The amount of such "sender-receiver" or "source-target relations", implies the control over resources and a certain amount of authority over other stakeholders by the prestigious stakeholder. Prestigious stakeholders often collect information from other stakeholders, making them interesting parties to be engaged. This makes them also a key player that should be engaged according to 'the law of the few' (Bakens et al., 2005).
The centrality and prestige concepts grant external stakeholders insight in their own position relative to other stakeholders. They can determine whether they have a strong position compared to other stakeholders ("Am I in a more central position than the others?").
Project managers benefit from the external stakeholders' better understanding of their positions through the two concepts. The external stakeholders are more likely to understand the decisions project managers make on stakeholder engagement. These decisions on stakeholder engagement can be based on the quick overview of the key stakeholders which a visualization of the social network grants project managers. This helps project managers when determining which stakeholders to engage. The key stakeholders, based on their centrality and prestige, are likely to be able to influence project outcomes and have information of the other stakeholders. Furthermore, because networks often show great variety between the stakeholders, it is time consuming for a project manager to approach every stakeholder with a tailor-made approach (de Bruijn & ten Heuvelhof, 2008).
External stakeholders benefit from the centrality and prestige concepts by knowing what their opportunities are, regarding their position in the network. They can make better decisions about what they can demand from a project manager. For example, they can try to attract a lot of attention for their interests, but if they are somewhere on the side of the network with only one tie to another remote stakeholder, they probably won't be noticed.

Cliques
Cliques give information about groups of stakeholders that are closely related to each other through their interdependencies and relational ties. Cliques consist of groups of stakeholders who have ties with all of the other members of the cliques, whereas no other stakeholder in the network has direct ties to all the stakeholders in the clique. Prerequisite is, that there are at least three stakeholders involved in a clique. Using these requirements, the boundaries of cliques within a social network can be determined. For example, see figure 2.

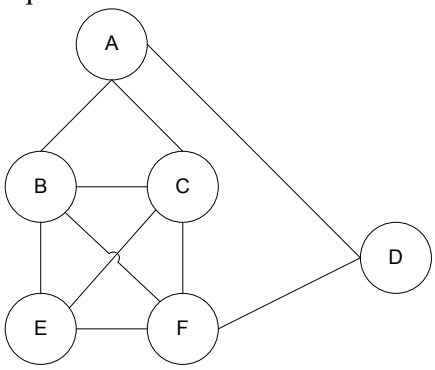


Figure 2: *Example of a clique in a social network (Knoke & Yang, 2008)*

Two cliques can be recognized in this example. There is a clique consisting of A, B, and C and a clique consisting B, C, E, and F. These stakeholders have mutual relations with each other, whereas no other stakeholder in the network has connections with all of the stakeholders in the clique. A, D, and F don't form a clique, because there is no direct tie between A and F.

Knowledge about existing cliques and prominent stakeholders within a clique is important for the project manager. Project managers can engage the prominent stakeholder that can then act as a representative for a group of stakeholders. The opposite can also be done: after determining the boundaries of a clique, the project manager can determine whether the clique has a prominent stakeholder in their midst. Furthermore, the cliques grant the project manager insight in the individual stakeholders that might be empowered by being part of a clique, and which cliques are present in the network.
Understanding about clique membership can also help stakeholders to get engaged with the project. In general, stakeholders can gain more influence as a group than individually. In combination with the technique to recognize prominent stakeholders, members of a clique can also again determine whether there is a prominent stakeholder inside their clique who can act as their representative.
Cliques are, like centrality and prestige, based on the relations and interdependencies between stakeholders in the social network. Possessing the same attributes or playing the same role in a project does not imply a mutual relation between stakeholders. Because of this, current models for supporting project managers with stakeholder management are not useful in recognizing cliques.

Insight in missing ties
The visual representation of a social network shows the relations between stakeholders. It also shows which stakeholders have no connection with each other: missing ties.
Project managers can also benefit from knowledge about missing ties. For example, through the complete oversight of apparent and non-apparent ties, the project manager can evaluate whether every stakeholder is adequately engaged in the social stakeholder network of the project. Stakeholders can also benefit from knowledge about missing ties. Stakeholders can, for example, initiate new relations to gain a more central or prestigious position in the network or to form a new clique. Another option would be to initiate a relation with a key stakeholder to get their information to the project manager.
Though project managers can use the current models to make sure every stakeholder is represented (simply by engaging all identified stakeholders), this does not grant them and the external stakeholders insight in the non-apparent relations. Because of this, external stakeholders can't use the information from the categorization models for strategic purposes.

Overview
In summary, visual representations of social networks can support project managers with their decisions on stakeholder management and help external stakeholders with understanding the decisions a project manager makes. An overview of the different concepts and their utility to respectively project managers and external stakeholders is in table 1.

Social Network Analysis technique	**Utility for Project Managers**	**Utility for external stakeholders**
Centrality	Grants insight in the key stakeholders within the network.	Grants insight in their own relative position compared to other stakeholders. Also, makes them better understand their position and the choices project managers make.

Prestige	Grants insight in the authoritative stakeholders within the network.	Grants insight in their authority compared to other stakeholders.
Cliques	Grants insight in the stakeholders who gain power by being a group.	Empowers stakeholders as they can reach more with a group than as an individual. Ability to choose a representative inside the boundaries of the clique.
Insight in missing ties	Grants a quick overview of the relations between stakeholders, so the project manager can evaluate who is represented in the engagement process.	Grants a quick overview of the relations they should initiate to become more central or to become part of a clique, giving them a strategical advantage.

Table 1: *Summary of the utilty of social network analysis*

RESEARCH METHOD

To provide empirical evidence and explore if social network analysis is useful in managerial practice, we conducted a case-study on a public-private partnership project of the city of Almelo in the Netherlands. The projects goal is to establish a building that accommodates a hotel, several catering companies, and other peripheral retail organizations. The project got the name Almelo Nouveau and had to be an attractive building, both inside and outside. For several years, the municipality of Almelo and the private party they cooperated with, a project developer, worked on the plans for Almelo Nouveau.



Figure 3: *Artist impression of Almelo Nouveau (Tubantia, 2010)*

However, the municipality has designated more sites in Almelo for peripheral retail. This means that the municipality is going to realize a lot of extra commercial space in the upcoming years. It is questionable whether the municipality can fill all of this space with private commercial parties, as the designated functions of the new locations are all similar. Additionally, the previous responsible politicians (from other political parties than the current responsible politicians) have initiated the revitalization and restructuring of the town centre, which will be under construction for the upcoming years. This has led to enormous opposition by entrepreneurs throughout the city against the realization of Almelo Nouveau. Eventually, the City Council decided to put a hold on the project.

The project managers of the municipality and the project developer wanted to know how this stakeholder obstruction could occur, as they thought they were working on plans that were good for the city. But, during the years of preparation, making the plans for Almelo Nouveau, the project managers of the municipality and the project developer hadn't paid much attention to stakeholder management. At the end, this led to the opposition of several stakeholders, delaying the project. So they wanted to know how to proceed *with* these stakeholders involved and how to engage the opposing stakeholders better in the planning phase. Hence, this project was an ideal opportunity to test our hypothesis on the utility of social network analysis in stakeholder management on a real life project and in close collaboration with practitioners. Figure 4 illustrates our overall research effort.

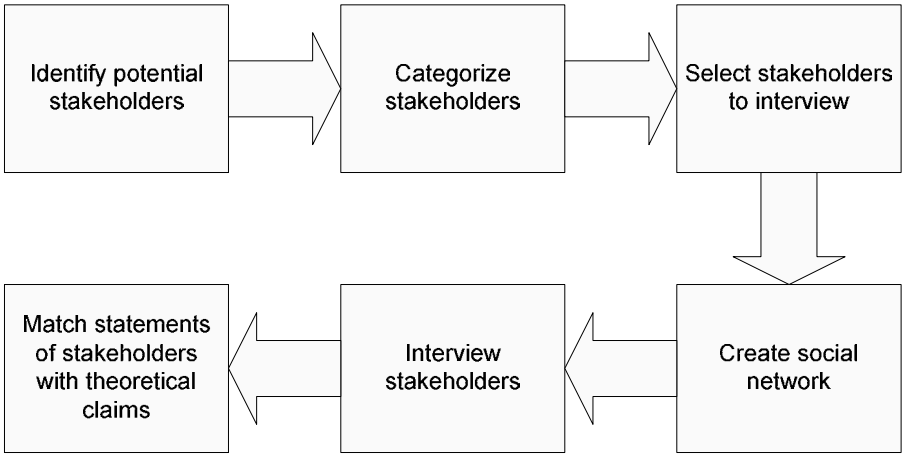


Figure 4: *Overview of research methodology*

When we started on the project, we first identified the potential stakeholders of the project. So, we conducted a brainstorming session with to members of the project team of the municipality; two employees of the Department of Economical Affairs. This resulted in a vast list of (potential) stakeholders.

From this list we selected seven stakeholders to interview. Overall, we selected some internal stakeholders from the community of Almelo (Alderman, project manager) and some external stakeholders. To allow for a meaningful collection of interview data, we selected only stakeholders which had already come in contact with the functional interpretation of Almelo Nouveau.

We also tried to select interviewees from a broad range of stakeholder groups to enable us to draft a complete image of the problem perceptions on the project. Table 2 lists the seven interviewees and why we selected them.

Stakeholder	**Selected because**
Alderman	He played an important role during his time in the opposition (till march 2010) and in the time he has been Alderman. He was part of the opposition in the City Council that has set a hold to the plans. As Alderman he still objects to with the initial plans for the project.

Project manager municipality	The project manager is responsible for the management of the project and the additional processes, including stakeholder management.
Chamber of Commerce	The objecting parties asked the Chamber of Commerce for advise about Almelo Nouveau. The Chamber of Commerce was also part of the group of speakers who convinced the City Council to bring the project to a halt. The main role of the Chamber of Commerce is giving objective advise to the municipality and entrepreneurs.
SOBA (Foundation Entrepreneurs Town Centre Almelo)	The SOBA is one of the objecting parties, but also the representation of most entrepreneurs in the town centre. With the revitalization plans for the town centre, the SOBA has a clear opinion about other projects.
Owners residential boulevard	The residential boulevard is another commercial part of town that struggles with the financial crisis and fears competition from Almelo Nouveau and other projects.
MKB Almelo (Small to Medium-sized Entreprises Almelo)	MKB Almelo is the organization that represents most of the objecting parties. MKB Almelo was also part of the group that spoke to the City Council to convince them that the current plans would harm the economical balance in the city.
Project manager project developer	The project developer is the partner in the Public Private Partnership with the municipality of Almelo.

Table 2: *Reasons for selection of interviewees*

In advance of the interviews, we created an example of the social network of this project. We created this network with the information we retrieved from our conversations with the project manager of the municipality and the information we got from the project team members during the brainstorm session. During the interviews, we presented a more detailed graphical representation of the network (Figure 5).

In Figure 5, the thickness of the arrows represents the frequency of contact between stakeholders. The arrows between stakeholders within the municipality the thickest arrows, as there is frequent contact between them. The arrows between the stakeholders of the municipality and the external stakeholders are thinner, as there is less contact between these stakeholders. They only communicate with each other when there are new developments to mention. The same is valid for the group of external stakeholders at the right side of the chart. They only communicate in relation to the project Almelo Nouveau when there is news to discuss.
After showing them the social network and the chart below, we asked the interviewees two questions regarding the social network analysis: (1) what they thought of their own position and that of other stakeholders and (2) what they thought of the value of such a visualization to them. After conducting the interviews we then analyzed the statements of the stakeholders.

During this analysis, we tried to link the interview statements with the claims we made in table 1 for the utility of the social network concepts centrality/prestige, cliques, and missing ties. In the next section, we will describe these analysis outcomes for each of the concepts.

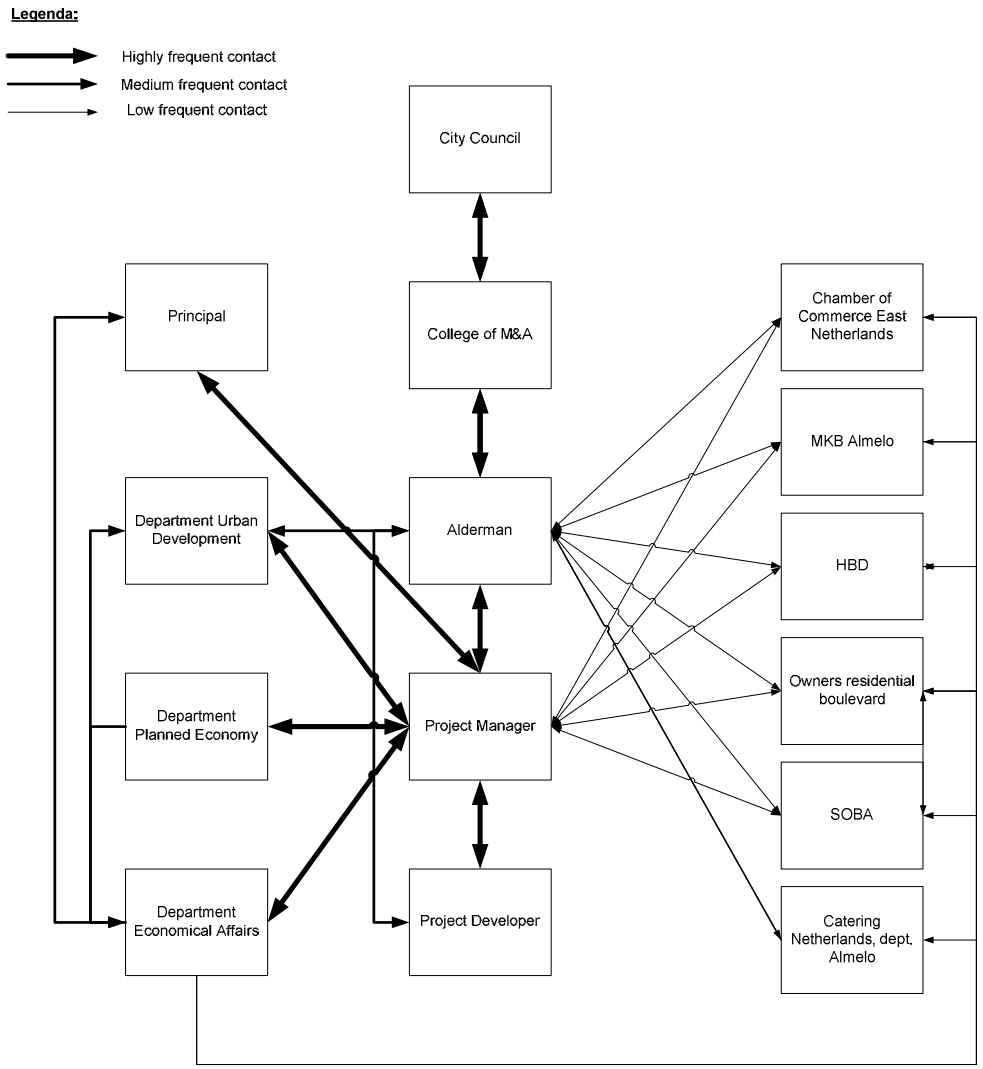


Figure 5: *Chart of relations between stakeholders, shown to interviewees*

RESULTS OF DATA ANALYSIS

Centrality & Prestige

Utility to external stakeholders: Grants insight in their own relative position and authority compared to other stakeholders.

In general, the external stakeholders saw a practical value in the visualization of the social network for determining their own relative position compared to other stakeholders. They could decide whether they felt they were on the right place or not. The representative of MKB Almelo said the following about his central position in the network and his resulting role as key stakeholder: “It’s our responsibility to represent entrepreneurs”. As a central

stakeholder in the network, MKB Almelo can act as a representative for the external stakeholders they are in contact with. The representative of the Chamber of Commerce is more a prestigious stakeholder, as he receives many ties that are initiated by external stakeholders. He tries "to group these a little bit and let them function better." As an authoritative stakeholder, he is asked for advice by the external stakeholders.
Utility to project managers: Grants insight in the key stakeholders within the network.
The first remark of the project manager of the municipality was the importance of the correct filling in of the network. If the right names are not on the right place and the information on ties and the direction of relations is not correct, the network looses its analytical value. If the prerequisite of correctness is fulfilled, the visualization of the social network clarifies the stakeholder environment to the project manager. This clarification of the social network is established through the insight in the relative prominence of the stakeholders, reflecting their importance to the project manager.
For the project manager of the project developer centrality also played a role. Especially their own centrality in the network. "We are not in the right place here. We have to be much more in the middle", was his first comment after seeing the visualization of the social network. He would like to be more central, to be visible to external stakeholders and proclaim the positive message of their building aspirations. He also saw in the visualization that the municipality has a central position in between the project developer and the other external stakeholders. This gives him the information to consider a strategy with the municipality as middle person: "All of the other stakeholders can bring their questions to us via the municipality". Furthermore, as "the importance of stakeholders is tested by the municipality and their project manager, and us", the visualization of the social network grants them insight in the importance of stakeholders based on the relations these stakeholder have.

Cliques
Utility to external stakeholders: Grants insight in the cliques they can join or leave, giving them a strategical advantage.
The visualization also gives the project managers and the external stakeholders insight in the existing cliques. As the representative of the Chamber of Commerce mentioned, the visual representation of the social network gives him an idea of which stakeholders he can group together to make them better organized in protecting their interests. The stakeholders we spoke to who where in the clique, where content with their position, as they had a strong position with the other stakeholders as a clique opposing the plans.

Grants insight in the stakeholders who gain power by being a group.
The experience of the project manager of the municipality is that "making an overview of the relationships between stakeholders is very enlightening". This is because of the insight in the cliques stakeholders form and the consequences of those alliances to their power to influence project outcomes.

Insight in missing ties
Utility to external stakeholders: Let's them better understand why they are in a certain position.
The final utility of the visualization of the social network is the insight in missing ties. The visualization helped the interviewees to determine which relations they should initiate for certain goals. External stakeholders could for example see why they were not in direct contact with the municipality: they were already represented by a prominent stakeholder in their clique, the MKB. As the Alderman said, "this also makes the structure clear". The

visualization makes clear to project managers and external stakeholders which relations are apparent and non-apparent between other stakeholders as well.
As we stated earlier, the visualization showed the project manager of the project developer that he was de-central in the network, despite his company having invested a lot of money in the project. The visualization gave him insight in the missing ties: there was no direct contact with the external stakeholders, whereas initiating these relations could enlarge his visibility within the network. Furthermore, the insight in the missing ties also emphasized the ties he did have: he had a direct tie to the Alderman and the project manager of the municipality. This led to the earlier mentioned strategy to give the centrally positioned representatives of the municipality a role as intermediate between the project developer and the external stakeholders.
Utility to project managers: Gives a quick overview of the stakeholder environment and the relations between stakeholders.
The visualization also showed the project manager of the municipality that he was a central figure within the project team and the municipality, but to the outside world, the external stakeholders, the Alderman held a more central position. “On the new project I have too little influence,” was the remark of the project manager. The visualization of the social network showed him why: the greater part of the communication with external stakeholders went through the Alderman. External stakeholders also mentioned during the interviews the minimal contact they had with the municipalities project manager. The Alderman is their ‘reference point’ for decisions.
Overall, the above shows that the visualization of a social network can indeed help project managers with stakeholder management, and external stakeholders with the determination of their position and strategies.

LIMITATIONS & SUGGESTIONS FOR FUTURE RESEARCH

Generalization comes with numbers. When executing a case-study, these numbers come in the number of cases that are studied in one research. A researcher does this to discover a pattern in the form of similarities between comparable cases. Due to a limited period of time to execute the research, we could only perform a study on one case. This makes the results possibly sensitive to deviations in comparison to similar cases. Nevertheless, the case studied in this research, Almelo Nouveau, is suitable for generalization because this sort of construction project is likely to be found elsewhere. A Public Private Partnership, where a municipality, or other governmental organization, cooperates with a private party on the realization of a commercial building. The public party facilitates, while the private party bears the risks. Furthermore, commercial activity is everywhere. The chance to find similar kind of construction projects elsewhere is quite high. At last, the kind of stakeholders identified in this research where quite general ones in relation to the realization of the construction of a commercial building (entrepreneurs from elsewhere within the city, umbrella organizations for these entrepreneurs, public party, private party). Nevertheless, we suggest that future research efforts start to evaluate the utility of social network visualizations on other projects as well to improve the generality of the here presented work.
Because the conclusions of the research are mainly based on the interview data collected during the twelve weeks of research and on a specific case, the data have possibly been influenced by the opinion of the interviewees or their emotional involvement with the project. Besides, the amount of interviewees has been very limited in comparison to the total amount of identified stakeholders. This has (partly) led to assumptions about the non-interviewed stakeholders.
Another limitation of this research is the relative simplicity of the used network graph. The more variety and interdependencies among stakeholders, the more complex and less

transparent the social network will be. That makes it harder for the project manager to oversee the network using a visual graph presentation (de Bruijn & ten Heuvelhof, 2008). For example, if a social network consists of more stakeholders, it will be harder for project managers to identify the central stakeholders or find out where the cliques are. However, mathematical methods exist that can allow for the calculation of centrality values and cliques within social networks (Knoke & Yang, 2008). We suggest that future research also evaluates the utility of these methods to support stakeholder management activities.

Another downside of this research is that we did not look at the process itself wherein project managers will use the social network analysis. In general, project managers should identify stakeholders at the start, during the initiative phase of a project. They should do this to build support among the stakeholders and give them the possibility to add their own ideas. In our research, we applied the social network analysis only late in the project planning efforts. In the initiative phase, the goals and implications of a construction project are still ambiguous. It is likely that boundary conditions (e.g. political environment, legal regulations) will change during the decision-making process, changing the stakeholders and their relationships which again will make it harder to understand a graphical network presentation. Additionally, the social network on projects will change over time. Researchers should evaluate how to best integrate social network analysis in the planning process and how once established social network graphs can be updated throughout a project.

Overall, we claim that social network analysis visualizations should make the work of project managers easier, because the external stakeholders better understand their own relative position. However, stakeholders will choose their own strategy to reach their individual goals and serve their interests which might be quite different from the ones of the project manager. Hence, there is a real chance that the application of social network tools in the stakeholder management process will increase the overall complexity of the planning process.

CONCLUSION

Social network analysis is a tool that can both help project managers and external stakeholders. The project managers get a quick overview of all the cliques, key players, and overall position of stakeholders. Through the interdependencies between these stakeholders, project managers can determine pathways of communication. This means, which stakeholders they can reach through other stakeholders they already have ties with. The visualization and analysis also helps in determining which cliques are apparent and which stakeholders are part of these cliques. If project managers take in account the expectations and opinions about the project of the stakeholders within the clique, threats or opportunities can be mapped.

The visualization and analysis of the social network gives external stakeholders insight in their own relative position, compared to other stakeholders. It can help them to determine whether they are central or at the side of a network and which ties to make or strengthen to gain more influence within a project by becoming a more prominent stakeholder themselves or forging cliques with equally minded stakeholders. This grants them better understanding of their possibilities to cooperate with other stakeholders. It also gives them better understanding of the choices made by a project manager about the stakeholders that project manager engage. They can also determine whether they are part of a clique and if they can choose someone in their midst to act as a representative on their behalf.

Our case-study shows that social network analysis is a useful tool in complementing the ‘tool box’ of project managers. It helps to determine positioning, cliques and key players within the complete setting of stakeholders. Not only the project manager(s) benefit, also the other stakeholders, in being able to gain a visual insight in their own positions and that of others, giving them information on the strategies they can follow.

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A PHASED CITY ENERGY PLATFORM FOR NETWORKED PRECINCT BUILDINGS IN THE CONTEXT OF MANAGEMENT INFORMATION SYSTEMS AND SMART GRIDS

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Abstract
This research investigates the context and advantages of energy sharing between networked precinct buildings in the context of pre-existing urban stock. The paper considers whether the sharing of patterns of use and knowledge of buildings' spatial, architectural and energy-related components can act as a phased prequel to energy sharing and provide a 'knowledge pool' to facilitate changes to the technological mix in a building, as well as modes of usage. In the context of energy use and conservation it is well understood that resource sharing can be advantageous across multiple buildings, but less is known about the potential benefits of energy knowledge sharing across buildings. The sharing of energy data across buildings with different owners/operators but offers the advantages of balancing demand across facilities, right-sizing technology components, intelligent planning and future usage pooling – particularly for smart buildings with energy storage and generation capacity. With a focus on the Australian context, this research investigation examines how an initial energy information platform phase could benefit a range of building stakeholders and be lead to a subsequent energy sharing phase. The author argues that there is value in a city energy information platform as a prequel to smart grids and subsequently as a complement to smart grids.

Keywords: building energy management; building information management; information aesthetics; green buildings; urban sustainability

INTRODUCTION

This research investigates the advantages of energy knowledge sharing between public, institutional and commercial buildings in the context of pre-existing urban stock. The purpose is to mitigate the energy-related environmental impact through the 3 primary areas noted in International Energy Agency Annex 31 (IEA, 2001) for Life Cycle Analysis (LCA), namely: energy and ventilation, and passive systems. There is significant demand: for example 75% of firms in the US consider that the driver for 'green building' is increased energy cost and view sustainability as consistent with their profit mission (McGraw-Hill, 2009).

The hypothesis of the research is that the sharing of patterns of use and knowledge of buildings' spatial, architectural and energy-related components could act as a phased prequel to energy sharing and provide a 'knowledge pool' to facilitate changes to the technological mix in a building, as well as modes of usage. The argument for phasing the energy platform in two stages is that a precinct of smart buildings can initially be established prior to a smart grid. When smart grids are available, the platform can then take advantage of the energy sharing options.

With a focus on the Australian context, this research investigation examines how an energy information platform tool could leverage real-time 'information aesthetics' techniques in visual interfaces for use by a range of building stakeholders.

Several contextual and developmental aspects are critical to the described energy phasing options for a precinct. These are: 1) the future direction of infrastructure, 2) smart buildings and energy efficiency, and 3) management information systems. Each of these is discussed in the paper. Following the consideration of an energy platform, the author concludes that there is value in a city energy information platform as a prequel to smart grids, and subsequently for the platform to become a core building feature.

Energy use in the Australian context

Australia has the highest per capita level of greenhouse gas emissions in the world (Turton, 2004). In the context of this situation, three objectives of this investigation were to explore unique ways of using city buildings to provide: (1) a better stakeholder understanding of energy use in a city and a sense of the scale of this energy use, (2) actionable advice to allow building stakeholders to reduce their energy use, and (3) a digital enterprise platform for Australian energy saving and alternative energy companies to get better reach.

There is a pressing need to achieve better energy management in Australia. Better energy management is a key component offered by the energy saving industry. Because of Australia's heavy reliance on coal-based energy which in 2001 contributed to 72% of CO_2 emissions (Saddler et al, 2004), the only short term approach to CO_2 reduction is to encourage conservation, which is typically driven by economic benefits and/or legislation – there may also be an element of corporate social responsibility and customer pressure. The researcher argues that making the energy reduction issue visible and actionable by stakeholders will get a much broader engagement across the city of Sydney. Building owners and operators will also see how their own energy use relates to other buildings, and finally there is evidence that social networking can encourage positive peer behaviour through example and information exchange.

Although there have been efforts to establish new sustainable cities globally, no such project has reached fruition. For example, the planned sustainable city Dongtan in China has been a notable failure that lacked an execution (Larson, 2009) despite a strong consulting team that included Arup. Sustainability work on new cities is important; however the vast majority of urban buildings is composed of existing historical stock. This puts the emphasis on ways of improving current cities.

In Australia, energy use per capita continues to increase. Between 1990-91 and 1998-99 Australia's total energy consumption increased by 23% (ABS, 2002). Over the same period, population increased by just under 10%. Recent figures show that an increase trend is still underway (DEWHA, 2004). This is not inevitable and good environmental policy and legislation can make a big difference: since 1974 California has held its energy use per capita constant, while the USA as a whole has leapt 50% (Mufson, 2007).

FUTURE OF INFRASTRUCTURE

The services infrastructure of a city comprises power and water distribution, gas, telecommunications and the internet, along with waste management. There are two main

challenges in the case of power management: firstly ensuring that the supply is closely matched to demand and secondly to make sure that the distribution supply allows power to be rerouted when parts of the network fail. In practice, to avoid power outages traditional power distribution requires power stations to generate excess electricity and this can rarely be stored. The inefficiencies of power distribution in the route from a power station via grid and substations to the customer due to losses are significant at 6.9% in the USA during 2008 (EIA, 2009). Traditionally, power management is based on analysing historical data to predict demand. The result is a supply-driven system. The concept of a smart grid is to create a demand-response system, effectively making the power supplied demand-driven. Through this approach, it is estimated that smart grid technologies in the USA can reduce peak demand by 5% in 2030 (EPRI, 2008). Additionally, smart meters allow other savings to be made by shifting customer usage with pricing patterns that are both responsive and clearly communicated.

The Economist Magazine's special report on smart systems (Economist, 2010) writes that:

'The physical and the virtual worlds are converging, thanks to the proliferation of sensors, ubiquitous wireless networks and clever analytics software. Increasingly there will be two interconnected worlds: the real one and the digital reflection.. and "Smart cities", in which more and more systems are connected, are multiplying.. the number of [smart] applications is vast. Yet the most promising field for now may be physical infrastructures.'

In terms of operation, smart grids use digital technology to achieve a two-way communication to control appliances at the user end of the distribution. The digital technology is an overlay to the existing power distribution that is interfaced into it with smart meters, also know as net meters, at the customer end. Smart grids allow consumers and other users to respond to changes in grid conditions in a way that has previously been the preserve of very large users or utilities. Smart grids also facilitate economically-intelligent generation and supply of power back into the grid from users that can create excess power from their own generating facilities such as renewables, cogen or trigen. Customers in 57 countries (Global Feed in Tariffs, 2010) are able to supply back into the grid – some for a number of years. This feed-in system predominantly pioneered by Germany in 1991 with the Electricity Feed Law (Federal Law Gazette, 1990). A more recent example is the UK's Renewable Obligation Certificates or ROC's, available since 2002 (Ofgem, 2011) for renewable customer generation of over 500kWh annually. This requires three devices: a generation meter to measure system output, an export meter to register the amount of electricity fed into the grid, and an inverter to synchronise voltage variations with the grid. With a smart grid and varying pricing schedules, these customers can benefit economically by fine-tuning when to use power, when to provide it to the grid and when to draw it from the grid. The ROC system incentivises providers to buy back renewable power from customers by setting a percentage of renewable power that the provider must source, currently 11.1% for 2010/11, with the penalty of paying proportionally into a fund when obligations are not met.

The dominant interest in smart grids is for power distribution, but they are also suited to water and gas supply. Although these utilities can get less value from a real-time demand-response because they don't suffer from supply-driven losses, they can benefit from demand-response control in the context of pricing and user control based on availability and demand. In advance of smart grids many governments have introduced legislation to incentivise renewables, along with retrofit programmes for insulation in buildings.

Smart grid development is gaining momentum. The American Recovery and Reinvestment Act provides $4.5 billion for smart grid demonstration projects (ARRA, 2009). In Australia, the government is providing $100M for a demonstration project called Smart Grid, Smart City (Smart Grid Australia, 2010). Based in the city of Newcastle, New South Wales, this will be the first commercial smart grid in Australia and covers power and water. The consortium comprises EnergyAustralia, IBM Australia, GE Energy Australia, AGL Energy, Sydney Water, Hunter Water Australia, and Newcastle City Council.

Better distribution and smart grids do not overcome legislative issues that can remove incentives for users to return power to a distribution system. Good energy tariffs in Germany have resulted in 200 time the solar production of Australia even though as a country it has half the amount of sunshine.

Australia does have a Renewable Energy Certificate or REC scheme that is not unlike the UK's ROC. However, the underlying feed-in tariff system is problematic. There is no national Australian feed-in tariff programme (Energy Matters, 2010) and although there are feed-in tariffs for a number of grid-connected renewable electricity generation sources, the rules vary between states and there are significant limits on the amount of power that will be bought back into the grid: at renewable premium tariff rates for photovoltaic solar only up to 5kW in Victoria, 10kW in New South Wales, and limited to solar panels in South Australia. Standard tariff rates are available for increased power feed-in in Victoria for up to 100kW from a range of renewables (State Government Victoria, 2010).

There is an issue for commercial building operators in Australia who wish to supply significant power back into the utility distribution system either to sell, for subsequent later use, or for use in another city precinct where a customer may have other buildings that can use the power at that time. This is because in many cases the energy utility company only has to buy a small amount of power at a premium tariff, some more at a standard tariff, but most power at wholesale prices. The utility provider is then able to sell it back to the customer at retail prices, representing a loss for the customer. Hence, there is a significant financial loss involved even if the power is moving only 100 metres between buildings.

It is worth noting that smart meters are required in Australia for feed-in of renewable power. Although these are installed on an ad hoc basis for domestic renewable suppliers, the aim is that the full roll out of smart meters will have been completed by the state of Victoria in 2012 and by New South Wales in 2017. The smart meters provide time based metering with 30 minutes update intervals.

Advanced power distribution and transmission

A promising area that relates to energy saving with smart grids is technologies for advanced power distribution and transmission. Power transmission from power stations to cities normally use three-phase alternating current (AC) at 110kV, but can run over long distances or underwater with high-voltage direct current (HVDC). The choice of system is based on keeping energy losses to a minimum. The original city-based power distribution used direct current (DC), and was set up by Thomas Edison in New York in the 1880's. AC replaced DC soon afterwards because it offered reduced energy losses. More recently, the development of high temperature superconductors may make DC distribution in cities viable once more for high load areas and can halve losses, even though the cables need cooling with liquid nitrogen or hydrogen. Hydra, a pilot project by Consolidated Edison and American Superconductor was recently launched in New York to connect two substations together

(New Scientist Tech & Reuters, 2007). Although this technology is not yet developed for low-load areas, the use of DC could result in 30% savings by eliminating losses that are caused by the mismatch between AC supply and electrical devices which are generally DC (EPRI, 2011).

SMART BUILDINGS AND ENERGY EFFICIENCY

The Lawrence Berkeley National Laboratory (LBNL, 2009) has created a smart building model for the US Government. In this, there are three strategies: enterprise operations, systems integration, and a high performance building core. The strategies give rise to enhanced operational effectiveness, enhanced productivity and improved tenant satisfaction, and energy efficiency.

Siemens is one of the world's leading integrated building services solutions providers of energy controls for buildings (Economist, 2010). The company bundles products and services together and offers guaranteed 'energy performance contracts' . Siemens defines smart buildings as:

'A safe, secure, reliable building, campus, manufacturing, or production facility that efficiently and productively consumes purchased or created onsite, electricity, natural gas, renewable, other fuels, and water, in a integrated, holistically planned and day-to-day executed, environmentally friendly strategy, from its initial green field design, through construction, migration, modernization, until retirement/demolition, that provides a acceptable return-on-investment.' (sugay, 2010).

How do these definitions of smart buildings compare with sustainable buildings? The International Energy Agency defines sustainable buildings as:

'*Those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting.*' (IAE, 2001).

The definitions of a smart building and a sustainable building have significant overlap when it comes to energy efficiency. Furthermore, given that 40% of the world's energy is consumed by buildings (IEA, 2002), smart buildings have the capacity to contribute significantly to sustainability.

MANAGEMENT INFORMATION SYSTEMS

The collection of information technologies that the construction industry can now take advantage of for building design and operation come under the umbrella of Management Information Systems (MIS). Recently a top-level, human-collaborative component of MIS has been identified as Integrated Project Delivery (IPD). IPD can be used for new build but it can also be used for retrofitting and refurbishment projects. IPD is defined by the American Institute of Architects as:

'*A collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase*

value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.' (AIA, 2007).

IPD typically uses collaborative software and internet-based software on demand, avoiding firewall issues between users. The value of collaborative working through web methods for improved efficiency and innovative working is highlighted by Taspscott and Williams in MacroWikinomics (Taspscott & Williams, 2010), and they quote Google CEO Eric Schmidt:

'Organisations that learn how to participate in (networks) can access a greater diversity of thought and talent than they could ever hope to marshall internally. Collaborative innovation is now an essential skill, as important as budgeting, R&D, and planning.'

Building Information Modelling (BIM) can be used in conjunction with IPD to offer increased communication and team efficiencies. For an advanced smart building project execution, the 3D model and building component data held in a BIM system can be used in conjunction with a Building Management System (BMS) or a Building Energy Management system (BEM) to operate the building. These systems can in turn integrate with Distribution Management Systems (DMS) for greater running efficiencies at a precinct or citywide scale.

Information aesthetics

The information technologies that comprise MIS have numerous human-computer interfaces (HCI – also known as human-computer interaction). Information aesthetics is an important dimension of HCI and hence MIS. Information aesthetics relates to the visualization and communication of information numerically, visually or symbolically for a computer system or application user.

Tractinsky, N. (2004) sets out three reasons why information aesthetics is relevant to information technology: 1) for many users, it is the critical aspect of interaction; 2) our evaluations of the environment are primarily visual, and the environment becomes increasingly replete with information technology; 3) aesthetics satisfies basic human needs which are increasingly supplied by information technology. Tractinsky also describes five categories of variable that exist within an information aesthetic framework: design characteristics, aesthetic processes, aesthetic evaluations of IT, outcome variables, and moderating variables. These variables collectively define the impact that information aesthetics has on user behaviour.

The positive benefits on decision making through affect – which is an aesthetic response type – in complex situations has been demonstrated (Isen, 2001). There is also research that highlights the significance of graphics in managerial decision making (Jarvenpaa & Dickson, 1988), as well as the user's acceptance and intention to use information technology (Davis, 1989).

ENERGY PLATFORM FOR A NETWORKED PRECINCT

In the context of energy use and conservation it is well understood that resource sharing can be advantageous across multiple buildings, but less is known about the potential benefits of *energy knowledge sharing* across buildings. Such knowledge relates to patterns of energy use based on: core 24/7 activities, seasonal cycles, and irregular events, the physical characteristics of a given building, along with the mechanical, lighting and services systems,

and external environmental data such as location and orientation. Effective decision-making environmental tools should allow a user of such a system to evolve solutions as well as understanding the problems (Williamson, 2003), and users should be able to explore 'what if' scenarios to investigate the impact of changes, and where those changes offer the best return when compared with a range of metrics.

Under the umbrella of MIS, retrofittable Energy Management Control and Information Systems (EMCIS) running applications such as the Siemens InfoCentre Suite® effectively inform where efficiencies can be made (Yee, 2004). Consequent upgrade options for individual buildings can follow, for example in terms of financial and/or CO_2 cost-benefit analyses. Upgrades of existing buildings can take place in many ways. These include: insulation, more efficient HVAC, heat-recovery, natural ventilation, building-integrated renewable energy devices, architectural components, passive solar architecture and spatial design. Additionally, a building or group of buildings within a single organisation can be improved in a site-wide context by systems such as trigeneration combined cooling, heating and power generation. These approaches offer significant improvements in energy use; the question is whether knowledge sharing can extract further notable savings. The sharing of energy data across buildings with different owners/operators is atypical, but offers the advantages of balancing demand across facilities, right-sizing technology components, intelligent planning and device usage pooling – particularly for smart buildings with energy storage and generation capacity.

The first phase of a planned city energy information platform for networked precinct buildings for Sydney, Australia, would be a process tool to facilitate such efficiencies. The visualisation components of the tool will be user-centered, but could also include a real-time public viewing system for energy awareness that can be used in building lobbies and public places.

The choice of a precinct is to allow several buildings to be part of the investigation, thereby differentiating from a MIS for a single building. Furthermore, the precinct can then be upgraded to be part of a smart grid within the confines of the precinct, or as part of a city-wide smart grid. This again offers a phasing route, on the basis that fully functional citywide smart grids are a number of year away. The city infrastructure has been discussed and this has a critical impact on the extent to which precinct-wide energy management is possible, as well as integration into a city's energy management.

For the phases of the energy platform to be successful, the measurement of where energy losses occur within the precinct buildings is vital, as opposed to simply the energy use. This requires extensive use of sensors and monitoring at a very granular level. This is where the EMCIS technology comes into play. The energy platform MIS should also permit the iterative development of the best possible associated information aesthetics through a user-centred design method (ISO 13407: Human-centered design process).

Six important considerations relating to the energy platform development are:

Stakeholder engagement: the demand-side stakeholders in a proposed energy platform would be developers, operators, tenants, city-wide authorities. The supply-side stakeholders would be systems suppliers and integrators, consultants, energy companies.

System and service design: energy use, energy prediction, energy efficiency, environmental responsiveness to location, knowledge sharing, information aesthetics, public visualization, internet technology.

Understanding retrofit hierarchy (listed as easy to hard): awareness, training, retrofit, smart grid, urban rebuild, new build (the typical focus on new build makes the least contribution).

Facilitation: visualising and communicating to stakeholders, modeling, integrated energy technologies, knowledge bank, new power management methods.

Economic benefits: Australia's National Objectives, competitive advantage for industry partners, understanding of 3, 5, 10+ years on financing and environmental benefit.

Strategic questions: what components are missing or needed to achieve it? What are the benefits of products, systems, services? What is the sensitivity of the options - value and effort assessment? Where are the technology gaps, ie: where is there is demand? What are the barriers to demand?

Stakeholder participants need to supply data from themselves and their energy providers, to allow the platform to model and visualize existing energy flows and usage in their buildings at a macro scale and relate this data to environmental climatic change and time cycles. A user platform and information architecture must be established, running the system using live data with real time stakeholder control. Data visualization nodes would be established in buildings and possibly for a public smart phone 'app'. A prototype platform comprises hardware, network and software for user testing and revisions to interface and functionality with prototypes located in each participant's building. During the location of the device, as well as measuring energy use, it would record data such as on energy information download use, collaborative aspects, and frequency of use of the device.

CONCLUSION

Over the last 20 years, major efficiency improvements in manufacture and supply among businesses in developed countries has come from computerised supply chain management – accelerated by uptake of web-based processes and Systems, Applications and Products (SAP). These effectively relate to efficient and effective use of information to streamline and re-organise functional physical processes that are already in place. In other words, the improvements are knowledge-based.

Networking now provides an opportunity for building efficiency: much of the physical infrastructure of existing building stock has to remain for economic reasons, and the vast majority of Australia's major city buildings are more than 5 years old. However, the continuous use of usage information to extract efficiencies, coupled with retrofitting, can produce energy improvements for existing buildings along with new build.

By setting out the context and future developments in the built environment, the paper has shown that there is value in a city energy information platform for networked public and commercial buildings as a process tool to facilitate energy efficiencies. The paper has set out the scoping for a program that would include site experiments and prototype evaluation in Sydney, Australia, planned during 2012-14 in collaboration with [name] corporation. The energy information platform tool envisaged would utilise the latest real-time information

aesthetics techniques in visual interfaces for use by the range of building stakeholders, as well providing a web-based viewing system for energy awareness that can be used in building lobbies, public places, or on the web.

Smart cities can be constructed from scratch and these are now emerging. The most notable examples under construction listed by the Economist (Economist, 2010) are: Masdar in Abu Dhabi using Siemens technology for 40,000 people and built on a raised platform with all services below; Songdo City near Seoul for 65,000 people with fully wired building devices by Cisco; PlanIT Valley near Porto in Portugal for 150,000 people using prefabricated parts with built-in urban IT infrastructure. While these new smart cities may point the way to the future of construction, with the bulk of cities already built the emphasis for many generations will be on retrofitting or replacing existing infrastructure.

Ultimately, smart buildings are needed to provide all the data for effective use of a smart grid. But as a prequel to the smart grid, smart buildings can provide energy savings now and also share information to help owners, occupants and operators to improve energy efficiency. As such, there is value in developing such a phased energy platform. The long term goal would be to provide energy saving across the city, encouraging businesses and raising the 'digital hub' profile of Sydney. The project could be scaled to other cities in Australia with an end goal to help meet Australia's national CO_2 targets over time.

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INTELLECTUAL CAPITAL MODEL DEVELOPMENT TOWARDS ADAPTIVE RE-USE SUCCESS: AN ANALYSIS ON HISTORICAL DEVELOPMENT OF CASE STUDIES

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Abstract
Adaptive re-use can be a significant strategy for achieving sustainability as it ensures a continuous building life-cycle and prevents it from destruction. Adaptive re-use projects have their own unique environment and specific challenges to ensure success. There are complex designs and construction problems unique to adaptive re-use projects thus specific skills and expertise are required. As Australia's building stock ages, more and more attention are being turned to adaptive re-use projects and the critical factors towards its success. The literature review identified and regarded project management as a critical success factor for these projects. Given the extremely complex and conflicting construction challenges we contend that construction management is a critical success factor. The aim of this paper is to identify the unique problems in the adaptive re-use process of historical buildings. It is a highly specialized field with significant learning accumulated and significant levels of intellectual capital created within the project teams. Two case study projects with similar project teams are examined to explore the relevance of the concept of reflexivity. We propose an intellectual capital model for project success to understand how to capture, transform and accumulate intellectual capital within project stakeholder's communities who are dedicated to adaptive re-use projects. The model is a step towards the development of a practical construction management methodology grounded in theory and empirical observations.

Keywords: Adaptive re-use, critical success factors, knowledge management, intellectual capital, case study methodology

INTRODUCTION

In late 1970s to early 1980s, the Australian Council of National Trusts defined 'recycling' as the best method to protect and maintain the historical building with new uses (Latreille 1982). Approximately 106 adaptive re-use projects have been analysed within that time related to functions and the benefit of recycling. However, the data is no longer relevant to the present situation due to new era of construction industry.

Adaptive re-use project has the complexity of the design and construction aspects. As example, the complicated regulations and requirement, the complicated of the process and involve with multidiscipline with different background. This paper focused on the issues

occurred around the complexity of adaptive re-use projects. According to Ball (1999) and Kurul (2007), lack of professional expertise in the adaptive re-use project leads to project failure. The cause of the project failure is that there is no expertise to reduce or overcome the complexity during the transformation process. In addition, incomplete and inaccurate design information also contributes to the complexity of the process (Shipley, Utz and Parsons 2006; Karim 2007). The reason behind this complexity is dealing with historical elements that need to be treated with care and skill. The empirical observations discussion on unpredictable circumstances elements is not included in this paper and it will be explored further in the interview data collection and analysis (second stage) of the study. This study will attempt to make two contributions towards knowledge accumulation. Firstly, by defining a set of critical success factors in proposing an intellectual capital model of project stakeholders' in regards to overcome the complexity issues in adaptive re-use project. London and Chen (2004) defined intellectual capital as a collection of skills, experience, competences and knowledge in organizations. It generally explains that the accumulation of intellectual capital would involve human capital, organizational capital and social capital.

The case study analysis on knowledge accumulation of complexity issues and critical success factors is the second contribution in this study. This is considered as to show the critical link between the past, present and future adaptive re-use projects. The involvement of multiple disciplines of stakeholders is also a key element to this study. Their understanding of history and the method of collection, creation and transfer of knowledge will support the management of intellectual capital in adaptive re-use projects.

To overcome the issues of complexity, this study seeks to propose the model to managing intellectual capital of multidiscipline project team members through knowledge management initiative and critical success factors. This paper begins by discussing the literature related to the root of complexity in adaptive re-use and the critical success factors. Since this paper is an on-going PhD research study, this paper set a limitation where the experiences and views of multidiscipline stakeholders are not included.

LITERATURE REVIEW

Adaptive re-use

The terminology of adaptive re-use can be interpreted in many different ways; however, all of the definitions are inter-related. Adaptive re-use can be defined as building recycling (Latreille 1982) which involves unique and complex processes (Bullen 2007; Kurul 2007) without altering the building façade (Tatum 2003), changing the intent of structure, interior spaces and building functions (Gorgolewski 2008; Cys 2008) to meet modern user's needs (Clark 2008).

This paper defines adaptive re-use as a process of transformation of the functions, the structures and the fabric or building envelope of historical buildings to new and contemporary design and construction process. The process is complex and needs to be managed appropriately and skilfully as there are multiple project stakeholders that may involve directly or indirectly through a knowledge approach in relation to creation, transfer, learning and sharing of knowledge.

Complexity issues

Kurul (2007) argued that there are barriers in adaptive re-use because of limited project stakeholder's knowledge and understanding of adaptive re-use processes and thus led to

complexity. This means that the limited knowledge and understanding on the process can increase the degree of project complexity. It can also lead to other issues where there are lacks of skill of project stakeholders due to limited adaptive re-use of knowledge. Within the limited knowledge and expertise, the design and construction confrontations or problems are impossible to be well managed. According to Shipley, Utz and Parsons (2006), lack of expertise of the design team can lead to poor design and cause client dissatisfaction with the design. It is considered as serious issues and makes it vulnerable towards the entire adaptive re-use project.

Inaccurate and incomplete information about the history of the buildings and the related information on design could contribute to the complexity in adaptive re-use project. It can be exemplified as inconsistent specification of workmanship and material clauses and such internal risks can affect the project implementation and project performance. Typically, the complexity in adaptive re-use project is mostly related with design development. Pham (2006) stated that incomplete information during the design process is the source of complexity in adaptive re-use projects. The similar issues were stated by Gorgolewski (2008) that lacking clear information would provide a challenge to the architect in the early phases of design decisions and contribute complexity to the entire process. It is important to investigate and locate the original information, as it will reflect the design decision. Any delay would cause the architect to require more time in preparing the design and negatively affect the whole project schedule. This relates with issues on the project management processes such as insufficient time of completion and risk of losing a historical significance of the original fabric resulting from negligence (Karim et. al 2007).

Differences in practice and discipline of multidiscipline stakeholders contributed to the difficulty in obtaining collaboration in making decision, especially in solving the adaptive re-use problems. An example of adaptive re-use problems that could occur during design development process is the design changes. Any further design changes will challenge the architect as it involves design amendments and increases the number of unscheduled meetings. Thus, it will effect on the project performance, for example, the construction project time and project cost will be extended from the original time and cost estimated (Ali, Kamaruzzaman & Salleh 2009). It is ideal if the architect has specialized experience in capturing the client's requirements, as they are unique building types. It is also critical that the design team has specialized experience and knowledge in heritage conservation. However, it is also important to all multidiscipline stakeholders to nurture and have the responsibilities to collaborate at any decision stage to avoid complexity to the entire adaptive re-use process.

On the whole, the lack of expertise, inaccurate and incomplete information and multidiscipline collaborative difficulties can be linked with understanding the critical factors contributed to the project success. As Baccarini and Collins (2003) notes, the critical success factors are important influences that contribute to project success. It can also enhance the ability of project stakeholders to forecast future project, identify potential problems and prepare the resources to the entire process (Khang & Moe 2008).

Critical success factors

Success in re-using historical building can be achieved through good planning at the early stage, followed by systematic process and full concerns by the project leader and project team to the project completion (Latham 2000). The systematic process involve with preparation feasibility study and building assessment on historical buildings. The role of project leader

and project team towards achieving success is related with the level of workmanship (expertise) and the collaboration. Since this study is related with historical buildings, this study presumes that preserving the historical value of historic buildings into new design is also critical factor for project success.

Feasibility study

Planning is an important stage for adaptive re-use process and possible creates the route of success to the projects. This is considered as the critical practice in planning stage is the preparation of feasibility study for the adaptive re-use project. The benefit of feasibility study by Watson (2009a) noted that "planning stage is related to how, when and where the project is to be carried out". Hence, as a critical factor for success, the feasibility study must be simple, flexible and contain accurate information for project resources such as material, workmanship and equipment for running the projects. Latreille et al (1982) suggested that to develop good feasibility studies, it is required and important to analyse all development cost including construction cost, new services cost, fireproofing cost and the degree of finish required. In particular manner such as delay in completion can also push up the development cost and need to be aware by the quantity or cost surveyor. It is related to cost planning for adaptive re-use projects and it should consider the initial cost and it is carefully distributed for the future running cost within the client's budget or fund (Watson 2009b). On the other hand, Watson (2009a, b) stated that the key to a successful adaptive re-use project lies on having no problems on cost thus the complexity of future adaptive re-use project can be reduced or avoided.

Building assessment by qualified and expert teams

Clark (2008), a professional project manager in Baltimore, United States mentioned that the investigation and assessment of the building condition by qualified and expert teams is a step to project success. A good assessment can help to reduce the unpredictable circumstances and avoid costly problems.

Good workmanship

The actual work on site must be performed with a high level of expertise to avoid errors and poor workmanship. Most importantly though is that with existing buildings, a level of adaptability and creative problem solving skills are required from the construction teams because often unpredictable circumstances can arise as redevelopment unfolds. A responsive attitude to such a creative construction problem solving environment is critical to project success. Clark's experience with adaptive re-use project proposes steps to success, but it is not associated with knowledge approach to project success (Clark 2008).

Collaboration

According to Roecker (2008), a potential critical success factors in adaptive re-use are to have the project stakeholders' collaboration and the historical dynamic. The collaboration refers to multiple partners and users involvement to adapt to the architecture and history in sustainable revitalization as input in design decision. Later, Clark (2008) also defines that a high level of collaboration between professional experts including the client or project manager, architect, contractor, historic conservator and the local preservation office as critical for adaptive re-use success.

Preserve the historical value of historic buildings in the new design

The history focused on the architectural that embeds spatial relationships within the buildings, meaningful information in the inter-relationships between environmental,

economic and cultural/social categories. The heritage building's history is to be interpreted in the context of contemporary design and in particular of a formal, spatial, structural, material and program (Roecker 2008).

In summary, complexity issues and critical success factors elements that contributed to intellectual capital model in this paper are as follows:

1- Causes of complexity
- Lack of expertise and knowledge in adaptive re-use
- Inaccurate and incomplete historical information
- Stakeholders collaboration difficulties

2- Critical success factors
- Good feasibility studies
- Building assessment by qualified and expert teams
- Good Workmanship
- Collaboration

3- Preserve the historical value of historic buildings in the new design

The professionals involved in adaptive re-use projects should integrate the context of complexity and critical success factors together with the higher level of skills as accumulative intellectual capital. This paper proposes that the accumulative intellectual capital on tacit knowledge about project complexity and critical success factors through human-capital based could benefit to the project success. Thus, this paper will develop the framework of adaptive re-use process within the knowledge approach that consist of the creation and transfer process of intellectual capital. The knowledge creation from intra-project knowledge and knowledge transfer to inter-project knowledge is necessary and important to continue and enhance the success of future adaptive re-use projects in intellectual capital approach.

Intellectual Capital Model for Adaptive Re-use Success

This section proposes a model of project success that supports the development of intellectual capital through critical success factors and the complexity issues (Figure 1). The model shows the importance of understanding the input by project teams in producing complex issues to enhance the experience and expertise of project stakeholders. The important point here is what and how they learn and share their tacit knowledge (experience and expertise) gained from previous projects within similar project characteristic. Experience and knowledge will critically enhance adaptive re-use project to ensure a continuous success. This model is composed of complex issues and proposed success strategy (highlighted from critical success factors literature) as a collection of intellectual capital elements. The following six components will explain how the intellectual capital relates with complexity issues, critical success factors and the connection of historical and architectural significance; providing knowledge creation (inter-project) and transfer (intra-project) for future references to enhance the project performance and promised success.

The Project
Critical Success Factors Strategy
Complexity Issues
Sharing and Learning

Knowledge Creation and Knowledge Transfer
Intellectual Capital

The Project

The Project represents adaptive re-use project that includes design and construction activities in relation with preserve the historical value of historic buildings in the design decision for new functions. It consists of the challenges and critical success factors strategy to achieve project success and provide existing intellectual capital for an adaptive re-use project. It will then utilise the strategies of the stakeholders through the process of sharing and learning to undertake the complexity. All created knowledge shall then be transferred to the intellectual capital of the project and serve as valuable information for future reference. This is particularly important and beneficial for the stakeholders who may be working back together to enhance the future project performance. It will also benefit project stakeholders who may not be involved with similar project previously as added knowledge in managing the design and construction process and challenges for future projects.

Critical Success Factors Strategy

At this stage, expertise can be assessed in terms of multidiscipline's experience and qualifications in carrying out the projects. Expertise may increase the creativity in providing design, highly skilled in managing the construction and high quality of workmanship in relation to heritage factors. It is also extended expertise in identifying all the channels that could provide source of information on historical buildings in helping to provide the best result for the entire development process. Establishing collaboration among multidiscipline project stakeholders is considered critical to achieve a consensus on the result of good design and construction.

This study also contributes new knowledge in intellectual capital by proposing process-based factors in relation with feasibility studies and building assessment on the historical building condition. This is the unique characteristic of the model suggested by this study, as it is not applicable in common projects. It is very critical for multidiscipline stakeholders to have the excellent knowledge in preparing two important documents for adaptive re-use project. First, provides good feasibility studies in relation with controlling the cost from initiation stage to the occupation stage since this type of project is full of surprises and unpredictable circumstances (Clark 2008). As well as providing good building assessment on structure and fabric could give the benefit to the new functions in terms of safety. The argument is not every multidiscipline stakeholder could prepare good building assessment without specific expertise in this process.

Complexity Issues

The issues in this model that are synthesizes from literature review are lack of expertise and knowledge in adaptive re-use, inaccurate and incomplete historical information and stakeholder's collaboration difficulties.

Sharing and Learning

The group should develop an understanding on the key problems to solve and develop approaches to solving future problems through the development of a particular group culture. Knowledge sharing is critical factor in achieving organization's success (Cohen & Levinthal 1990 in Jasimuddin 2008). Knowledge is important in the historic environment because transforming historical buildings is full of richness in interpretation. Shared understanding about the importance of history in relation to the building, hence history of the area and

history of the building is significant and a shared understanding and respect for this amongst the stakeholders is critical.

Hence, it is important to identify that there is a history with some of the key stakeholders and project team members associated with adaptive re-use projects. The project stakeholders in many cases may have developed a shared learning capacity over time within the group. As often it is a specialized, small and unique market segment, a group may have previously collaborated and carry out all the activities and processes of adaptive re-use projects. This is an ideal situation whereby the teams can capture what they have learnt from past projects and share their knowledge to the current project.

Knowledge Creation and Knowledge Transfer

An important part of understanding the creation and transfer of knowledge within a shared professional collaborative environment often comes with a shared history. It is important to identify a working history with some of the key stakeholders associated with adaptive re-use projects. The group may have developed an intellectual capital which is then aided by past project completion. Past involvement in adaptive re-use processes particularly during design brief development makes it much more comfortable to confront the problems related to design creativity and flexibility, design information and stakeholders' collaboration for the current project in hand. As it is with a new and different project, new approach and solution are created and later transferred into the intellectual capital for future project undertakings (Senaratne & Sexton 2011).

Intellectual Capital

It is an accumulation of information, knowledge of issues and solutions. Identifiable approaches in handling a situation and many other valuable inputs that are generated by actual experiences. The intellectual capital would serve as the main reference for having a better outcome with a faster response time due to its prior occurrences in other similar projects.

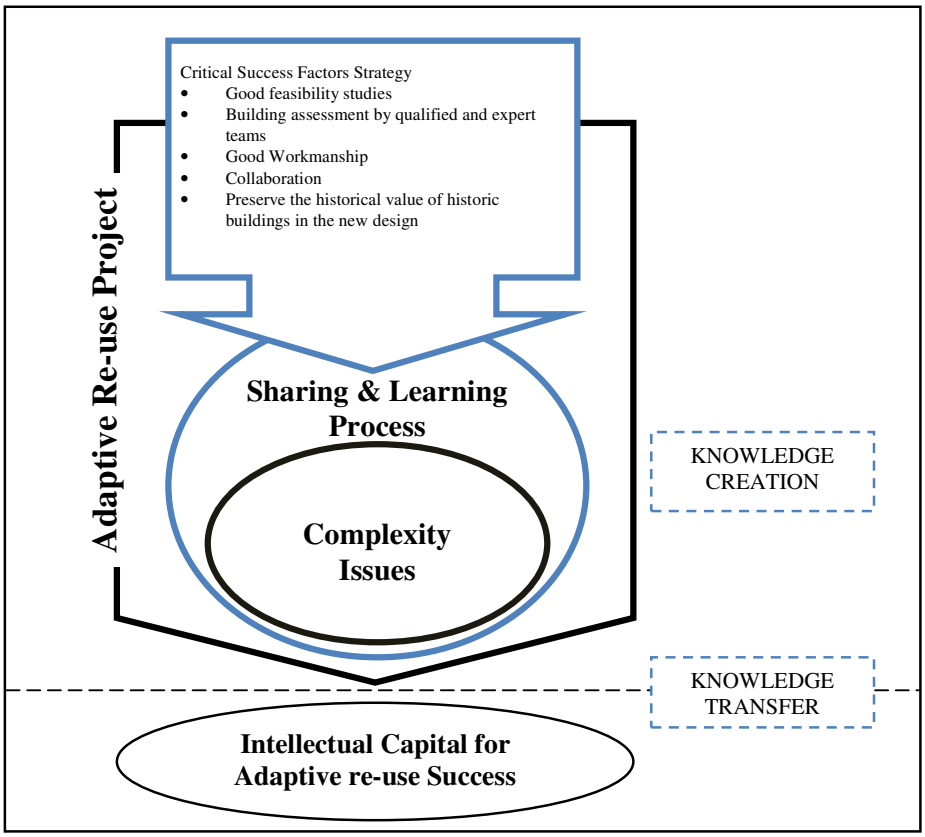


Figure 1: *Intellectual capital Model for adaptive re-use success*

The knowledge created and transferred reflects the different backgrounds of project stakeholders and impacts upon how they individually and collectively approach the current issues. Shared understanding about the importance of history in relation to the building and the area is significant and a shared understanding and respect amongst the stakeholders is critical.

Research questions generated from the above model based on the findings from project management and adaptive re-use literature and need to be tested in related case study are as given below.

1. To what extent does 'historical' knowledge contribute to the combined intellectual capital on adaptive re-use projects?

2. How do stakeholders experiences contribute to the intellectual capital required for adaptive re-use project success?

The research question one, to what extent does 'historical' knowledge contribute to the combined intellectual capital on adaptive re-use projects will be answered in case study document analysis.

RESEARCH METHODOLOGY: CASE STUDY DOCUMENT ANALYSIS

This study is using a case study methodology using a qualitative data collection and analysis method. The methodological design for this study is summarized in figure 2. This study presents the exploratory and preliminary results and describes the data collection and analysis from the two case studies. The first step towards developing an understanding on the unity and wholeness of the particular case begins with developing a deep understanding of the history of the original buildings and the relationship with the historical development analysis

for adaptive re-use. The second step is an empirical study involving interviews with the multi-disciplines teams. However, this paper only focuses on reporting the document analysis. The historical documents that were reviewed were conservation management plans, contract documents, drawings and other related project documents. Two completed adaptive re-use projects in Geelong were selected and used and the detail of the case studies is explained in the following sections.

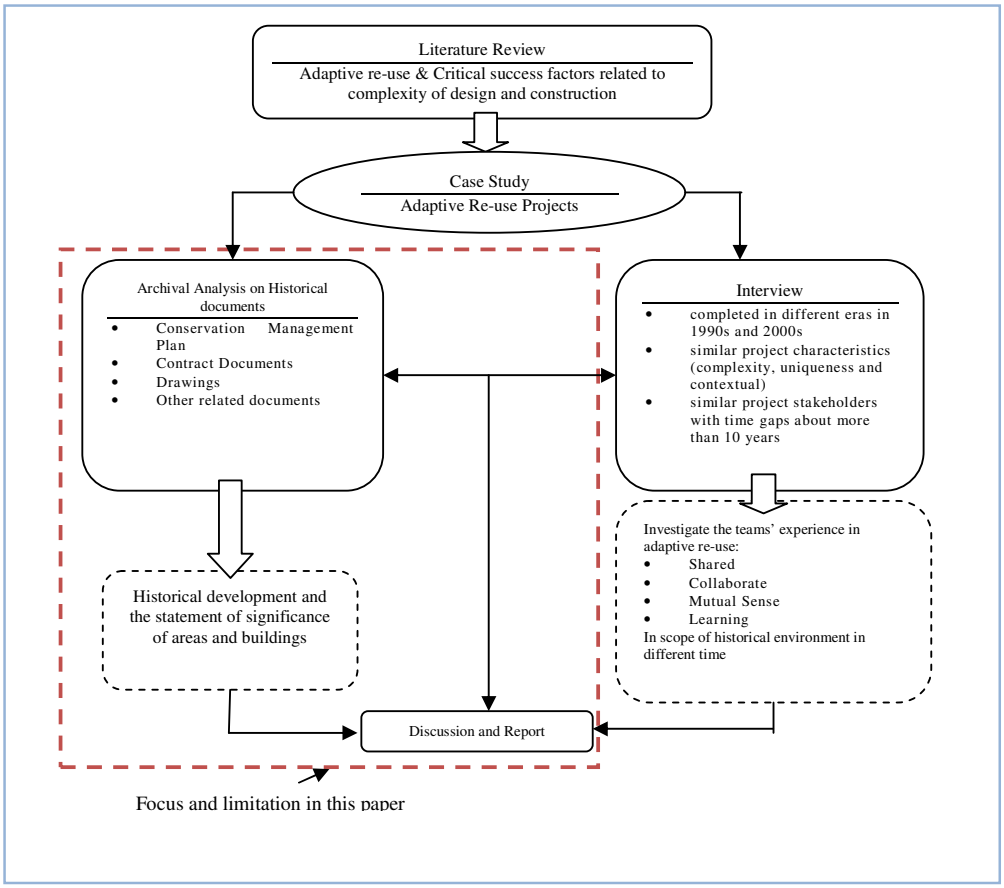


Figure 2: *The methodological design*

Case studies

A case study methodology was considered appropriate to explore the role of design management of intellectual capital as a mean to ensure project success. According to Kurul (2007), a case study approach enables us to develop a holistic and meaningful view of real-life events. It also facilitates "getting inside the project or the minds of individuals", to uncover explanations (Punter 1989, Larkham 1996 in Kurul 2007). According to O'Leary (2004), case study can produce a knowledge contribution in itself because a case study is unique and interesting with an intrinsic value. Through the analysis of case studies, we can begin to develop theory and exploratory case studies can bring new understanding. Most importantly, case studies can provide strong supportive evidence for a proposed conceptual model. The evidence from the 'real world' provides anecdotal evidence to support a theory. Besides that, the research provides concrete findings that will assist in generating a new theory in relation to project success for adaptive re-use projects. Once the development of the two buildings was completed, they were transformed from unused wool stores to a modern university. The redevelopment was undertaken in two different eras, 1990s and

2000s. The paper of course has limitations in relation to data collection and data analysis because the empirical study has not been completed yet.

Archival analysis

To support the data analysis from the interviews, the documents for both case studies will be used towards understanding the completed projects. The documents analysis in this paper has been used for the development application for approval and along with the project life-cycles until completion and occupation stage. The analysis on related documents is important as documentary is evidence that reflects on the importance and significance to the history of the area (Geelong, Australia) and the buildings (the former Dalgetys Woolstores and former Dennys Lascelles Woolstores) for adaptive re-use application. The discussion on the documentation analysis understands the historical value in regards to manage the complexity of adaptive re-use process. It is also related to the experience on knowledge creation and knowledge transfer to future projects and developed intellectual capital particularly for adaptive re-use success.

CASE STUDY DISCUSSION: ADAPTIVE RE-USE PROJECT OF FORMER WOOLSTORES TO UNIVERSITY

The importance of information or knowledge in the history of the original buildings in relation to develop a historical development for intellectual capital in adaptive re-use projects will be discussed in this section. The decision to develop Deakin University in the Dalgety Woolstores and Dennys Lascelles Woolstores is influenced by historical factor and the importance of protecting the historical heritage. According to the statement of significance in the Victorian Heritage Database states that "the architectural significance of this building relies on the retention of the remaining parts of the wool store complex". In this section, there are two significant relationships of Dalgetys Woolstores and Dennys Lascelles Woolstores are discussed.

Historical development of buildings: the adaptive re-use project background and the significant of former Dalgetys Woolstores

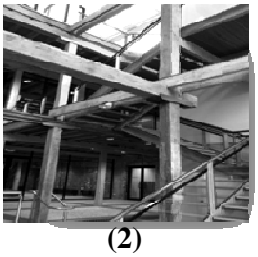
The Dalgetys Woolstores have been built through seven major stages. The building is four storeys and it was used and functioned as wool storage and business until the mid-1980s. In 1990s, the action to protect this woolstores was started with a national architectural competition to conversion of these buildings to appropriate functions. The design competition was held in May 1993 and the local firm McGlashan Everist won this competition with the function of a university. The refurbishment of the wool stores includes removal of the three floors of hardwood timber. The construction strategy that has been used by contractor is to maintain the structural conditions; the floor has been removed from the roof all the way down to foundation steps. The top floors have been used as scaffolding for roof refurbishment work. The architect for this project won the Royal Australian Institute of Architect's President Award for recycled buildings in 1997. The winning criterion was based on the following:

- The design and management skills of the architect and his team when dealing with client and contractor.
- The level of achievement of identification, maintenance and enhancement of the heritage value is quite high in this project. The merging of a existing and new components, provide comfortably and naturally into space and light quality for a different building function as been successfully achieved.

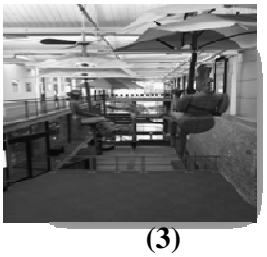
As evidence, there is collaboration and sharing attitude among the design team with other disciplines such as the contractor and at the same time oversee the interests of the client requirements and ensured a quality preserved historic value as stated in Conservation Plan prepared by Alan Willingham in 1994 based on building's condition assessment. The most important are the issues on design flexibility and information provide guidance, learning process and mutual sense in proposed the appropriate design decision for modern and smart university. As described in Authentic Heritage Services Pty Ltd Report for Local Government Planning Scheme, "the architect was reviewed based on their design and ensuring the retention of as much of the original building fabric as possible as part of their contemporary design" (Victoria, 2010). This is important of blended the knowledge about design and cultural significant related with historically and architecturally in the development of intellectual capital for future re-use projects.



(1)



(2)



(3)

Photo 1: *the front view (external) of former Dalgetys Woolstores; the signage, the parapet and the external wall were maintained*
Photo 2: *inside the building, the timber structure were maintained and merged well with new staircases*
Photo 3: *inside the building, view from the 4th floor*

Statement of cultural significance in Authentic Heritage Services Pty Ltd report was prepared by Dr. David Rowe, the heritage advisor for the City of Greater Geelong, stated that this building have architectural and historical significance at a LOCAL level. "The architectural significant attached with design qualities that associated with the late 19th and early 20th century of Dalgety and Company Limited Woolstores". The design qualities includes redbrick external wall and parapet wall, roof and the rainwater downpipe, lintel above openings, doors and windows and the signage of "Dalgety Company Limited" need to retain those remaining parts of the wool stores complex. The report also stated that "the historically significant building are associated with the development of the Dalgetys Woolstores from 1891, 1929 and 1940 and parts of the building also have associations with the Geelong architectural firm of Laird and Barlow, and later, Buchan Laird and Buchan" (Victoria 2010).

Historical development of buildings: the adaptive re-use project background and the significance of the former Dennys Lascelles Woolstores

One of the largest wool stores was erected in adjacent with the Dalgetys woolstores in 1934. The original plan of Dennys Lascelles Woolstores is to accommodate more than 25,000 bales of wool which cover over 3.5 acres of floor space. The Dennys Lascelles Wolstores was equipped with lifts and modern wool-handling appliances (Victoria 2010). The Dennys Lascelles building was constructed by C.J. Taylor and Sons in May 1934 based on a design by Buchan, Laird and Buchan.

In 2009, the six storeys of the Dennys Lascelles Woolstores have been redeveloped for new functions as the Alfred Deakin Research Institute, the Deakin Geelong Health Precinct and the Alfred Deakin Prime Minister's Library. This section of the wool stores complex was officially opened as Deakin University on 10 June 2009. The project cost to refurbish 1934 sections was approximately $37M AUD and was a joint project between Deakin University and the Victorian and federal governments. On the other hand, the collaboration, sharing and mutual sense existed at the beginning/early stage. This project was also funded by the Commonwealth and Victorian Government who provided approximately $15.6M each. The project started on October 2006 and was completed in 2009. The project manager was the Facilities Management Services Division at Deakin University. Again, the architect responsible for the design of former Dennys Lascelles is a local professional architect, McGlashan Everist. This study assumes that the project stakeholders (focused on architect, project manager and contractor) applied and developed the knowledge transfer and knowledge creation through the attitudes of learning, collaboration, sharing and mutual sense among multidiscipline in Dalgetys Woolstores project in 1993 until 1996. This refurbishment project has been constructed by Wycombe Constructions. Thus, future stage in this study is to explore the intellectual capital among multi-disciplines stakeholders in managing the adaptive re-use stages from both projects.



(4)



(5)



(6)

Photo 4: *the external view of the former Dennys Lascelles Woolstores, more creative and well merged between the existing external walls with wall cladding*
Photo 5: *the internal view, new staircases inside the existing brick wall and timber floor*
Photo 6: *the internal glass partition with the face of former Prime Minister Alfred Deakin (1903-1910) /after the building/ is for The Alfred Deakin Prime Ministerial Library of Deakin University*

According to Authentic Heritage Services Pty Ltd report, the heritage advisor for the City of Greater Geelong, the former of Dennys Lascelles Woolstores have cultural significance which is architecturally significant and historically significant at a LOCAL level. Architectural significant demonstrates some original interwar qualities on unpainted and redbrick external wall, windows, doors and the signage below the parapets wall that stated "Dennys Lascelles Ltd Woolbrokers". It also relies on the retention of the remaining parts of the wool stores complex. The report also mentioned that "historically significant is associated with the development of the Dennys Lascelles Ltd woolstores from 1934, and in more recent years as part of the Deakin University Waterfront Campus" (Victoria 2010).

As a summary in the case study discussion, the Dennys Lascelles woolstore has proposed to create an exciting multipurpose environment, providing light filled spaces of varying dimensions. The historical value of this building merges with technology, and environmental

sustainability as a critical part in design development for Dennys Lascelles that the stakeholders learned from Dalgetys woolstores. The location of this building at well-known corners and waterfront views also provide /the answer/ that understanding the history of the area (surrounding) and buildings itself is important and critical in the way to get the intellectual capital. The decision on designing Deakin University is under historical influences and its importance of protecting the architectural and historical significance. According to the statement of significance in Victorian Heritage Database stated that "the architectural significance of this building relies on the retention of the remaining parts of the wool store complex". This study provides assumptions that the knowledge creation in Dalgetys projects has been transferred as accumulative intellectual capital or knowledge to achieve project success.

CONCLUSIONS

This paper considered lack of expertise and knowledge about/on adaptive re-use, inaccurate and incomplete historical information and the difficulty of getting multidisciplinary stakeholders collaboration could cause difficulty to achieve adaptive re-use success. However, this study suggested critical success factors strategy which could provide intellectual capital for multidiscipline stakeholders as the best strategy to overcome the complexity and achieve success especially for the difficulty of transformation process. In relation with the case study preliminary analysis on the contribution of 'historical' knowledge, there were initial findings that critical success factor is in used in the beginning process. As for example, the architect used his expertise to define the sources of historical information for design purposes and to get development approval particularly, information on assessment of buildings significance. The critical success factors are identified in case study is collaborative problem solving according to the winning criteria "the design and management skills of the architect and his team when dealing with client and contractor". However, there is an assumption for this study that this project has prepared good feasibility studies, building assessment by qualified and expert teams and good workmanship for the construction process. There is little theoretical development and empirical research in relation to developing an intellectual capital influenced by critical success factors to overcome the project complexity. We began exploring the proposed Intellectual Capital Model for adaptive re-use projects success into two heritage listed buildings which were located in an Australian city adjacent to each other and had architectural and cultural heritage significance and were developed more than ten years apart largely by the same project team and client. The document analysis provides substantial background towards understanding the nature of the projects within a case study research methodology. The document analysis is ongoing. This paper has served to described the historical characteristics of the project in order to give an indicate the scope of knowledge, expertise, collaborative problem solution skills required in order to respond to the complex design and construction issues that may have arisen.

Further research

This study is a part of an on-going research for a PhD on the critical success factors and intellectual capital in the adaptive re-use projects. The chosen case study provides the guidance in establishing research aims and identifying research questions for knowledge creation and knowledge transfer from one project to another. In addition, it also gives attention to investigate what happened in the time period between project 1 and project 2 in terms of knowledge gained from experience and other external factors.

The contextual background of the two adaptive re-use projects provides a unique situation to explore the knowledge and skills gained from internal experiences (inter-project knowledge and intra-project knowledge) and external experiences (from external sources during the gap between completion time) that contribute to the development of intellectual capital within the project team members. We propose three situations that could contribute to the pool of intellectual capital of adaptive re-use projects (Figure 3).

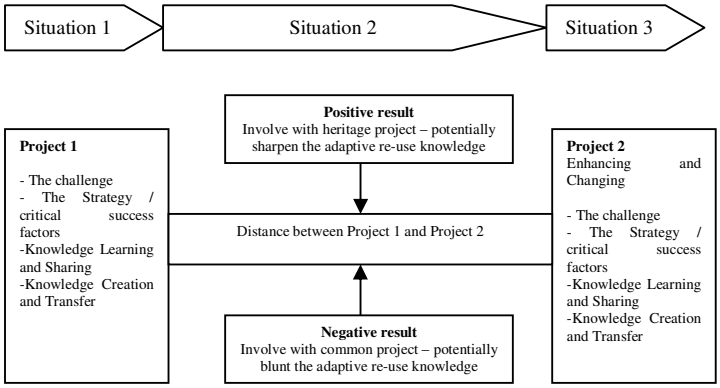


Figure 3: *Summary of on-going research framework*

Situation 1 is what and how knowledge creation in project 1 managed. How project stakeholders understands historical significance of the building and area towards integrating client requirements with existing structure. It also involve with design review approach in preparing the document for development approval on historical buildings. Other specific identification in project 1 is how the project stakeholders overcome adaptive re-use issues during the processes of changing the building functions, the steps taken to solve the problems and the approach taken in knowledge accumulation and management within human-based capital and historical dynamic capital. However, the potential critical success factors of adaptive re-use projects remained as intellectual capital mechanism in this study.

The distance or gap between project 1 and project 2 is the second situation in this study. The aim is to investigate the knowledge contribution from project 1 and the distance period. The positive assumption was a better knowledge on heritage when they were involved with related heritage projects. The negative assumption could be a blunt of their knowledge on heritage due to their involvement with many common projects within the year gap. It could influence the knowledge creation and knowledge transfer to project 2 when the similar stakeholders are working back together.

Situation 3 involves with project 2 that started more than 10 years after project 1 was completed. The investigation on knowledge impact from project 1 successful criteria and the knowledge change (positively and negatively) from the distance period is critical to understand the intellectual capital in human based capital and historical dynamic capital. The interconnection between situation 1, situation 2 and situation 3 results could be providing a dynamic managing approach in managing the intellectual capital uniquely for adaptive re-use project.

This study will further embark on the empirical phase and face–to-face interviews with project team members, the client, and document analysis on key project documents. To ensure the validity of the situations, the project manager, client, the architect and the

contractors chosen are of the same person for both projects. The empirical data analysis will seek to refine the conceptual model proposed and evaluate its effectiveness in relation to critical success factors for multi-disciplinary design management with different backgrounds, skills and knowledge for continued success of future adaptive re-use projects.

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RESEARCH METHODOLOGIES FOR STUDYING THE INFORMAL ASPECTS OF CONSTRUCTION PROJECT ORGANISATIONS

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Abstract
The complexity inherent in construction project environments can lead to emergence of informality and vice versa. This paper suggests that studying informalities in projects could lead to identifying paradoxes. Informalities in construction could be conceptualised through an economic or social perspective. Informalities may be explicit and visible, or simply implicit and thus invisible; commonly encountered in projects or specific to a particular project's context; ethical/legal or unethical/illegal. These dimensions suggest a framework within which to describe the emergence of a project's organizational behaviour. Non-functionalists and subjectivists argue that the informal issues are best understood through subjectivist paradigms. This paper presents an approach to the design of research approach appropriate to such tasks. In doing so it accommodates various philosophical perspectives, and the blending of various methods, to construct rigorous analysis to deliver context specific outcomes. It is argued that conceiving informality through alternative methodologies such as hermeneutic-emancipation and critical realism-semiotics offers opportunities to study informality in a meaningful way. Moreover, a design that combines multiple research strategies, e.g. case studies-ethnography, case study- ethnomethodology, is most suitable for informality investigations. It is suggested that operational aspects, such as ethical protocols and participant's concerns, are taken into consideration in the design of a research methodology.

Keywords: informality, methodology, method, construction.

INTRODUCTION

The complexity perspective of projects (Bresnen, Goussevskaia, and Swan 2005; Marrewijk et al. 2008; Baccarini 1996; Remington, Zolin and Turner 2009) and paradigm shifts in qualitative research methodologies (Denizen and Lincoln 2005) has enabled alternative conceptualisations in the study of construction projects. It is argued that the connectivity and interdependencies between the multiple systems in projects, operating in uncertain, ambiguous and dynamic environment, pose the difficulty in understanding and predicting the projects overall behaviour (Geraldi 2008). The interdependencies occur between a number of sub-systems including, organisational, technical, social or social systems. Increasing recognition of the role of fussy socio-cultural-political environments in management of project, necessitate understanding projects as socially constructed realities (Cooke-Davis et al 2007; Small and Walker 2010). Moreover, studying complex connections between the systems can develop insights into project behaviour; including issues relating knowledge sharing; communication and relationships building etc. However, such studies can be challenging when the complexity underpinned by informal and shadow elements in the project organisations. Some of the informal issues that could create chaos in projects may not even be visible to warrant an inquiry or hinder at times hinder research studies (see Small and Walker 2010). Moreover, paradoxes emerge when irreconcilable contradictions exits between systems, including between elements of formality and informally (Bourne & Walker 2005; Alderman & Ivory 2007; Baresnen 2009). This suggests that studies into informality could assist in understanding project organisations as complex systems while providing an opportunity to identity paradoxes.

Recently the interest in 'informality' research in the construction management discipline has gained significant attention (Chan and Räisänen 2009). The need for such a research focus arises from the recognition of inadequacies in the current approach to studying construction organisations (Dainty 2008) and gaps in developing meaningful understanding or solutions to some of the complex issues (Berggern and Soderlund 2008; Moldoveanu 2004) facing construction. This trend can also be attributed to a movement that is seeking to understand projects as socially constructed realities. This provides much-needed subjective relevance while maintaining high levels of dependability, authenticity, transferability and auditability (O'Leary 2004).

The key element of 'informality' refers to the informal, casual or unofficial activities that occur in business firms, industries, societies and the economy as a whole. The conceptualisation of 'informality' is discipline specific, and in construction management informality is implicit in a number of research areas e.g. communication (Gorse and Emmitt 2007), safety practices (Lingard Rowlinson 2005), gender/ethnicity based research (Byrne, Clarke, and Meer 2005; Pink et al. 2010), procurement/recruitment practices (Bresnen et al. 1986), knowledge management etc (Senaratne and Sexton 2008; Bresnen 2003). These studies develop an understanding of key issues in projects, in the context of complex project environments with elements of informality.

However, explicit accounts of how to research informality in construction are limited (see Chan and Räisänen 2009, Rooke, Koskela and Kangioglou 2009). In this paper, 'informality' definitions from Economics, Urban Studies and Organisational Theory domains are reviewed to develop a conceptual understanding of informality. The conceptualisation is notably influenced by both economic and sociological perspectives, and subjected to alternative philosophical paradigms. As a consequence it seems likely that multiple worldviews of the

concept exist. While the conceptualisation presented in this paper is dominated by a sociological view, the economic view is briefly discussed.

The choice of an appropriate research paradigm in designing a strategy/method to study 'informality' is critical to produce meaningful outcomes. However it is equally important to accommodate the practicality of the research design. Aligning the conceptual research design to the operational research design is a frequent challenge faced by researchers (see Gorse and Emmitt 2007, 2009; Pink et al. 2010). In some instances practical execution of the most appropriate conceptual research design may prove impractical or impossible. The practical challenges can arise from the unwillingness of subjects to cooperate in the study (because of commercial sensitiveness, discomfort of participants of them been studied in-depth and profiled) and challenges posed by the national/institutional ethical protocols' (not allowing some pursuits based on privacy, risk, benevolence etc) (Australian Government 2007). This paper builds on the extensive intellectual debates that have taken place from time to time about the choice, relevance, understanding and adequacy of research methodologies when studying construction phenomena (see Rooke & Kagilogou 2007; Dainty 2008; Rooke, Koskela and Kagilogou 2009). Much of this debate is central to designing methodologies to study informality from a social perspective.

This paper explores three interrelated aspects critical for designing research approaches to study 'informality'. They are (a) a conceptual understanding of 'informality' in project organisations (b) the worldviews underpinning the ontological and epistemological positions relating to the concept of 'informality' and (c) the practical design of appropriate research methods to explore informality within various worldviews. These three aspects are reviewed in the context of selected studies that dealt with informalities in construction. It concludes by providing an overarching framework to identify appropriate research methods to study informality in construction. In doing so it consciously avoids prescribing the best approach to study different informality issues since the multiplicity of possible combinations of research approaches renders such recommendations as both naive and misleading.
To develop a meaningful understanding of the informality phenomenon a shift from the positivist paradigm is warranted. O'Leary (2010) suggests that "without an appreciation of how attributes, positions of power and privilege, and worldviews conspire to create subjectivities, researchers can easily fall into the trap of judging the reality of others in relation to their own reality" (p. 47). This could mean looking at the same issues with two different worldviews could lead to two different, but relevant and meaningful outcomes. The deeper the sociological perspective in the research approach, the greater the need for researchers to evaluate their philosophical predispositions when dealing with biases in constructing their research strategy, in order to improve the credibility of their research.

CONCEPT OF 'INFORMALITY': A REVIEW

'Informality' can be understood and defined from a variety of perspectives. By reviewing definitions and attributes of informality from other disciplines this paper develops a conceptual basis for informality for construction. The aim is neither to unearth the roots of 'informality' research nor to give an in-depth account of informality research in other disciplines. Rather it is to generate a broader perspective of 'informality' in order to to identify alternative paradigms/worldviews underpinning it. This provides an opportunity to develop research approaches that could unearth informalities that create paradoxes.
This informal sector was characterised by activities and people not being clearly identifiable. However, the essence of the informality discussions can be attributed to two perspectives-

economics and sociology. The migration of people (between countries or regions) caused situational changes to the society (attracting the interest of urban architects, sociologists etc) and often created informal sectors, which attracted the interest of economists (Alsayyad 2004).

The study of '*urban informality'* is about discovering the social actors and forms of social organization (Alsayyad 2004), and has similarities to organisational informality. Urban informality is 'a way of life [and] may be approached from three interrelated perspectives: the physical structure, comprising a population base; a system of social organization, involving a characteristic social structure and related patterns of social relationships; and a set of attitudes and ideas of individuals or groups engaged in or operating under forms of collective behaviour and/or social control' (Alsayyad 2004p.8). The research on urban informality focused on developing an understanding about the functions and structure of informal groups/enterprises. However, some studies looked into the nature of informalities. Alsayyad (2004) suggest that informality is theorised as a marginal activity that is (i) a temporary manifestation occurring as a transient feature within an organisation, or; (ii) closely connected to the formal structure and is an essential and permanent component of way of life. Here the research focus is more about understanding the meanings. Meyerson (1991) suggests that any ambiguity in meanings can create paradoxical situations that could lead to irreconcilable contractions.

Studies on *'economic informality'* focused on illegal economic activity (Parry et el. 2007) taking place "below the radar" of government. The illegal activities could take many forms including the activities of unregistered small firms, street labour and large registered firms employing workers without written formal contracts (Oviedo, Thomas, and Karakurum-Özdemir 2009). It is important to be precise as to what kind of economic informality is studied – e.g. unregistered firms, unprotected workers, or the self-employed- so that appropriate approaches can be devised to study the problem (See Lewis and Hosein 2006; Wells 2001, 2007). Inaccurate comprehension of the nature of the illegal economic activity could lead to suggesting inappropriate response strategies. Economic informality research has focused on: (i) Identifying and measuring informal economic activities; (ii) The impact of the informal sector on an industry and nation e.g. labour market, unemployment, productivity, GDP etc, and; (iii) Strategies for managing or controlling informal sectors e.g. regulation, legislation etc (Oviedo, Thomas, and Karakurum-Özdemir 2009; Parry et el. 2007). Here the focus is more on causal impacts of informality on economic outcomes and the effectives of regulation to deal with informality.

The conceptualisation of '*organisational informality'* is largely underpinned by a sociological perspective, while the economic domain is also acknowledged. Morand (1995) makes an interesting point about informality in organisational research, noting that the term is 'often used as conventional descriptors of social behaviour and social situations in organisation… [and] researchers generally have avoided rigorous attempts at construct definition and validation' (p833). He describes that the 'term, informal, and its accompanying noun informality, refer to social situations or gathering that are generally characterized by behavioural spontaneity, casualness, and interpersonal familiarly'. The distinction between informal and formal aspects of organisations translates into interpretation of artefacts such as dress codes, jokes, behaviour in meetings etc. However, his articulation of informality relates to interactional behaviours between actors in social construction and production; and the subsequent categorising of organisations (e.g. organic, inorganic, bureaucratic etc.) and their traits (e.g. innovative, agile etc).

The non-hierarchical, self-coordinated, new means of communication along with significant division of labour are all creating transient boundaries in the organisation and complex organisational setups. Informality emerging in this context is viewed as a contributor to creativity and innovation. It plays crucial role in developing links and trust among business partners operating in turbulent and uncertain business environments. Therefore, informalities can operate as a control mechanism offering flexible arrangements and fast solutions, where it is impossible to deal with all possible events formally. However, informality can also be seen as a threat to social justice (e.g. aiding discrimination) and hierarchical rules. Misztal (2000) suggested that creation of the Asian economic crisis could be attributed to the failure of 'informal connections' - such as nepotism, leading to a lack of accountability and transparency - as a way of doing business. He argues that informality is best understood when explicitly compared with formality and suggests that maintaining a delicate balance between formality and informality is critical for order and control in the new forms of organisations. The formality is described as structures, processes and protocols. This reinforces interactional nature of informality as proposed by Morand (1995).

Informality issues can be related to interpersonal relations, informal leadership, behavioural control and informal communication (Hodgetts & Hegar 2008). Activities associated with interpersonal relationships could include informal advice, trust, or communication. Informal leadership is associated with the development of power within non-formal structures: this may best be described as gate keeping or perimeter guarding. Behavioural control is a form of manipulation of members of an informal group using a variety of control strategies including establishing in-groups, coercion or persuasion.

INFORMALITY IN CONSTRUCTION: TAXONOMIES OF RESEARCH

Complexity, chaos and paradox in projects, at least in part, can be attributed to emergence of informality. The loosely coupled nature of project organisations (Dubois and Gadde, 2002) is a setup conducive for informalities to emerge. Informality in construction in the context of a firm, project or industry could be argued to be a blend of both economic and organisational elements. Chan and Raisanen (2009) have discussed the informality concept in the context of construction and identified a number of challenges facing researchers. In essence any of the informality issues examined within a construction organisation are related to its practices, structures/systems, or social groupings (e.g. "networks/clans of actors") in the context of a phenomena (e.g. knowledge generation, safety management, competitiveness, learning process etc). However, studies explicitly designed to study paradoxes or identifying paradoxes as part of research outcomes are limited in construction management.

It is synthesised that the informality research conceptualisation involves five aspects, and they influence the design of the research approach. However, subsequently it is argued that methodological paradigms also influence the conceptualisation of informality. This complex interactional process is disused later in this paper. This framework (ref. Figure 1), along with the methodological framework in the subsequent section (is Figure 2) is then used to review how the existing studies of informality are approached. This will assist to identity the research approaches practices in studying construction informality and possible alternatives.

Conceptual underpinnings

Using the above review potential directions for informality studies in construction can now be conceptualised. This conceptualisation is intended to serve as a guide in the choice of research strategies for informality studies. It suggests four related aspects underpin

taxonomies of informality research: Informality domain, Research issue, Legality/ethics of the issue and Informality visibility (refer Figure 1).

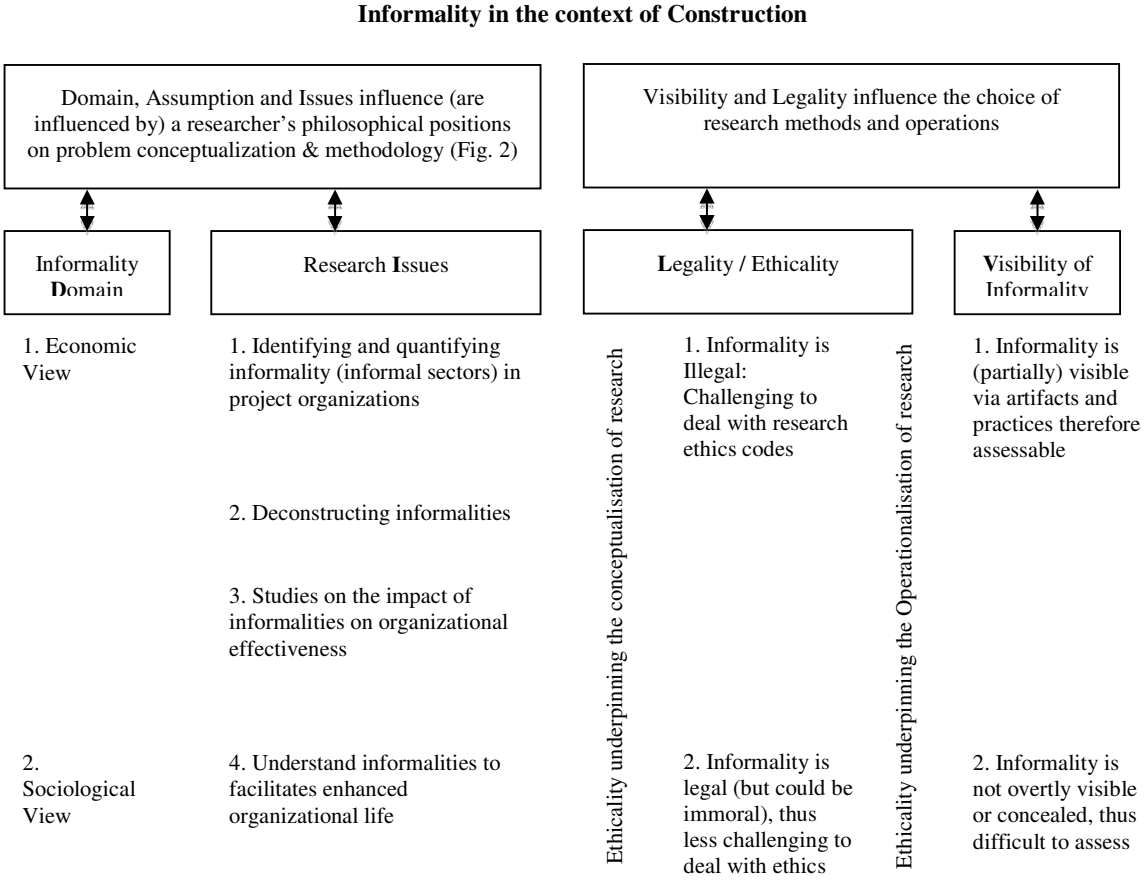


Figure 1: *A framework for conceptualising informality in construction.*

Informality Domain refers to the disciplinal - that is economics or sociology - attributes influencing the core conceptualisation of informality research. As the areas of research in construction management are diverse, treatment of topics can be influenced by different disciplinal assumptions and training (Rooke & Kagioglou 2007; Runeson 2007). In this context an economic view of informality is focused on identifying and quantifying illegal economic activities and devising regulation and strategies to mange them. The social view is focused on 'structural and interactional' issues of socially constructed realties (and some times with the real world). Ethical and moral aspects are central to both social and economic of informalities research conceptualisation and operationalisation (Denzion and Lincoln 2005).

Conceptualisation of *research issues* is influenced by the attributes of the *'research domain',* and *methodological predispositions* (as identified in Figure 2) of a researcher. In the context of this paper four general research issues are identified. Each informality aspects e.g. interpersonal relations, informal leadership, behavioural control and informal communication etc, could be researched via one or mix of the four-research issue. The research issues can be: (i) assessing actors' interpretations of informal interactional orders, (ii) Developing meanings of informality issues and their associated characteristics via observed behaviours (e.g. bodily postures, conversational interruptions, phonological slurring, etc), or deciphering

unobservable deep beliefs (values, assumptions tc) (iii) Assessing the impact of informality on organisational effectiveness and (iv) Understanding informality in terms of enhancing organisational life (not directly associated with improvements in organisational effectiveness). One could argue researchers' deep assumption about the nature of informality, whether it is a temporary or permanent phenomena, could influence research conceptualisation. Researchers, assuming informality as a permanent aspect, may not seek to identify strategies to eradicate informality. They rather conceptualise their research with an interpretative, hermeneutic- emancipatory tradition- that enables them to understand the meaning and/or transform the socially constructed realties by liberating the members from their traditionally held beliefs (Alvesson and Willmott 1992; Alvesson 2002). Assumptions of the temporary nature of informality could lead to technical and rational approach to eradicate informality [Refer Figure 2].

The level of *visibility of an informal* issue is dependent upon on how it is conceptualised. For example interpersonal relations in an organisation can be studied via more visible rituals depicted by artifacts (e.g. jokes, form of language), or via less visible trust and advice networks. The visibility of the issues has a significant influence on the method section. *Legality/illegality* of the aspect under study has significant influence on the operational design and choice of method. Almost all universities are bound by research ethics protocols that aim to minimise the risks associated to research design and upholding the welfare of the participants (see Australian Government 2007). Research projects studying illegal issues (even a possibility inadvertent identification) are imposed with additional statutory obligations. The minimal obligations attached to anonymous illegal studies could attract researchers to engage with methods that offer anonymity.

Although research on unethical and immoral informal actives (but not the explicitly illegal) are not subjected to additional statutory obligations, data collection and reporting of the findings should nevertheless be treated with sensitivity, and the findings should not exploited out of context. Ethics is not solely about 'procedural ethics' that seeks compliance with established protocols (see Guillemin and Gillam, 2004; Brydon_Miller 2008), being an intrinsic aspect of the research conceptualization, where researchers sublimate their power positions, privileges and prejudices (O'Leary 2010). The argument that all research is value-ridden (as opposed to value-free), makes it is essential that researchers understand the value system and its impact on their own research position (Corbin and Struss 2008; Christians 2005).

It is inaccurate to view the conceptualisation process of interaction between the above five aspects as linear. Conceptualisation of an informality research problem is a resultant of highly complex interactions among the numerous aspects under consideration- e.g. domain, assumptions, issues, methodological paradigms. The following section discusses the methodological issues associated to study of informality. Subsequently aspects discussed in this and following section will be used to review selected published informality studies to identify some of the current research approaches and propose any possible alternative strategies.

Research Approaches and Processes

Keeping pace with the rapidly emerging paradigm variations in the qualitative methodologies (the 'isms' revolution) is challenging (Denizen and Lincoln 2005). Most evolving paradigms are arguably variations to existing post-positivist paradigms, accommodating deviations in ideology or research process (Joesph, and Roberts 2004). The evolution of alternative paradigms can be observed as staying true to the cause of the fundamentals of post-

positivism: that is to acknowledging multiple worldviews (Denizin and Lincoln 2005). The evolution of paradigms constantly challenges the prevailing worldviews (constructed by the ontological and epistemological positions) that may stand in the way of developing a clear understanding of a problem (O'Leary 2010; Bryman 2008).

Process 1: Selecting a Methodology: Paradigms/ worldviews	**Process 2: Selecting a Methodology: Research Strategy**	**Process 3: Selecting a Research Method-Data collection**	**Process 4: Selecting a Research Method-Techniques**
Positivism Post-positivism Constructivism Interpretivism Critical Theory Hermeneutics-Emancipation Critical Realism Pragmatism (as proposed by Creswell and Clerk 2007)	Case study Ethnography Action research Grounded Theory Phenomenology Ethnomethodology Discourse analysis Semosis	Surveys (open ended-close ended; postal-email-online etc) Observation Interviews (face to face-telephone etc) Focus groups Diaries Artefacts, documents, and records Visual (video) methods	Descriptive statistics Inferential statistics: Paramedic and Non-Parametric statistical techniques Coding: (Open codes, Axial Codes, Selective codes, Memos, diagrams etc) Conversion analysis Thematic analysis Textual analysis

Figure 2: *A framework on the possible Research methodologies for informality research*
Synthesis based on Strauss and Corbin (1998); Scale (1999); Denzin & Linclon (2005); Clerk and Creswell (2007); Corbin and Strauss (2008); Bernard and Ryan (2010)

Two key terminologies, methodology and method, are used in Figure 2 to describe the methodological practices in informality research. Strauss and Corbin (1998) say that methodology is "[a] way of thinking about and studying social reality' and method is '[a] set of procedures and techniques for gathering and analysing data' (p3). Morse and Richards (2002) use the term 'research strategy' in lieu of methodology and describe research strategy as 'a way of approaching data with a combination of techniques that are ideally consistent with the method the researcher has chosen to use. … [T]he term method … refers to a more or less consistent and coherent way of thinking about and making [collecting] data, way of interpreting and analysing data, and way of judging the resulting theoretical outcome' (p 10). The term 'Technique' to refers to a way of attempting or completing research task (e.g. data coding). Although 'techniques' themselves do not indicate which method is employed in the research, the ways in which the techniques are applied could indicate the research method in application.

Figure 2 identifies four processes to the methodological design of research. The first two processes are related to the choice of a methodology, a worldview(s), and a research strategy(ies) that is accommodative of that worldview. The last two processes are related to choice of methods that focus on data collection and analysis techniques. Despite the numerous combinations of possible research practices, some combinations may not be

philosophically aligned. It is obvious that positivist, critical theory, close-ended survey and qualitative coding are one such combination. It is not the aim of this paper to give an in-depth review of methodological aspects, but rather to discuss the possible combination of methodologies and methods in studying informalities.

Selecting a methodology which aligns with the paradigm (Process 1) and strateg(ies) (Process 2) is interactional with the conceptualisation of an informality issues (i.e. the domain and issues). The worldview or paradigm affiliation of a researcher is intrinsic to the way a research issue is conceptualised (Morgan and Smircich 1980). As indicated earlier, this means conceptualisation of a research issues occurs in multiple interactional layers, constituting the worldviews (as described in Figure 2) and informality conceptualisation aspects (as identified in Figure 1). Varieties of post-positivist or constructivist philosophies "enable researchers to deal with complex layered and often unobservable strata of reality that impact upon our action and thinking" (Joseph and Roberts 2004, p1). One of the eight worldviews proposed in the Process 1 in Figure 1 could conceptually underpin informality research. The subtlety of the paradigm variations demands deep engagement with the literature to perceive the differences. Moreover, it is instructive to map the development of philosophical alternatives beyond the dominance of social constructivism and interpretivism. The tensions between emerging constructivist/ interpretivist/critical theorist philosophies is evident in literature (Joseph and Roberts, 2004). In essence, during the Process 2, researchers conceptualize their research issues with a worldview they uphold (if they are fundamentalists) or the worldview they want to adopt (if they are pragmatists). Researchers need to carefully evaluate and respond to critiques of the chosen worldview and why it will deliver meaningful outcomes.

Process 2 is about identifying a *research strategy* that complements the choice of worldviews. A research design to study informality could combine multiple strategies. As an example 'ethnography' is complementary to 'case studies' and 'grounded theory' (see Barrett and Sutrisna 2009). In the case of a construction project the nature of the project, and identification of the boundaries defining the social units of which it is comprised are best investigated using case studies. The case study is an overarching research strategy rather than simply a data collection method or a research design concept (Yin 1994). Stake (1995, p. 2) says. "The case study methodology/strategy allows any selected method to "study a case analytically or holistically, entirely by repeated measure [positivist] or hermeneutically, organically or culturally and by mixed methods…" (Stake 2005, p. 443). Therefore, the case study could be designed with combinations phenomenology, ethnomethodology, discourse analysis and semiosis.

The methodological position will influence the selection of the appropriate *methods to collect and analysis data (*or vice versa). In theory the choice of a data collection method should be predominantly underpinned by the methodology. However, in practice, numerous other considerations, such as ethical protocols or the cooperation of participants tend to act as constraints on the choice of data collection method. Although methods supporting positivist paradigm are reduced to surveys and published numerical data, a trend has developed for the use of quantitative methods to analyse the results arising from non-positivist methods such as Key Word in Context analysis (Bernard and Ryan 2010). Almost all non-positivist methodologies could use interviews and focus groups as data collection methods. Ethnographic studies in addition to the interviews and focus groups could use observations and any relevant artefacts/documents as data. Patterns of informal behaviour can also be studied with visual (video) methods and use of diaries. Nevertheless, Coding used in quantitative analysis techniques, is commonly understood as a qualitative analysis technique.

Strauss and Corbin (1998) have provided an extensive discussion on coding process (e.g. open codes, axial codes, selective codes, memos, diagrams etc. Conversion analysis technique is central to discourse analysis. Thematic analysis identifies themes emerging from data and is a technique that is conceivably applicable to most qualitative approaches (See Bernard and Ryan (2010) for guiding the operationalisation of these methods).

The researcher as the 'Research Instrument': The fundamental issue

Designing an appropriate non-positivist research approach is only a part contributor of good and meaningful research. The research design only establishes the ideology underpinning the research and the processes that are followed in the design and execution of the research. However, the fundamental concern is 'how this methodology will be executed by the researcher, who is the instrument, in arriving at a meaningful research outcome. In contrast to quantitative research, where researchers rely upon validated statistical instruments, qualitative research believes that researchers themselves are the instruments. Corbin and Strauss (2008) argue that good qualitative research emanates form the researchers who share the characteristics of having a humanistic bent, curiosity, creativity and imagination. The key characteristic that distinguishes the good qualitative researchers from the others is the ability of the researchers to deal with risk and to live with ambiguity. Moreover, researchers who develop trust and confidence in the self as the research instrument (as opposed to established tools and techniques) conduct good qualitative research. However, designing good quality research practices that maintain the adequacy and deliver meaningful outcomes is crucial (see Dainty, 2008 on the principles of methodological plurality)

A SELECTED REVIEW OF INFORMALITY RESEARCH

This section reviews methodologies used in studying informalities in construction, based on selected published work in the arena. This review includes papers in which informality is dealt implicitly and/or explicitly. It should be noted that the selected studies are not a representation of the informality studies in construction. However, this review can inform a range of research approaches that can be discussed in the context of Figure 1 & 2. This can assist in developing an understanding of taxonomies of methodologies that can be used for studying different informality issues.

Review of informality studies based on the economic perspective

A study by Lewis and Hosein (2006) focused on estimating of the size of the informal (hidden) construction labour force in the Trinidad and Tobago (T&T). That is identifying the nature of illegal labour and quantifying the extent of informal (illegal) labour employed in construction projects/sectors in a particular region. Lewis and Hosein (2006) rationalised the methodological approach using anecdotal evidences and citing the difficulty in obtaining reliable data on illegal sectors or activities within the construction industry. This study used published statistics from a number of sources to estimate the extent of informal construction labour in T&T. The human research ethical issues impacting their study are irrelevant, as the paper is based on published documents. However, in the context of current National ethics guidelines (at least in the context of Australia), the primary data collection related to identifying and quantifying the hidden sector will pose significant challenges.

The paper by Wells (2001) focused on unrevealing the informal sector in a region in the context of capital formation in less developed economies. In this paper the illegality aspect of the informal sector is not overtly discussed. Like the previous study the assumption about the temporary/permanent nature of the informally is difficult to gage. The paper is based on

observations and/or discussions with participants and published data. Mentioning of not to interpret the findings along the racial context highlights the ethical issues confronting the researchers beyond the study.

Oviedo, Thomas, and Karakurum-Özdemir (2009) identify a number of other methods that could be used to study economic informality. The approaches are classified as direct (micro) methods and indirect methods (macro) methods. The micro methods could employ (i) voluntary surveys (Nuget and Sukiassyn 2009), interviews and Tax audits (Oviedo, Thomas, and Karakurum-Özdemir 2009). Use of the survey method, specifically anonymous surveys, to collect primary data is relatively less challenging from an ethics clearance point of view. The unidentifiability of personalities associated to any illegal activity, minimises the risk to and responsibilities of the researchers and institutions conducting.

The interview method could pose significant challenges due to the identifiablility of the actors in the illegal informal sector. The protocols call for reporting such accounts to relevant authorities. With tax audits, the collection of private nature of the data could also prove challenging. Moreover, any identification of informality associated to tax evasion could be treated as criminal activity; researchers are required to notify this to appropriate authorities. Debating about doing the 'right thing' could spark difficult ethical dilemmas for researchers who assume both economic . However, tax-based analysis can be conducted suing secondary published data, if available. These methods include (i) studying the discrepancy between aggregate and income expenditure, discrepancy between total labour force and formal employment and physical input of resources (e.g. use of electricity or water consumption). In essence economic informality studies can be said to be dominated by positivist methods, although there is room for the use of post positivist methods.

Review of informality studies based on the sociology perspective

Baarts (2009) and Pink et al. (2010) studied safety practices in the construction sites using ethnography. Baarts studied the collective individualism as an informal emergent social process relating to construction site safety practises (fits into Research Issue 2 in Figure 1). Making meaning of partly visible emergent informalities was approached through an in-depth ethnographic study. Ethnography is commonly used as a means for exploring cultural aspects of human organisation (Geertz 1975; Morse & Richards 2002; Schein 2004). Ethnography can unearth hidden informal practices as part of the culture of an organisation. In this study researcher become part of the cultural group, conducing observations during the normal course of work. The ethnographer has questioned/evaluated the ethical concerns and personal prejudices in an explicit manner in the conceptualisation and operationalisation of the research study. The descriptions made during the site observations and data from semi-structured interviews were used to create meaning and develop an understanding of the informal social process.

Pink et al. (2010) discussed the opportunities offered by the new bread of ethnographic approaches in developing better understanding of social phenomena. This study through the ethnographic process developed an understanding of invisible routes of communication in construction sites employing migrant workers (research issue 4 in Figure 1). The use of photographic and video-based data in addition to conventional ethnographic data is also proposed. Pink et al. (2010) indicate the 'essential criteria [of their study] is that the researcher retains the reflexive awareness of how her or his work is informed by theory and a self-consciously considers how theory and practice remain in dialogue though the ethnographic process'. The focus on developing meaning of social practices to understand

organisational life fits will with the hermeneutic-emancipatory paradigm. The above two studies analysed both visible (using observations) and hidden aspects (using in-depth discussions) of informalities. However, they did not report any ethical practical challenges in executing the research design. Moreover,
Gores and Emmitt (2007, 2009) looked into the informal aspects of communication process during the construction progress meetings (research issue 1 in Figure 1). The analysis of the observable/visible physical behaviours and linguistic interactions during the site meeting (across 10 projects) was used to unearth the not so visible socio-emotional interactions influencing informal relationships among the team members. They used observation methods and Interaction Analysis Process approach (a qualitative approach to generate quantitative data) to analysis the communication process. The difficulties faced with executing the conceptual research design in practice are highlighted. A study by Styhre, Josephson and Knauseder (2004) implicitly dealt with informalities associated to learning capabilities in organisation networks (Research Issue 2 in Figure 1). They employed case study and action research strategies using individual interviews, group interviews and published documents as data to identify informal networks.

Bresnen (2009) employed inductive approach to study emergent practice of partnering through a practice-based approach. The study used interviews, documents and observations to grasp the emergent nature of partnering practice (research issue 2 in Figure 1). Furthermore, the paper discusses alternative methodologies and methods for generating knowledge, reinforcing need for multiple lenses to study informalities. Barrett and Sutrisna (2009) have advocated the use multiple approaches within the context of case study strategy for generating meaning for social phenomena (Research Issue 3 in Figure 1). However, caution in the abstraction process is urged to maintain the relevant meanings of events and not to delude the meanings by making it out of context. Their study on understanding process in construction projects was conceived within the critical realism paradigm, using case study and grounded theory strategies. The critical realism paradigm enables them to assume both objective and subjective realities of constructs associated to their study. They used condition consequence matrices and cognitive maps to show relationships between concepts and to identify some causal relationships.

DISCUSSION

The above review highlights that diverse, but effective methodologies and methods employed in studying informality and emergence in construction. The studies on economic informalities, due to difficulties in gathering reliable primary data, have used anecdotal evidences and existing published data in identifying and quantifying informalities. Studies on sociological perspective employed multiple strategies including case study, ethnography, action research, and grounded theory, using different types of data gathering techniques, including observations, interviews, published documents etc. It can be inferred that all the above studies, except Gorse and Emmitt (2001, 2009), used qualitative methodology conceived by the non-positivist tradition. Although not explicitly stated, expect Barrett and Sutrisna (2009) who assumed the critical realism paradigm, all the other sociological studies fall into one or blend of constructivism, interpretativism, and hermeneutic-emancipation paradigms.

Although not reviewed in this paper, limited use of discourse analysis (Kao, Green, and Larsen 2009) and ethnomethodology strategies (Hugill 2001, c.f. Gorse and Emmitt 2009; Rooke, Koskela, and Kagioglou, 2009) to study informality is evident in the literature.

Discourse analysis, phenomenology and ethnomethodology are focused on understanding realties based on the use of language in written or oral form. These strategies are closely aligned to the interpretativist paradigm. Discourse analysis can enlighten the different types of informal structures of the language used by different project team members (e.g. architect, contractor, engineering talks). The phenomenology and ethnomethodologies, focused on "micro-social interactions- that is interaction on a small scale, between individuals or within small groups" (Seale, 1999 p. 30) can also provide different lenses to study informality as a social construct.

The discourse analysis, phenomenology and ethnomethodology in the context of constructivism, interpretativism and hermeneutic emancipation paradigms can provide a sound base to develop an in-depth understanding of informalities through the use of language. This enables transformation of (or liberation from) the traditionally held beliefs and practices underpinning informality in construction (Alvesson and Willmott 1992).

The use of semiotics could deal with analysis of structures, generative mechanisms and practices beyond language. This can provide an alternative to critical theorists who reject the use of discourse strategies to explain causality, keeping in line with the hermeneutic emancipation tradition. Therefore, semiotic strategies, conceived within the critical realism paradigm could offer a better research approach to study informality enabling causal analysis while maintaining some the rich attributes of non-positivist paradigms (Fairclough, Jessop and Sayer, 2004).

CONCLUSIONS

The complexity in project environments can lead to emergence of informality or vice versa-that could create paradoxes. This paper suggests that studying informalities can in part enable identifying paradoxes. This paper explored three interrelated aspects critical for designing research approaches to study 'informality'. Four key dimensions were identified in conceptualising 'informality' research: the disciple context (economics or sociology), nature of the research issues, ethical/legal dimensions and visibility of the informality. This is established Processes associated the conceptual and operational research designed is also discussed. The methodological process involves identifying a paradigm(s) within which the research is conceptualised. This will influence the way the strategies and research methods are used for colleting and analysing data. Practical (ethical and operational) considerations of conceptual research design are paramount for meaningful outcomes. A number of methodological taxonomies, in studying different informality research issues, are identified from existing literature. It is evident (within the limited observations) that the case study strategy, ethnography and action research, conceived in the tradition of interpretative/ constructivism/hermetical emancipation paradigm are used to study informality from a sociological perspective. Moreover, it is also evident the critical realism could prove to be worthwhile paradigm alternatives to study informality in construction. Furthermore, it is proposed that the alternative methodological lenses such as ethno-methodology, phenomenology and semiotics could add richness to the of informality studies. This paper shy's away from prescribing the best approach to study different informality issues. Numerous probable combinations of research taxonomies suggest that developing a prescriptive approach to constructing a research methodology to study informality (distinctively as a social phenomenon) is naive.

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A REAL OPTIONS APPROACH TO EVALUATING INVESTMENT IN SOLAR READY BUILDINGS

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Abstract
Sustainable building technologies such as Photovoltaics (PV) have promising features for energy saving and greenhouse gas (GHG) emissions reduction in the building sector. Nevertheless, adopting these technologies generally requires substantial initial investments. Moreover, the market for these technologies is often very vibrant from the technological and economic standpoints. Therefore, investors typically find it more attractive to delay investment on the PV panels. Nevertheless, they can prepare "Solar Ready Buildings" that can easily adopt PV panels later in future at the optimal time; when their prices are lower, energy price are higher, or stricter environmental regulations are in place. The conventional valuation methods such as Net Present Value (NPV) are unable to identify the optimal timing for investing in the PV panels. Hence, in order to avoid over- and under-investment, the decision makers should be equipped with proper financial valuation models that help them identify the optimal investment timing. We apply Real Options Theory from finance/decision science to create an investment valuation framework for finding the optimal time for investing in PV technologies. Our proposed investment analysis model uses experience curve concept to model the changes in price and efficiency of the PV technologies over time. It also has an energy price modeling component that characterizes the uncertainty about future retail price of energy as a stochastic process. Finally, the model incorporates the information concerning specific policy and regulatory instruments that may affect the investment value.
Using our mode, investors' financial risk profiles of investment (i.e. Cumulative Distribution Function of the Investment Value) in the "fixed" Solar Building and "flexible" Solar Ready Buildings will be developed. This will determine the Financial Value (if any) of investing in the Solar ready building and identify the optimal time for installing the PV panels.

Keywords: Investment Valuation, Photovoltaics, Real Options

Introduction

Given the increasing scale of investments in sustainable building technologies such as the Photovoltaic (PV) panels, it is of crucial importance to offer the proper financial decision-making tools to the stakeholders and decision-makers. Without a proper methodology, the risk that funds are misappropriated is imminent, e.g., by choosing wrong technologies or by timing the investment incorrectly.

Proper allocation of resources to sustainable building projects (e.g. installing Solar Panels) requires an assessment of the cost and performance of proposed solutions to establish their profitability. Metrics such as Payback Period (PP), ROI and NPV have been traditionally applied to measure this profitability. Of all these measures, Net Present Value (NPV) is the widely prescribed metric, e.g., in ASTM E917–05 (2010) for conducting life cycle costs and benefits analysis for a building system. Despite the popularity of NPV, this method has serious limitations in financial assessment of an energy retrofit solution.

A NPV analysis approach assumes that all decisions related to an energy investment are made at once and are completely irrevocable. These assumptions are not consistent with real-world decision-making processes for investing in sustainability projects such as installing the PV panels. Many of the PV technologies are still in their early development stages. It is expected that their prices will go down and their efficiencies will improve in future due to the economies of scale and learning by doing effects. Therefore, it seems reasonable that building owners delay investing in these technologies but maintain the capacity to implement them in future when investors become more confident about technical and financial aspects of such investments. Thus, constructing Solar Buildings (with PV panels already installed in the building) may not be an economically attractive solution today. However, it could be a financially-wise choice to prepare Solar Ready Buildings that enable the easy installation of PV panels at the optimal time in the future; when the electricity retail price reaches a new high level or the price and efficiency of PV panels improve significantly. Nevertheless, the NPV method ignores the significant impact of timing on the financial value of investment in the PV technologies. It is inherently unable to address Investment Timing. Hence, if NPV is used, the financial performance of investing in the solar ready buildings is computed erroneously. This, in turn, may lower the overall effectiveness of the sustainable investments.

Any efforts towards advancing the valuation process will improve the quality of investment decision-making in energy interventions and, considering the multibillion dollar nature of the green building industry (McGraw-Hill Construction 2010; SBI Energy 2009), this can lead up to enormous savings through smart investment choices. To avoid under- and over-investment and ensure that scarce financial resources are efficiently allocated an appropriate valuation method is needed (Ellingham and Fawcett 2006). The Real Options Theory from finance/decision science could be utilized to evaluate the investment in the solar ready buildings and price the delayed investments for PV panel installation.

Real Options Analysis

Generally, the financial assessment of a delayed investment (e.g. installing PV panels in the case of solar ready buildings) is performed under the uncertainty about whether and when the investment should be implemented. Real Options Analysis properly meets this objective. The term “Real Options” refers to the application of financial option pricing techniques such as the Black and Scholes (1973) formula to assessment of non-financial or “Real” investments with strategic management flexibility features like delayed retrofit solutions (see Dixit and Pindyck

(1994) for a detailed overview of real options analysis). This field has gone through a significant transition from a topic of modest academic interest in 1990s to considerable, active academic and industry attention (Borison 2005). However, the applications of real options in building design and engineering have not been numerous. (Greden et al. 2006; Greden and Glicksman 2005; Ashuri 2010; Ashuri et al. 2010). To the best of authors' knowledge, real options analysis has not been applied to evaluate energy investments in buildings including the investments in PV technologies and solar ready buildings. Considering the expected increase in the level of investments in sustainable buildings, creating more appropriate investment valuation models in order to avoid under- and over-investments is crucial and the application of the real options theory from finance/decision science can result in significantly improvements in the investment valuation of energy retrofit solutions.

Investment Analysis Framework for Solar Ready Buildings

An Investment Valuation Model based on Real Options Theory is at the core of the framework proposed in this paper. It receives input from external modeling components, which generates the information that proper financial analysis of the investment in solar ready buildings requires. Specifically, the model receives input from an external Building Energy Simulation component, which is used to assess the energy performance of the solar ready building prior and after the installation of the PV panels. Thus, the module determines the potential energy savings resulted from the installation of the PV panels. An important component of our model is Retail Energy Price Modeling module, which shows future projected paths for the energy price. The financial benefit of installing the PV panels will be calculated based on these energy price models. The other component is Experience Curve Modeling, which is used to characterize how price and efficiency of the PV technologies evolve over time. This is critical in finding the optimal investment time for a proposed energy retrofit. The modeling process is described in the following sections

Building Energy Simulation: Characterize Energy Savings Performance

The Building Energy Simulation component explicitly addresses the determination of the energy savings performance of PV panels. The analysis first quantifies the performance of the solar ready building prior to the installation of the PV panels considering a variety of factors including the meteorological, urban and micro climate effects, related to the environmental conditions around the building. Next the simulation model quantifies the expected level of energy saving in the building following the installation of the Solar Panel. The detailed discussion about the implementation of Building Performance Simulation is out of the scope of this paper. Our financial analysis only uses the expected energy consumption of the solar ready buildings prior to the installation of the solar panels and after their potential installation as the essential inputs.

Retail Energy Price Modeling: Create a Stochastic Model for Energy Price

Retail Energy Price Modeling explicitly addresses uncertainty about energy price as major benefit driver of an energy retrofit investment. Financial benefits of energy savings depend on the price of energy in the utility retail market. Although average energy price rises over time, it is subject to considerable short-term variations (Figure 1). A Binomial Lattice model (See Hull (2008) for detailed descriptions) can be created to characterize the energy price uncertainty. A binomial lattice model is a simple, discrete random walk model, which has been used to describe evolving uncertainty about energy price (Liski and Murto 2010; Ellingham and Fawcett 2006).

The modeling choice of binomial lattice is also consistent with the general body of knowledge in real options (Hull 2008; Luenberger 1998). In economics and finance, binomial lattice is an appropriate model to capture uncertainty about a factor like energy price that grows over time plus random noise (Dixit and Pindyck 1994).

Binomial Lattice Model

To define a binomial lattice (Figure 2) for energy price (S), a basic short period with length Δt will be considered. Suppose the current energy price is S_0. Energy price in the next period is one of only two possible values: $u \times S_0$ or $d \times S_0$ where both u and d are positive rates with $u>1$ and $d<1$. The probabilities of upward and downward movements are p and 1-p, respectively. This variation pattern continues on for subsequent periods until the end of investment time horizon. Binomial lattice parameters can be determined using data on the expected annual growth rate of energy price (α) and the annual volatility of energy price (σ) as explained by Hull formulation (2008). This binomial lattice can be used as a basis to generate future random paths for energy price.



Figure 1: *Annual Average Residential Electricity Price (EIA 2010)*

Monte Carlo Simulation

Next, Monte Carlo simulation technique can be applied to generate several random paths for energy price S – from the start to the end of investment time horizon – based on the described binomial lattice. Considering the binomial lattice formulation, energy price in any period of the lattice is a random variable that follows a discrete binomial distribution; this is the basis of applying Monte Carlo simulation technique for generating a large number of random energy price paths along the investment time horizon (Figure 2). Random energy price paths are used to compute respective energy savings series. In addition to benefits, it should be specified how the initial cost of the PV panels changes over time to find when it is optimal to invest in. This is discussed in the following section.

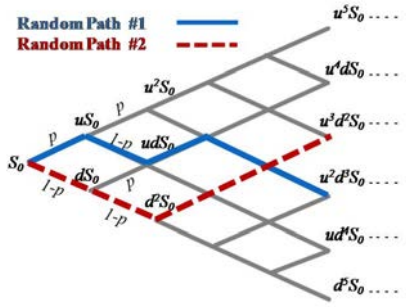


Figure 2: *Random Energy Price Paths along the Binomial Lattice*

Experience Curve Modeling: Create an Experience (Learning) Curve for the Proposed Emerging Technology

The concept of Experience Curve describes how the marginal costs decline with cumulative production over time (Hartley et. al 2010; Weiss et al. 2010). Typically, this relationship is characterized empirically by a "Power Law" of the form: $Pt=P_0X^{-\alpha}$ where P_0 is the initial price ($ cost of first Megawatt MW of sales), X is the cumulative production in MW up to year t, and $2^{-\alpha}$ is Progress Ratio (PR); for each doubling of the cumulative production (sales) the cost declines to PR% of its previous value. For instance, Figure 3 shows an experience curve created for PV modules. The apparent decline in costs may be due to several reasons, including process innovation, learning-by-doing, economies of scale, R&D expenditures, product innovation/redesign, input price declines, etc. (Hartley et. al 2010; Yu et al. 2010). Experience Curve Modeling characterizes price reduction and efficiency improvement trends of a proposed emerging technology. The parameter α in the experience curve – i.e., $P_t = P_0X^{-\alpha}$ or $\ln(Pt) = \ln(P0) - \alpha\ln(X)$ – is defined using historical data of marginal costs and cumulative productions of the emerging technology. α can be estimated by a standard Ordinary Least Square (OLS) method. Nevertheless, the development of experience curves is not without trouble mainly because the estimation of PR for each technology is subject to great uncertainty (van Sark et al. 2007); it is not easy to forecast whether this PR remains constant or change over time (Yeh et al. 2009). Research has been focused on development of models that incorporate such uncertainties (Yeh et al. 2009; Gritsevskyi and Nakicenovic 2000). The best engineering judgment for the future level of decline in price of a technology can be used in these circumstances to characterize the cost trend of the PV technologies.

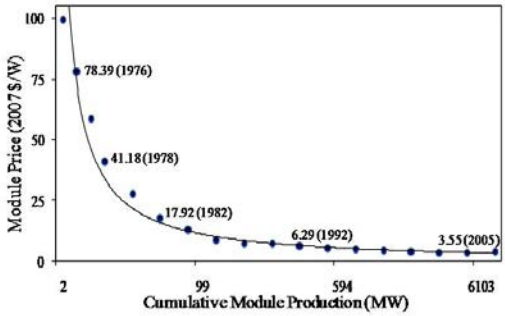


Figure 3: *Experience Curve of PV Modules 1968 to 2006*

Investment Valuation Modeling based on Real Options Analysis

With the input from above three steps, Investment Valuation Modeling will determine the optimal time to invest in the installation of the PV panels in a solar ready building. It also establishes the value of embedding flexibility in the building.

A probabilistic NPV analysis can be conducted to describe the financial risk profile of the immediate investment in the PV panels. This is carried out under the assumption that investors adopt the current PV technologies right away at the current price and efficiency rate. Randomly generated energy saving streams are used to characterize investors' NPV distribution (Figure 4). Investors' cost of capital or required rate of return can be used as the discount rate in NPV analysis.

In addition, using the risk-neutral valuation method – developed in mathematical finance for pricing options and derivatives –the correct market-based value of a delayed PV installation in the solar ready house can be determined. In this technique, the probabilities of upward and downward movements in the initial energy price binomial lattice are modified – as described by (Luenberger 1998; Hull 2008) – to conduct option valuation. Risk-neutral binomial lattice can then be used as Decision Tree to determine the optimal investment time. Hence, investors' NPV distribution is calculated considering this optimal PV installation time. The difference between

expected investors' value under immediate and delayed investment represents the expected value of optimal delayed investment (Figure 5).

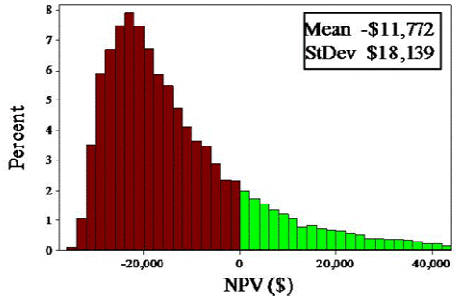


Figure 4: *Investor's NPV Distribution of Immediate PV Installation*

Impact of the Political and Regulatory Environments

Political and Regulatory Environments component encompass the impact of energy efficiency policies and incentive programs on investment valuation. Scenario analysis should be applied to specify possible energy targets and their likelihoods. Random upgrade scenarios, e.g., regulatory, political, technical, and/or market environments, in which an energy retrofit solution takes place should also be generated. Each scenario can be investigated with respect to its impact on future level of energy price, as well as its contribution to cost reductions of the proposed energy technology. Through what-if analyses, the impact of the regulatory conditions on the investment timing for an energy retrofit solution can be evaluated.

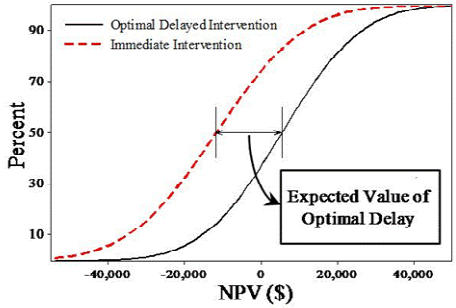


Figure 5: *Investment Value of Optimal Delayed Investment*

Illustrative Example

Approximately half of the installation cost of a solar power system on a building is spent on brackets, inventers, structural support (reinforcing the roof, repairing the roof, patching holes, etc.), and reconfiguration of the building electrical system. Rye (2008) summarizes several features, which can be included in the initial design, to proactively build a "Solar Ready Building": (a) Two additional slots on the electrical main panel; (b) A reserve location for an inverter; (c) Two conduits: one from the main panel location to the inverter location and one from the inverter location through the attic and onto the roof where the panels would be installed; (d) Reinforced roof rafter structure to support the weight of solar panels; and (e) Electrical jacks through the roofing material. The total cost of a Solar Ready Building with these additional features is approximately 3-5% higher than of the overall cost of a standard building. However, adding the same features to existing buildings could cost up to $15K in future solar upgrades. Based on the proposed investment analysis framework, the financial performance of the "flexible" Solar-Ready Building was compared with the financial performance of the "fixed" Solar Building. The initial cost of preparing electrical, structural, and roofing systems for PV panels was considered to be $10,000. This is the additional cost of embedding flexible features in

a solar-ready building. Also, it was supposed that the purchase price of PV panels with the service life of 40 years is currently $4/W and is anticipated to decrease every year due to experience curve effect (PR=0.46329). It was assumed that the solar panels for this building were will provide 6,300W power. The initial retail price of electricity was also assumed to be $0.1031/kWh; this unit price changes over time with the expected annual growth rate 4% and the volatility of 20%. These values were used to create a binomial lattice to model electricity price variations. Financial benefits of PV panels are in terms of energy savings, which must otherwise be purchased from the utility company. Federal and State tax benefits are $5,000 and the homeowner's discount rate is 7%/year. Under these circumstances, the real options analysis methodology was applied and the financial performance of solar building and solar-ready building under uncertainty about the electricity price were evaluated. It was also determined whether and when it is optimal to convert a solar-ready building to a solar building and how much embedded flexibility in a solar-ready building is worth investing.

Figure 6(a) shows the optimal electricity price, which triggers conversion from a solar-ready building to a solar building; the increasing boundary effect is due to the option expiration in 2030. Below the price threshold, an investor or homeowner should delay the installation of PV panels. When the electricity price rises to a substantially high level, the value of waiting becomes lower than the energy savings benefits of the immediate PV panels installation; therefore, the solar-ready building should be converted into the PV building. Figure 6(b) shows the likelihood profile of the optimal conversion year; this is the probability of the event that the random electricity price path reaches the optimal investment threshold specified in (a) for the first time in the current year. It can be seen that initially waiting is more valuable than immediate exercise; but, as the time passes, the opportunity cost of waiting becomes large enough that triggers investment. Figure 6(c) shows the NPV distribution of a solar-ready building under uncertainty about energy savings. Figure 6(d) shows the NPV Cumulative Distribution Functions (CDFs) of solar and solar-ready buildings. The expected NPV of the solar building is $-11,772 and the chance of investment loss, i.e., Probability (NPV<0), is approximately 75% , which make the solar building an unattractive retrofit solution. Delayed retrofit decision-making can enhance the value of solar upgrade. The two-phase development of the solar-ready building represents the hidden value of flexibility in the solar upgrade. It can be seen that the expected NPV of the solar-ready building is $5,480, which is much larger than the expected NPV of the solar building $-11,772. Therefore, the expected price of flexibility in the solar-ready building is $5,480-($-11,772) =$17,252. Also, due to the two-stage installation of PV systems, the chance of investment loss for the solar-ready building is approximately 35%, which is much lower than 75% for the solar building.

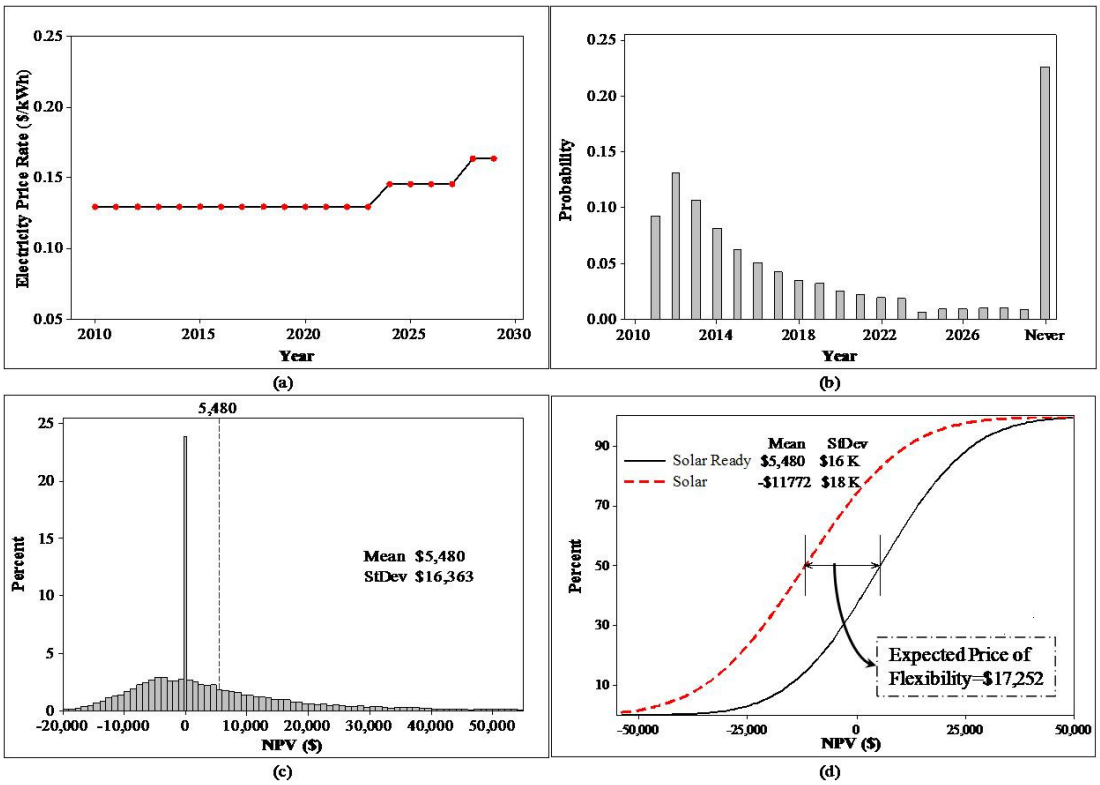


Figure 6: *(a) Optimal Retail Price of Electricity ($/kWh) Triggering the installation of Solar Panels; (b) Installation Likelihood of PV Panels Over the House Service Life; (c) NPV Distribution of Solar Ready Home; (d) NPV Cumulative Distribution Functions (CDFs) of the Solar House and Solar-Ready Building and Price of Flexibility*

Conclusion

Better investment decision models can facilitate achieving energy savings in the buildings through increasing the efficiency and effectiveness of investments in energy efficiency measures. The proposed investment analysis framework for evaluating investment in solar ready buildings will enlighten investors about the economic inefficiencies that conventional fixed energy investment strategies produce and facilitates the valuation of the flexible solutions that mitigate such inefficiencies. Explicit pricing of flexibility is significant for systematic decision-making beyond the current energy target; embedded options in delayed retrofit solutions reflect on the possibility to meet future stricter targets and prepare for future upgrades.

The proposed investment framework can be used as a decision making instrument, looking at different scenarios in technology and market developments, and deciding between immediate or delayed investment in PV technologies. Thus, it can also become an instrument in the selection of the right government incentives over time. As a corollary, the methodology will be used to single out the type of technologies that are ripe in the expected market of competing sustainable technologies.

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USING POSITIONING THEORY TO UNDERSTAND STRATEGIC MANAGEMENT CONTRADICTIONS

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Abstract
The purpose of this paper is to take up a call for more "identity" research in construction management by exploring the potential of position theory as a framework for examining the ongoing construction of self through discourse. Using some basic constructs: storyline, speech-act and position, we examine how tensions and contradictions unfold in high-stake conversations at the micro-level, and how these micro-level features may be linked to contradictory institutional practices. The data – consisting of audio-recordings and extensive field notes of body language, facial expressions and stance of the meeting participants – were collected during five strategy meetings focused on an organisation's new environmental strategy. We argue that a positioning theory lens enables the researcher to "get inside" the discourse and provides better understanding of how actors construct their identities in discursive practice with others.

Keywords: contradictions, discursive practice, positioning theory, self-concept, strategy.

INTRODUCTION
Managing organisational activities challenges actors' abilities to negotiate contradictions and paradoxes inherent in much human practice. To help deal with these challenges, organisational scholars have devised generic, cognitive models for dealing with paradoxes, e.g. engage, avoid or transcend (Poole and van der Ven, 1989), or manage paradoxes by embracing and balancing them (Smith and Tushman, 2005). Such models, albeit helpful for researchers at an abstract macro-level, do not address the dynamic, relational and elusive nature of contradictions as they emerge through organisational talk and action at the micro-level.

Based on a review of strategy literature in construction, Price and Newson (2003) argued that strategic-management success depends on strategists' ability to balance binary opposites, e.g. rational versus creative strategies, strategies versus organisational effectiveness. Their study is predicated on the claim that construction organisations lack "appropriate" knowledge and skills to develop formal strategic processes. To remedy this situation, the authors rather than offer a model, prescribe normative, textbook propositions, e.g. construction organisations must develop an effective strategic planning process; they need a guide to best practice and a framework to serve as a checklist; they need to supplement their short-term approaches with long-term approaches. Although these prescriptions may be sound on a general macro-level,

the authors ignore the empirical evidence emerging from the strategy-as-practice field, showing the situated messiness and contradictions that obtain at the micro-level of strategising (e.g. Whittington, 1996; Johnson et al, 1998; Hendry, 2000). The strategy-as-practice scholars argue that strategy is not a stable product that an organisation develops and then possesses; rather it is something that the people in an organisation continuously do through talk and action.

Beech et al (2004) criticised the notion of cognitive, unitary solutions to paradoxes, suggesting that if left open, paradoxes could rather serve as resources to stimulate creative and transformative actions. Using an action research approach and designing a "serious play" framework (focusing on emotions, creativity, meaning making and rule breaking), the authors explored how paradoxes may be dealt with in practice. They argued that attempts to solve paradoxes through the use of cognitive models and problem-solving approaches are likely to lead to inertia, while "living with paradox" and using it as a stimulus increases possibilities for creative action. Further research would need to be carried out to test this claim.

Still, much of the literature on organisational paradoxes remains theoretical. There is a need for empirical studies of how paradoxes and contradictions arise and are negotiated in situated practice. Influenced by the "practice turn" in the social sciences (e.g. Schatzki et al, 2001), organisation and management studies have increasingly been taking a practice-based approach to the study of organisational activities (e.g. Nicolini et al, 2003; Hendry, 2000). Simultaneously, if not consequently, more and more attention is being paid to the role of discourse and discursive practices in the construction of organisational identity, culture, knowledge and routines. This "linguistic turn" (Alvesson and Kärreman, 2000) has resulted in an upsurge of qualitative and interpretative studies of organisational and managerial discourses (e.g. Holman and Thorpe, 2003; Räisänen and Linde, (2004); Westwood, 2001).

Shotter & Cunliffe (2003:18-20), drawing on Bahktin's (1986) view of dialogue, show the advantages of studying the "moment-by-moment unfolding of relationally responsive events occurring in the 'interactive moment.'" They suggest that managers in their management of interactions can be "practical authors" of the textual outcome of the organisational conversations they have since they "create meaning in relationally responsive ways … [and] might be seen as someone able to restore a flow of action, giving shape and direction to the actions of other participants in the organisation when they are either disoriented or stuck." This view seems to be an idealized view of managers' reach, pertaining mainly to their authority embedded in predetermined transactional behaviours primarily aimed at solving problems, achieving goals and generally getting things done. It tends to see "manager" as an organisational role, underscoring the formal, static and ritualistic functions of "manager".

Yet, the job of managers spans a continuum of activities, in which transactional objectives are intricately intertwined with relationally oriented actions and idiosyncratic behaviours. Affordances and constraints for the deployment of these behaviours exist not only in the contexts in which they are deployed – the institutionalised structures and local situations – but also the perception of self that an individual enacts in a particular situation. Individuals' beliefs and representations of themselves are neither consistent nor always coherent; they may even be contradictory. In one and the same conversation, the way individuals think of themselves may shift depending on the context, situation and unfolding of the actual conversation at hand. By extension, this same conversation may have unpredicted implications and consequences for some future conversation. To understand the complexity of social interaction, position theory offers an analytical tool that enables us to examine the

ways in which individuals position themselves in conversation with others. Moreover, understanding how contradictions arise and unfold in situated discursive action will raise interlocutors' sensibilities to the relational aspects of social interactions and mitigate face-threatening acts (Brown and Levinson, 1987).

The purpose of this paper is to take up the call for more "identity" research in construction management advocated by Brown and Phua (2011) by exploring the potential of position theory as a framework for examining the ongoing construction of self in a discursive practice. We use some basic constructs of positioning theory to examine how tensions and contradictions unfold, get resolved or get locked in high-stake conversations at the micro-level, and how these micro-level discursive activities may be linked to broader institutional practices. The data is drawn from strategy-audit meetings focusing on an organisation's new environmental strategy. The issues under scrutiny in the audits were: Top-management's intention with the audit; the interpretation of the strategy downstream; and the actions generated by the strategy downstream.

POSITIONING THEORY

The constructivist view sees individuals as continuously constituted and reconstituted through the multiple discursive practices and activities in which they participate. As such, individuals are active agents in the development of their identities; who one is at a specific moment in time will depend on the positions that are made available in conversations with others as well as with oneself (Langenhove and Harré, 1999). Individuals use fluid positioning to cope with the situations that they find themselves in. Positioning theory as defined by Moghaddam et al (2003: 140) is "concerned with the process by which short-term and small-scale moral orders are established and maintained, and with the way the actions of participants are constrained to flow in accordance with sharply delimited schemata or conventions."

The root of the theory is that the self or personhood of an individual is "ongoingly" produced and is relational to the ongoing production of others' selves in discursive practices (Harré and Moghaddam, 2003). Positioning theory thus offers a framework for analysing the dynamics of micro-social relationships as these are being negotiated in conversations, in contrast to role-theory in which an individual's personhood is separated from his/her formal and pre-determined set of behaviours.

Discursive action takes place within a specific local moral order of speaking and acting. The force (or impact) of an individual's speech-act or utterance within this context is relative to the rights, duties and obligations that obtain within the moral order in which the conversation unfolds. In other words, in a conversation the interlocutors locate themselves and others according to personal stories, *storyline,* which render their actions intelligible to themselves as social acts. A speaker positions him/herself within his/her story as well as opens a position for the interlocutor to take up. The moral and personal attributes of the speaker, *moral order,* and the force of the speaker's utterance, *speech-act,* determine his/her success of legitimising the particular position that allows the speaker to be both effective and powerful. Hence, conversations have a tri-polar structure consisting of a storyline (culturally influenced and conventional description of events and cast of characters) enacted through speech-act (linguistic acts defined by the intention, belief and attitude of the speaker (illocutionary force) and a position (the implicit or explicit actors' adoption of a set of rights, duties and obligations that avail them in the ongoing storyline). This position may or may not be changed during the conversation. In this paper we focus on four types of positioning (Langenhove and Harré, 1999):

- Deliberate self-positioning: strategic positioning with a specific goal
- Forced self-positioning: position established by the institutional structure
- Deliberate positioning of others: positioning another to enable an objective to be attained.
- Forced positioning of others: positioning to bring people into order by using institutional power.

THE SETTING AND DATA

As part of the current greening wave, contractors are keen to demonstrate that they are harnessing their resources to mitigate negative impact on the environment. In accordance with this trend, the contractor in this study focused on greening in its 2008-2010 strategy revision, highlighting one specific strategy: "to be a sustainable builder of society". This strategy, according to the environmental top-manager, should distinguish the contractor from its competitors in the eyes of the clients. Therefore, this strategy was to be prioritized and compliance evaluated by means of an audit throughout the levels of the organisation.

In 2008, data were collected from one initial top-management meeting with audit consultants and from four audit-meetings carried out by one of the consultants in one geographical region sorting under a regional manager. The four audit-meetings, lasting approx. 15 hours in all, were audio-recorded and transcribed in part. The initial top-management meeting was not audio-recorded, but extensive field notes were made. The meetings took place at different venues in the contractor regional offices. In all, 11 actors from the constructor were involved in the audit meetings, some attending two or more. These represented all the management levels in the organisation as well as HR, executive development staff, and environmental management. Since the focus of this study was micro-level interpersonal interaction, detailed notes were taken on the speakers' body language, facial expressions and gestures. 'Water cooler' conversations between the meetings and during short breaks were also documented.

We listened to the audio recordings several times, first separately and then together, resulting in a rough analysis of the meetings in terms of speech-acts and storylines. We then transcribed one meeting in full and mapped the ongoing construction of the interlocutors' selves through identifying the positions they took up and made available during the conversation. We compared our detailed analysis with our rough ones and with our field notes. For this paper we discuss three short speech-acts from the initial meeting and one short exchange from one of the audits at district level.

CONVERSATIONS AT CROSS PURPOSES

In the following section we present the interlocutors followed by the examples and our analysis of the conversations. In the examples, the left-hand column identifies the speaker, followed by the speech-act in the middle column, and in the right-hand column is our interpretation of storyline and of position taken up or made available by the speaker.

Interlocutors

Environmental Consultant (CON): Female in her 50s; soft-spoken and conciliating; older woman with expert knowledge and genuine interest in environmental issues; she carried out the auditing at all the levels of the region.

Corporate Environmental Manager (CEM): Male in his 40s; executive; very busy; only time to attend part of the initial meeting; used hortatory discourse.

Corporate Development Staff (CDS): Male in his 30s; close to top management; actively involved in the process of strategy formulation and communication; no decision-making mandate, familiar to most managers in the organisation.
District Manager (DM): Male in his 40s; non-compliant with the audit; lacked familiarity with corporate management systems; had not prepared for the audit; dominant and charismatic.

Most of the representatives from the constructor were men in some kind of position of power. The few women in this study, apart from the consultant, had advisory roles with no decision-making mandates and very little power.

Example 1. *Initial meeting at corporate level: Corporate Environmental Manager, Corporate Development Staff representative and 6 Auditing Consultants.*

[1] **CDS**	Our environmental strategy: to be a sustainable builder of society, has to be funnelled downstream in the organisation.	Instruction storyline Forced self-positioning
[2] **CEM**	Sustainable builder of society is an overarching principle…it is this strategy that shall distinguish us from other constructors. The environmental bit is now being strongly pushed in the company.	Instruction storyline Deliberate self-positioning
[3] **CDS**	It is ok though to clear "hygiene level".	Clarification storyline Forced positioning of consultants

Note: The speech-acts in this example are not consecutive utterances.

The venue for the initial meeting was a conference room at the constructor headquarters and included three organisational strategists, the environmental top-manager and six audit consultants. These consultants were from an environmental-auditing and accreditation firm with long-standing professional experience. The purpose of this meeting was to inform the auditing consultants of top-management's intention with the strategy and audit as well as to identify the areas upon which the audit should focus. The consultants' jobs were to assess the degree of compliance with the strategy out in the organisation, the level of competency concerning environmental issues, and how the environmental measures and indicators were being handled.

An "instruction" storyline was consistent throughout the initial meeting. The consultants were gathered to receive information and instructions for their upcoming audits. The corporate development staff representative opened the meeting. He was used to this kind of situation and took up the forced self-position that his role ascribed him, i.e. as proxy for top-management. This position allowed him a cluster of rights, duties and obligations: the right to instruct people that were senior, older and more knowledgeable than he; the duty to behave in a manner conforming to the values of the organisation; and the obligation to provide the consultants with the information that would enable them to carry out their commission effectively. It should be noted here that when he positioned himself, he automatically positioned his interlocutors, the consultants. They willingly took up the deliberate positioning made available to them by the executive, namely that of "being instructed," and typically responded by back-channelling, posing questions, asking for clarifications and repeating information. The Corporate Environmental Manager arrived in the middle of the meeting and only stayed long enough to reinforce the instructions using hortatory statements, see example 1. He maintained the "instruction" storyline and deliberately positioned himself as an authority. He did not add any information to what had already been conveyed, but his presence bestowed weight and corporate legitimacy to the younger executive's speech-acts.

The third speech-act in the example had a different force from that of the CDS's earlier speech-acts. Rather than "instruction," the storyline now seemed to be "clarification," in the form of a proviso. As we interpret it, the CDS is implicitly force positioning the consultants to carry out the audits according to informal norms rather than the "objective" audit procedures of the consultancy. This speech-act contradicted much of the hortatory discourse that had preceded it, and may have contributed to the locked positions shown in example 2. The phrase "hygiene level" appeared to be commonplace in the organisation, meaning to fulfil the base qualifications of greening. However, "hygiene level" and the notion of "sustainable builder of society" are somewhat paradoxical, which the participants of the initial meeting chose to ignore.

Example 2: *Audit District B: Consultant, District Manager, Environmental Rep, Environmental Project Rep*

CON	Your SCI is 80%. Is that an objective for this year or have you always had 80%? Do you work with continuous improvements?	Audit storyline Deliberate positioning of DM
DM	Well, I think we have had index at 70 as well as 100. But I don't know the average value.	Competent manager storyline Deliberate self-positioning
CON	I mean do you set goals that are a little bit higher each year in order to sharpen your efforts further?	Audit storyline Forced positioning of DM
DM	No, we have had 80 for a long period of time. Sometimes we reach our goal, and sometimes we do not.	Competent manager storyline Deliberate self-positioning
CON	But isn't it interesting to try to perform better and better for each year?	Audit storyline Forced positioning of DM
DM	It depends on your reasoning. Sometimes it is fun to exceed the expectations. […]	Game storyline Deliberate positioning of CON
CON	But I do not agree with you	Refuses storyline and position
DM	Well, then we have different opinions.	Competent manager storyline Deliberate self-positioning
CON	From the quality perspective, it is all about trying to improve…	Reverts to audit storyline Tries to re-establish her position
DM	But there is nothing that prevents improvement. The main thing is that you know what to do, and that the group is behind it.	Competent manager storyline Deliberate self-positioning
CON	That's true, but isn't the result supposed to be a little bit better than last year?	Audit storyline Deliberate positioning of DM
DM	But how do you get that result, then?	Competent manager storyline Deliberate positioning of CON
CON	By taking exactly the measures that you have.	Competent manager storyline Takes up the position made available
DM	Yes….	Competent manager storyline Reinforces his position

Note: This example is part of a longer dialogue between the consultant and the district manager.

The audit at district level, of which example 2 is an extract, took place in a conference room in one of the regional offices. Present are the consultant, the district manager, a district environmental official and a project support official. The latter two audit participants took minor parts in the conversation, but played important roles in the interaction. When needed they were either mobilised by the district manager to support his storyline of competent and caring manager thereby strengthening his position, or they themselves volunteered with expert commentaries and digressions. Either way, they supported the manager's resistance to the audit.

In order to make this extract intelligible, more details are necessary. As for all audits, this one started with a round of self-introductions of the participants, which was set in motion by the consultant. She responded to each introduction with small talk thus evoking a storyline of

"friendly conversation" and positioning herself as competent consultant. However, the tense atmosphere in the room created by the body language of the district manager, whose facial muscles were taught and arms were crossed, contradicted her storyline. Without saying a word, he had positioned himself as antagonist. When it was the consultant's turn to introduce herself, she signalled a shift in her storyline to "environmental audit" by code shifting to formal discourse and deliberately positioning herself as competent environmental expert. She ended her presentation of herself by saying: "So I have seen the problematic side of construction." No sooner had she completed the utterance than the district manager interposed: "Yes, yes, yes, exactly, may I ask a question? Do you live in Sweville?" Through this speech-act he refuted the position of auditee that the consultant made available for him, reverting back to the earlier story line of "friendly conversation," but with a rather aggressive undertone. He enacted the rights, duties and obligation his institutional role bestowed on him, shifting the prerogative of controlling the conversation to himself. He then maintained the storyline of "friendly conversation" over several exchanges, subtly making available the position of "guest" for the consultant. Since she did not want to confront the manager, her only option was to play along and accept the position he offered. The DM frequently used these kind of interruptions and non-sequiturs during the conversation to resist the audit and destabilise the consultant.

The extract in example 2 took place in the latter half of the audit and was part of a longer exchange concerning the district's Satisfied Customer Index. The CON tried to maintain the "audit" storyline and fulfil her task of evaluating the environmental compliance to the corporate strategy in terms of goals and actions. In her three first speech-acts she tried to force position the DM, but he refuses to take up the position and counters by deliberate self-positioning. The DM resists her attempts by refusing to align with her storyline. Instead he maintains his own storyline of competent and caring manager. He challenges her right to question his authority, his control or his routines, justifying his decisions as being the outcome of co-worker consensus. What we see in the excerpt, which epitomises the audit, are two parallel storylines and incompatible positions. The DM either purposefully refused to answer the CON's questions, or he did not understand them. She wanted concrete measurable figures in answer to her questions concerning goal setting and actions, which she could then report back to top-management. The DM gave her equivocal answers. The CON was not able to break the locked positions nor was she able to fulfil her audit satisfactorily. The DM evoked the patriarchal values of a good leader and the importance of engaging and motivating co-workers. His district was performing well, and this, according to him, should be sufficient information for the CON. The audit ended in a deadlock.

DISCUSSION AND CONCLUSION

The brief analyses presented here suggest that individuals seek to demonstrate distinct social identities or self-concepts that position them as knowledgeable and responsible members of a social group. As such, through the storylines they create and the speech-acts they use to enact the storyline, they reveal not only the value, but also the emotional significance that they attach to their membership (Tajfel and Turner, 1979). In the case of the audit meeting, the DM's attitude and affect toward the audit is patently reflected in his speech acts, his behaviour and his actions. He almost takes pride in showing ignorance of index figures: "Well, I think we have had index at 70 as well as 100. But I don't know the average value." Earlier on in the audit, he shows his lack of familiarity with the organisation's performance-assessment system and his total lack of preparation for the audit. At one point in the meeting, he even has to go to his office to get his laptop.

In a study of organisational change, Moghaddam (1997) found that informal aspects of organising sustained normalcy in spite of formal rules and directives. In the case of the audit, it is interesting to observe how the DM subverts the institutional and formalised audit discursive practice that the consultant tries to achieve by imposing an informal meeting discourse that he is probably more comfortable with. For example, he answers her questions with questions, he questions her knowledge of the organisation, and he refuses to provide the information she seeks in the form she wants it. These micro-level features are revealed using a positioning theory lens, which allows the researcher to "get inside" the discourse. It also enables a deeper understanding of how actors construct their identities in discursive practice with different others, e.g. superiors, blue-collar workers, inspectors.

In example 2, we showed how the storylines of the consultant and the DM are "self-sealed" (Beech et al, 2009) with no attempt at engagement. The storylines militate against dialogue, which we can predict will have negative effects on the strategic environmental change that top-management is advocating. Beech et al (2009) in their study of three contesting change stories in a financial service company found that the stories, in spite of their proximity, did not, or could not, engage with each other. Each story had its own logic, constructing problem and solution according to its storytellers' world-view and work-view. The positioning of each story did not open up for dialogue across the self-created group boundaries. The consequence for senior management of these three change story processes according to Beech et al (2009) was that the change initiative remained at the strategic level. Senior management created a platform for the change, but failed to translate the rationale for the change in a discourse that the various groups could make sense of.

The focus of positioning theory is to understand how psychological phenomena are produced in discourse. However, conversations take place in a context, and between interlocutors that have some kind of association with each other. It is therefore important for the researcher to have knowledge of contextual and relational factors. For example, a conversation always has a fore-life and an after-life (Pearce, 2007). Example 1 serves to illustrate the importance of taking account of these dimensions of a conversation in one's analysis. From the consultant's point of view, the initial meeting is an important part of the fore-life of the audit, and could help explain some of her behaviour during the audit. At the initial meeting, the consultants are sent off to do their job with the somewhat paradoxical proviso "it is ok to clear hygiene level." This proviso contrasted to the hyperbolic discourse of the corporate environmental manager earlier on in the meeting could have given rise to uncertainty even in an experienced consultant: on the one hand she has institutionalised rules and routines for the audit, but on the other she has to relate to the somewhat vague proviso. This could explain her seeming reluctance to wield the rights, duties and obligations that the moral order of the audit avail her, e.g. to confront the district manager's refusal to cooperate and, more importantly, to forego her duty to report the environmental-management flaws that were so obvious. The latter puts in question the purpose of the audit, and, we can speculate, will have an effect on future conversations. For the district manager, the outcome of this conversation underpins his storyline of competent and caring leader who knows what is best for his district and co-workers.

As Shotter & Cunliffe (2003) suggest, the DM in this case could be viewed as the practical author of the textual outcome of the audit, rather than the consultant as would be expected. The likely after-life of the audit conversation, in the same way as the change stories discussed earlier, is an entrenchment of the current (informal) environmental practices and solutions already authored by the DM. Rather than lacking "appropriate" knowledge and skills to

develop formal strategic processes as suggested by Price and Newson (2010), organisations and their members seem to lack awareness of the psycho-social mechanisms and dynamics that underpin or undermine organisational structure and processes. No matter how effective the strategic plans, process diagrams and checklists are to strategists, if the operational levels cannot make sense of them they will not appropriate them. The consequences will inevitably be lip-service compliance or overt non-compliance.

This study has introduced positioning theory and illustrated the value of micro-level analysis to raise researchers' and practitioners' awareness of the inextricable link between talk and action. If we are to understand how construction managers think and function, and why they behave the way they do, or what drives them, we need, as Brown and Phua (2011) promote, "a sophisticated appreciation of how they conceive their selves." We would like to suggest position theory as a strong candidate for achieving such an appreciation.

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THE AREA-BASED PLANNING PROCESS OF DUTCH HOUSING ASSOCIATIONS

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Abstract
Dutch housing associations are important actors in the field of urban planning. They are independent social enterprises, which take their own decisions on this stock. Many housing associations work with asset management plans to secure that their portfolio meets company goals and market demand. However, in practice decisions of housing associations are often not a direct result of these plans, but of incidents at the neighbourhood level, or of emerged opportunities. Next to that, housing associations nowadays do not only focus on the quality of their own housing stock, but also on the physical, economical and social quality of the whole neighbourhood, which implies cooperation with a wide variety of local actors. As a result housing associations in the Netherlands are increasingly employing an area-based approach towards asset management. In order to analyse the different ways housing associations implement this area-based approach, the concept of planning is used. Five planning types are identified (rational, incremental, collaborative, political and advocacy planning) and transformed into propositions that are tested in a survey among housing managers. From this survey a diffuse picture arises. Housing associations use different elements from different planning types. However, emphasis is on the elements of the rational and collaborative types.

Keywords: Housing, planning, the Netherlands, asset management

INTRODUCTION

Housing associations in The Netherlands are important actors in the field of urban planning. They own and manage nearly one third of the total Dutch housing stock and account for 49% (2009) of all newly developed housing (Centraal Fonds Volkshuisvesting, 2010). Next to that, as a consequence of the concentration of their stock in, often less affluent, areas, they play an important role in the upgrading of deprived neighbourhoods. This upgrading can take shape in numerous forms. It can consist of merely physical activities in the form of maintenance, renovation, demolition, new construction of dwellings and other real estate. It can also encompass socio-economic measures like improving schools, care and welfare arrangements.
Traditionally housing associations were focussed on building and managing dwellings for low-income households. Nowadays they have taken up a wider role.
Since the 1990s housing associations developed into independent social enterprises that take their own decisions, with their stock as their main asset. How to manage these assets, how to take decisions on the stock, is an important issue within housing associations. Because decisions affect the people living in and around the stock, these decisions are also important for external actors.

There are two notions that make it relevant to look at these decisions on area level. First of all, this level is seen as the suitable level for the process to come to decisions. Secondly, more

related to the content side of planning, on this level a combination of physical, social and economical factors determine the quality of a neighbourhood.

In this paper the area-based planning process of Dutch housing associations will be elaborated using concepts of planning, of the social enterprise, and of urban renewal. Normative propositions are constructed which are used in a survey to provide an overview of the way Dutch housing associations in urban renewal areas make decisions on their asset management activities. First I will introduce the Dutch housing association sector, including the development into social enterprises and the urban renewal agenda. Next, the concepts of asset management and planning will be discussed. Finally, the results of a survey will be shown.

THE DUTCH HOUSING ASSOCIATION SECTOR

418 Housing associations own 32 percent (2.4 million dwellings) of the total Dutch housing stock, resulting in the largest market share of social housing in Europe (Centraal Fonds Volkshuisvesting, 2010). Since the introduction of the *Besluit Beheer Sociale-huursector* (decree on management of social rented sector) in 1993 and the abolition of structural government subsidies for new construction and renovation in 1995, housing associations operate relatively independently. Since then, they had to decide for themselves what to invest where and how to finance their investments. In practice, the sale of existing social housing is the main source of income which is used to finance urban renewal.

Housing associations operate in a system in which they are supervised on the basis of general 'fields of performance': accommodation of target groups; preservation of the quality of dwellings and their environment; consultation of tenants; securing financial continuity; and providing housing and care arrangements (Ministerie van VROM, 2005). To contribute to these 'fields of performance' the main asset of housing associations is their housing stock.

Housing associations are nowadays often regarded as social enterprises (e.g. Boelhouwer, 1999, van Dijk et al., 2002, Marshall and Lovatt, 2004, Gruis, 2005, Pawson, 2006) and less as task-oriented agents of government. Social enterprises are private organisations operating on the market, pursuing social goals which are related to the general interest, producing goods and services and of which the financial surplus is (re)invested in the social goal (Toonen et al., 2003).
Although social enterprises have a hybrid position between the state, market and society, Dees (2001) has identified in his definition some shared characteristics. He states that:

> "Social entrepreneurs play the role of change agents in the social sector, by:
> • Adopting a mission to create and sustain social value (not just private value),
> • Recognizing and relentlessly pursuing new opportunities to serve that mission,
> • Engaging in a process of continuous innovation, adaptation, and learning,
> • Acting boldly without being limited by resources currently in hand, and
> • Exhibiting heightened accountability to the constituencies served and for the outcomes created."

Next to the increased autonomy and independence which led to the development of housing associations towards social enterprises, the increased focus on the neighbourhood is a major development among Dutch housing associations. In 1997, 'liveability' of the neighbourhood

was added as a field of performance to the BBSH. Since then, housing associations are also accountable for their activities to secure or improve the liveability of the neighbourhoods where their dwellings are located. This enabled as well as stimulated housing associations to develop activities that benefit the living conditions in the neighbourhood, to develop non-residential real estate and to maintain and improve the environment of their estates (Ministerie van VROM, 2005).

Area-based planning of housing associations should contribute to 'better' neighbourhoods. What constitutes a good neighbourhood depends on the specific characteristics and context of that neighbourhood. However, goals that are shared in most urban renewal neighbourhoods can be distinguished. For that purpose I use the main policy document of the national government on urban renewal: *Nota Stedelijke Vernieuwing* (Memorandum on Urban Renewal) (VROM, 1997).

According to this memorandum urban renewal encompasses 'policy that is centred on the attractiveness of areas as places to reside, to work, to run a business and to sojourn'. Goal is to create vigorous cities, being differentiated, varied, but not divided. One of the measures is *urban restructuring:* building new housing, selling rental housing and adapting existing housing to increase the quality of housing conditions. Goals are to stop spatial segregation, to ameliorate liveability and to retain and attract the well-to-do residents and businesses (VROM, 1997).

The memorandum states that the process of urban restructuring requires the joined effort of all stakeholders. The local authorities have the lead. Housing associations are seen as partners that act out of their social mission and out of financial self-interest (to prevent voids, poor lettability, and vandalism). Housing associations are expected to contribute to restructuring by the adaptation of their stock. They sign performance agreements with and are accountable to the local authorities. Urban renewal is focused on neighbourhoods. Different forms of policy come together in the neighbourhood, keeping the wider relationship with the city in mind (VROM, 1997).

This neighbourhood focus was strengthened by the 'action program urban restructuring'. 56 Neighbourhoods were assigned by the Housing Minister in 2003 that were in need of specific attention and extra investments and financial support. This was part of a more general government policy to stimulate urban regeneration. One of the main objectives of this policy was also to achieve a more comprehensive approach towards urban regeneration, including not only renewal of the housing stock, but including physical, social and economic measures in a balanced way. In practice, however, the emphasis remained on physical measures (e.g. Gruis et al., 2006).

Partly in reaction to this, in recent years several reports were issued on Dutch housing policy of which the most prominent are the advice reports of the Dutch Scientific Council for Government Policy "Vertrouwen in de buurt" [Confidence in the neighbourhood] (Wetenschappelijke Raad voor het Regeringsbeleid, 2005) and the Council for the Ministry of Housing, Spatial Planning and the Environment "Stad en Stijging" [City and Upward Mobility] (VROM-raad, 2006). In both reports the neighbourhood is seen as the place where the social and political confidence of residents can be regained. The reports plead for more attention for social regeneration of deprived areas, including measures for empowerment of socially disadvantaged people and to keep the upwardly mobile people attracted to their

neighbourhood as to retain them for the city. Both councils recognize a key role for housing associations.

In the end of 2007, the former Housing Minister Vogelaar has designated 40 neighbourhoods where extra funds have come available. Furthermore, policy is focussed explicitly on increasing socio-economic measures, in addition to physical renewal. Many housing associations have taken up a much broader task and have taken on new roles. They remain primarily responsible for the physical renewal of their housing stock, but also have begun to facilitate, finance and develop activities to stimulate safety, care, welfare, education and employment (e.g. Brandsen et al., 2006). Many of these activities are developed at neighbourhood level, in cooperation with the local government and other societal organisations, thus increasing the neighbourhood focus in housing associations' management.

THE DECISION-MAKING PROCESS OF SOCIAL LANDLORDS REGARDING THEIR HOUSING STOCK

Housing associations have to fulfil their objectives with their stock as their main asset. Many housing associations in The Netherlands work with asset management plans to secure that their portfolio meets company goals and market demand. However, in practice decisions of housing associations are often not a direct result of their strategic plans, but of incidents at the neighbourhood level, or of emerged opportunities.

Due to the reduction of government control and the abolishment of financial support housing associations have developed their own asset management strategies to fill in the gap in the housing associations' policies and to cope with financial risks (see e.g. Gruis and Nieboer, 2004a, Gruis and Nieboer, 2004b). Asset management is meant to secure that the housing portfolio meets the organisation's goals and market demand. It can be seen as 'the decisionmaking process of social landlords regarding their housing stock' (Gruis, 2005). This process results in (proposals for) physical and non-physical activities regarding the housing stock. Physical activities can for instance be maintenance, renovation, demolition and new building. Non-physical activities can for instance be adjusting the rent, changing the target group and hiring a caretaker. Physical activities (like the building of community centres) and non-physical activities (like organizing social events) that are not directly focused on the housing stock can influence asset management strategy, but is not considered as a part it.

Several models for determining asset management strategies have been developed since the 1990s (van Vliet, 1993, van den Broeke, 1998, Gruis and Nieboer, 2004b, Eskinasi, 2006, van Os, 2007). In general, these models have been derived from theories on and models for strategic business planning in which strategies for individual estates are derived from general portfolio objectives in a systematic, rationalized manner. According to Nieboer and Gruis (2004) all models have the same general outline of analysis, formulating provisional policy options, testing (ex ante evaluating) these options (option appraisal), and formulating definitive options. Many models follow a top-down approach, in which general strategies for the development of the portfolio are linked to investment strategies for the individual estates. The existing models can be seen as part of the rational-analytical paradigm of strategy formulation within organisations (Nieboer, 2007).

These models, however, have various drawbacks, some of which are linked to the fundamental drawbacks of strategic business planning and others to the specific context of social landlords. Nieboer (2009) states that investments of housing associations do only

partly result from systematic decision-making. He explains this by the difference in the level of abstraction between the portfolio policies and the investment choices and by the assumptions behind the process models (investment decisions follow from central policy, the housing association is one undivided actor, the housing association decides on its own) that are not applicable to housing associations.

In practice decisions of housing associations are often not a direct result of their plans, but of incidents at the neighbourhood level or of emerged opportunities (e.g. Nieboer, 2007). According to Straub (2002) a clear link between the strategic stock and the planned maintenance is lacking as well. The existing models for asset management can be seen as normative models. The models describe how strategic planning could be done, but not how strategic planning is actually done. The models put great emphasis on analysis and translation into policy. The strategic relationship between the asset management plans and the actual investments is, however, weak. Formal documented strategies do not reflect the actual strategies followed in practice (Nieboer, 2007). Gruis (2006) also notes that on paper many housing associations already transformed to dynamic enterprises that are customer- and society-driven, but that there is a discrepancy between policy formulation and policy implementation. Mintzberg et al. (1999) refer to this difference as the difference between the 'intended strategy' and the 'realized strategy'. The realized strategy is a combination of intended and emergent strategy.

There are specific circumstances that make it difficult for housing associations to incorporate effective top-down planning mechanisms. Gruis (2006) lists four properties of the housing association that make it difficult to plan top-down: the rigidity of the product (the house); the complexity of the environment; the functional organizational structure; and the vague border between supplier and buyer of the housing service.

Housing associations nowadays do not only focus on the quality of their own housing stock, but also on the physical, economical and social quality of the whole neighbourhood, which implies cooperation with a wide variety of local actors. As a result housing associations in the Netherlands are increasingly employing an area-based approach towards asset management, which takes into account the characteristics of areas and the other actors present in the area. Several authors have suggested that a neighbourhood-based asset management fits better with the practice and context of housing associations. Gruis (2006) and Van Os (2007) mention the following reasons for a neighbourhood-based approach:

- The neighbourhood is important for the living experience of people. It is the level on which residents identify themselves and on which outsiders form an image;
- The neighbourhood level is concrete enough to debate on and to plan on in cooperation with external parties;
- It is often the level on which partnerships with stakeholders and urban restructuring plans are made;
- The neighbourhood level is a suitable level for balancing costs and revenues and for planning in stages;
- Planning at neighbourhood level can contribute to internal cooperation. Representatives from the 'functional' departments within the organisation (such as the maintenance department, the real estate development department, treasury and the front-office) can work together on neighbourhood plans.
- Thinking about the portfolio, the quality of public and commercial services and social structures coincide on this level.

Next to these reasons, location is of great importance for housing associations as real estate owners. The quality of the surroundings of a property is an important determinant for the value and popularity of a dwelling. Secondly, the dwellings of housing associations are often concentrated in certain neighbourhoods, which give them a specific interest in the development of the neighbourhood quality.
In Dutch practice, there are already several housing associations where management decisions are not based on portfolio considerations, but on considerations on neighbourhood level. Activities originate from negotiations with different parties and are based on social problems, technical quality and future market position of estates in a specific neighbourhood (Nieboer, 2007).

PLANNING BY HOUSING ASSOCIATIONS

In order to analyse the different area-based approaches the concept of planning is used. Planning is concerned with 'shaping futures in which better conditions for human life and planetary survival can be achieved' (Hillier and Healy, 2008: xxiii). Planning is thus aimed at future improvement of the environment. This fits well with most asset management strategies of housing associations, which aim to improve the quality of the housing stock, and with the wider role they have taken in not only improving the housing stock itself but also contributing to the improvement of social and economic quality of neighbourhoods. In the past planning was primarily the task of the government, but nowadays also other actors engage in planning.

Planning has both a process side and a content side. As Healy (2006) notes: "The planning tradition […] represents a continual effort to interrelate conceptions of the qualities and social dynamics of places with notions of the social processes of 'shaping places' through the articulation and implementation of policies" (Healey, 2006: 7). Planning can also be described as 'an activity centrally concerned with the linkage between knowledge and organized action' (Friedmann and Hudson, 1974: 2). Since the action is organized, we can see the organisation as another component of planning. An organisation can be seen as 'a goal-directed entity that serves an explicit purpose' (Anheier, 2005: 142). So planning can be deconstructed into the following general elements which I will use in describing the practice of housing associations: actors, activities, knowledge and purpose.

Next to these descriptive criteria, I will use evaluative criteria formulated by Hudson et al. (1979). They developed criteria "for comparison of different traditions' strengths and weakness, along with their varying intentions and accomplishments". They are "basic criteria that one might use for assessing the scope, character, and adequacy of the various planning traditions" (see Table 1).

Criteria	Characteristics and applications
Public interest	Explicit *theory of the public interest*, along with methods to articulate significant social problems, and pluralist interests in outcomes. May include principles of distributive justice, and procedures for dealing with conflict.
Human dimension	Attention to the *personal and spiritual domains* of policy imp acts, including intangible outcomes beyond functional-instrumental objectives -for example, psycho-social development, enhancement of dignity, and capacity for self-help.

Feasibility	*Ease of learning and applying* the theory. Implies the theory is practical to translate into policy implications, and adaptable to varying types of problems, scales of action and social settings.
Action potential	Provision for carrying ideas into practice, building on experience underway and identifying new lines of effective solutions to problems.
Substantive theory	*Descriptive and normative theory* of social problems and processes of social change. Predictive capacity based on informal judgments, not just trend extrapolation; ability to trace long range and indirect policy consequences; historical perspectives on opportunities and constraints on action.
Self-reflective	Capacity for laying analytical assumptions open to criticism and counter -proposals; provision for learning from those being planned for; capacity for depicting concrete experience in everyday language, as well as conceptual models using aggregate data.

Table 1*. Criteria for evaluating planning traditions (Hudson et al., 1979)*

PLANNING STYLES

Planning can be done in different ways, with various interpretations of the above criteria. Many authors have tried to classify these ways. The classification in this paper is based on classifications of Healey (2003), Hudson et al.(1979) and Innes et al. (2005) and encompasses the rational, incremental, collaborative, political and social movement style.

Rational planning

Within the rational planning approach (also called rational–technical, synoptic, rational comprehensive or technical-bureaucratic planning) planners try to formulate policy in a scientific way. “Planning is the application of scientific method –however crude- to policy-making” (Faludi, 1973). Important characteristic of rational planning is the distinction between ends and means. According to Davidoff and Reiner (1962) the formulation of values (ends) is the first step in the planning process. These values are delivered by the client and are the result of a political process. Second step is the identification of possible means to reach the ends. This is the rational-technical process, which includes the selection of the best means to reach the end. Last step is the effectuation of the goals through the application of the selected means. This approach offers ”flexibility to address the particularity of decision circumstances while constraining corruption by clear accountability of actions to policy criteria” (Healey, 2006: 23).

Incremental planning

Incremental planning (also called successive limited comparisons) is planning where a plan is based on a limited number of alternatives. These alternatives originate out of the planner’s experience and consist of little steps to accomplish a part of the goal. By successive repetition of this process and adjustment to changing circumstances eventually the ends can be reached (Lindblom, 1959). This approach is characterised by Lindblom (1959):

- “Selection of value goals and empirical analysis of the needed action are not distinct from one another but are closely intertwined.
- Since means and ends are not distinct, means-end analysis is often inappropriate or limited.
- The test of a "good" policy is typically that various analysts find themselves directly agreeing on a policy (without their agreeing that it is the most appropriate means to an agreed objective).

- Analysis is drastically limited: Important possible outcomes, alternative potential policies and affected values are neglected.
- A succession of comparisons greatly reduces or eliminates reliance on theory."

Collaborative planning

The concept of collaborative planning (also called communicative planning) assumes a pluralistic society where local conflicts arise between people from different cultural communities. These conflicts can be dealt with through collaboration by recognizing 'the potential cultural dimensions of differences' and by creating 'an additional "layer" of cultural formation' (Healey, 2006: 64).

Collaborative planning can be characterized with the following concepts:

- integrative place making: interrelation of economic, social, and environmental relationships;
- collaboration in policymaking: emphasis on collaboration in strategy development, and a mingling of formal politics with pressure groups, citizens groups, business lobbies, and environmental groups.
- inclusive stakeholder involvement: to generate both mutual learning and even consensus building before people come to 'fix' their positions.
- use of 'local' knowledge; the mixture of knowledge built up through practical experience and the frames of reference people use to filter and give meaning to that experience.
- building 'relational' resources: a rich social infrastructure of positive relationships between governance, citizens, and companies (Healey, 1998).

Political planning

Within the political planning approach (also called 'manipulative politics', 'political influence') a leader works on a one-on-one basis with people which he offers benefits in exchange of support for his agenda. This approach depends on personal loyalty, reciprocity, behind-the-scene deals, promises and rewards (Innes and Gruber, 2005). It refers to relations of power in everyday life as well as to 'deliberate efforts to gain influence and exercise power in the public realm […] beyond the household and the firm' (Healey, 2006).

Social Movement

Planning based on the social movement (also called advocacy planning) is characterized by defending the interests of the weak against the strong (Hudson et al., 1979). It originates from groups of people who feel excluded and/or unrepresented. Typical instruments of the social movement are demonstrations, media-attention and instigating legal action (Innes and Gruber, 2005). A social movement planner develops an alternative vision (compare the alternatives in the rational style) that support the interests of the excluded groups. He uses arguments that serve their interests and that cast doubt on the contested plans (Davidoff, 1965). The goal is 'to convert people to support this vision and to make their collective voice powerful enough to force a response' (Innes and Gruber, 2005).

In table 2 the different planning styles are summarized using the general elements of planning.

	Actors	Activities	Knowledge	Purpose
Rational	Specialists (and client)	Analysing	Scientific/objective	Optimal solution
Incremental	Experienced planner	Adapting/adjusting	Experience	Satisfying/agreed upon solution
Collaborative	Stakeholders	Deliberating	Local	reach a consensus

Political	Leader (and constituency)	Negotiating	Strategic/selective	have support of all powerful players by serving their interests.
Social Movement	Unrepresented (and 'lawyer')	Demonstrating, opposing	Legal/logical Arguments	'to convert people to support their vision and to make their collective voice powerful enough to force a response'

Table 2. *Summary of planning styles*

SURVEY

These planning types and their elements are transformed into propositions that are tested in a survey among housing managers working in priority neighbourhoods (see Appendix for the propositions) in order to get a general picture of how housing associations plan their area-based asset management in practice. The survey was restricted to these neighbourhoods because in these areas we expect to find the most complex problems resulting in an area-based process. 34 Surveys out of a potential 51 (in some neighbourhoods more than one housing association is active) were returned of which one was not useful because it was evident that it was not filled out seriously.

The survey was divided into three parts. In the first part, respondents were asked if they completely agreed, agreed more than disagreed, disagreed more than agreed or disagreed with propositions concerning the general process resulting in (proposed) activities concerning the housing stock. In the second part respondents were asked to indicate if the proposition was (almost) never, sometimes, often or (almost) always applicable to the (proposed) activities in their area in the last four years. In the third part respondents had to place elements relating the planning styles in order of importance.

Expectations

Although no housing association is the same, housing associations working in priority neighbourhoods do have some shared characteristics. They all have the same legal status and function in the same regulatory framework. They can all be considered social enterprises, working on the renewal of problematic areas. Out of these shared characteristics expectations regarding their planning style were derived.

If we relate the concept of the social enterprise to the elements of the planning styles, we expect that the planning style of a social enterprise has elements of the rational style. First of all, ends and means within a social enterprise are separated. The ends relate to the mission to create and sustain social value. The opportunities to serve that mission can be seen as the means. Secondly, the relentless pursuit of these opportunities can be seen as the rational emphasis on analysis (think of the O in the SWOT analysis). Thirdly, the process of innovation fits well with the rational style. The continuous adaptation and learning fits with the incremental style and the heightened sense of accountability fits well with the collaborative style. Political and social movement styles are expected to occur less frequent.
When we look at the general urban renewal agenda, a combination of collaborative and rational planning elements are expected. The joined effort, the agreements with and the accountability to the local authority, and the connection with wider urban and national policy fit with the collaborative style. The housing market analysis and the denomination of explicit goals fit with the rational style.

Results

The survey shows that housing associations use different elements from different planning styles. However, emphasis is (as expected) on the elements of the rational and collaborative styles. Activities often result from planning based on elements of these styles. Elements of the social movement style and the political style are reported to be used least. In between are elements of the incremental style.

When we take a look at the different elements of the planning process, it seems that the actors that are most involved in the planning process are the stakeholders (including the housing association) and the policy advisors. Often the process consists of activities such as the balancing of alternative means to reach the formulated goals and the adaptation to changing circumstances. Proposed activities regarding the housing stock are often based on objective, local and/or personal knowledge. Often consensus on the (proposed) activities is reached and often the (proposed) activities take the wishes and interests of all stakeholders into account. Often there is a clear relationship between de (proposed) activities and the goals that are formulated for the area.

When asked to place different elements in order of importance, collaborative elements are considered as most important, incremental elements (except for staff carrying out the work) are ranked second most important. Remarkably, the rational elements on average are ranked second lowest (except for the (policy) advisor) (see table 3). So it seems that in practice rational elements are often used to formulate (proposed) activities, but that they are not recognized as being of top importance.

	Actors	**Knowledge**	**Activities**	**Concepts**
1	Stakeholders (C)	Local knowledge (C)	Consulting / collaborating (C)	Consensus (C)
2	Management (P)	Personal experience/ common sense (I)	Piecemeal adjusting activities/plans to changing circumstances (I)	Experience (I)
3	(Policy) advisors (R)	Strategic/selective information (P)	Exchanging means/interests/positions and deal making (negotiating) (P)	(collective) Action (S)
4	Special interest groups (S)	Scientific/objective (R)	Analysing/Researching (R)	Ratio (R)
5	Staff carrying out the work (I)	Logic/legal arguments (S)	Agitating against other plans / developing alternative plans (S)	Power(P)

Table 3. *Elements of planning in order of importance*

A possible explanation is that the rational style is seen as a 'basic' style, which is taught at school and is omnipresent. The other styles can be seen as departing from or reacting on this basic style (see also Hudson et al., 1979). In many planning processes rational elements are used; for instance explicit goals are set, alternatives means are compared, or a thorough quantitative analysis is made. However, these rational elements are combined with other elements that are distinguishing the process and are more visible. These elements are defining the perception of the planning process, and not the 'basic' rational elements.

Most housing associations in this study often act as a social enterprise. Four out of five of the characteristics of the social enterprise are subscribed by most of the respondents. On the proposition that activities are innovative or based on innovations, most respondents indicate that this is only sometimes true. An explanation might be that the nature of innovation requires a small share of activities (if all activities were innovative, how innovative are these activities?).

In general, activities of most housing associations in the survey contribute to the urban renewal goals of the government. The goals to attract businesses and to serve the business interest of the housing association are an exception; activities contribute less frequent to these goals. This can be explained by the core mission of the housing association, which is to provide affordable housing on a non-profit basis. Also in urban renewal areas emphasis is on housing and not on attracting businesses to neighbourhoods. Because of the non-profit status of housing associations the contribution of activities to the business interest is not necessary.
Most respondents agree on the propositions derived from the evaluative criteria of the planning process, except for the feasibility criterion. Most respondents do not think the process is easy. This shows the need for a better understanding of the process.

DISCUSSION

The survey's focus is on the actual and proposed activities of the last four years. However, because the respondents are employees of the housing associations, results are possibly biased. Responses reflect the perceived reality of the respondent. Especially with the propositions concerning the criteria to assess the planning process, this bias can be expected. With the other propositions we tried to avoid bias by not asking their opinion on an abstract proposition but by relating these propositions to the actual situation in the actual neighbourhoods the respondent works in. In this way respondents were forced to look back at real situations.

Also, the propositions and expectations are based on normative concepts on how planning should be done. In reality the picture might be quite different. Political elements are for instance often not that overt and may not be written down as a formal, designed planning style. The social movement style can be seen as a style that is employed in reaction to the failure of other styles to acknowledge the interests of all stakeholders and as a consequence is not likely to be formally promoted as the preferred style. The incremental style can be seen as a reaction to the flaws of the rational style. Moreover, the urban renewal agenda reflects the politically desirable situation, and can be different from the societal and scientifically desirable situation. This agenda is based on assumptions that can be contested (e.g. Kleinhans, 2005). It is possible that this normative preference for certain styles has influenced the answers of the respondents.

Furthermore, the survey gives a general overview of the use of planning styles. It does not describe the specific local context in which the different planning styles are used. For instance the different characteristics of the dwellings, of the stakeholders, and of the organisation are not taken into account.

Therefore, these findings will be further explored in a multiple case study. In this case study the planning practice of housing associations for a neighbourhood will be studied more in-

depth, taking into account the local context and the type of activity. Document research and interviews with internal and external people involved in the planning process will provide a better understanding of the process and of the strengths and weaknesses of the elements of planning applied in different situations.

CONCLUSION

Housing associations, being private actors with public tasks, have become more important in the production of places, especially in urban renewal areas where they own a large share of the housing stock. They have taken up a wider role in theses areas, which made their asset management strategies become more complex. With this growing complexity a pure rational approach does not seem to be sufficient. From literature it was expected that, next to rational elements, elements from other planning styles, especially from collaborative planning, play a role.

The survey confirms this expectation. It shows that, in general, rational elements of planning still play an important role in decision-making on activities regarding the housing stock in regeneration areas, but that these rational elements are combined with elements from other styles, of which the most important is the collaborative one.

Raising awareness within housing associations on the different ways to plan their activities regarding the housing stock can help them to improve their performance in urban renewal. Next to raising awareness a better understanding of the pros and cons of the styles and of when and how to apply the different styles is necessary.

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APPENDIX

Proposition	*disagree*	*disagree more than agree*	*agree more than disagree*	*agree*
The execution of the process to come to (proposed) activities regarding the housing stock is easy *(feasibility)*	9 (27%)	17 (52%)	5 (15%)	2 (6%)
The process to come to (proposed) activities regarding the housing stock leads to actions *(Action potential)*	0 (0%)	1 (3%)	15 (45%)	17 (52%)
The process to come to (proposed) activities regarding the housing stock, is adapted to the specific substance of the area problems *(Substantive theory)*	1 (3%)	2 (6%)	10 (30%)	20 (61%)
The process to come to (proposed) activities regarding the housing stock includes explicit methods to deal with pluralist interests *(Public interest)*	0 (0%)	10 (30%)	15 (45%)	8 (24%)
The process to come to (proposed) activities regarding the housing stock has room for internal and external reflection, criticism and counter –proposals *(Self-reflective)*	1 (3%)	3 (9%)	17 (52%)	12 (36%)
Social Enterprise	*(almost) never*	*sometimes*	*often*	*(almost) always*
(proposed) Activities regarding the housing stock in the area are delivering outputs for the society which are not (exclusively) focused on the business goals of the housing association.	1 (3%)	7 (21%)	17 (52%)	8 (24%)
(proposed) Activities regarding the housing stock in the area are the result of a relentless pursuit of new opportunities to create social value.	3 (9%)	10 (30%)	13 (39%)	7 (21%)
(proposed) Activities regarding the housing stock in the area are innovative or based on innovative ideas.	3 (9%)	19 (58%)	9 (27%)	2 (6%)
(proposed) Activities regarding the housing stock in the area are financed by a mix of own and external means.	2 (6%)	11 (33%)	13 (39%)	7 (21%)
Account is given for the outcomes of the (proposed) activities regarding the housing stock in the area to the stakeholders of these activities.	0 (0%)	4 (12%)	16 (48%)	13 (39%)
Urban Renewal				
(proposed) Activities regarding the housing stock in the area take the context of the city and its surroundings into account	0 (0%)	3 (9%)	20 (61%)	10 (30%)
(proposed) Activities regarding the housing stock in the area are connected with the other social, economical and/or physical activities in the area.	0 (0%)	3 (9%)	12 (36%)	18 (55%)
(proposed) Activities regarding the housing stock in the area are connected with national policy that displays itself in the area.	5 (15%)	11 (33%)	11 (33%)	6 (18%)
(proposed) Activities regarding the housing stock in the area attract well-to-do residents	0 (0%)	14 (42%)	16 (48%)	3 (9%)
(proposed) Activities regarding the housing stock in the area prevent spatial segregation	1 (3%)	13 (39%)	15 (45%)	4 (12%)
(proposed) Activities regarding the housing stock in the area contribute to the goals, performance and activities of the 'area action plan'.	1 (3%)	4 (12%)	14 (42%)	14 (42%)
(proposed) Activities regarding the housing stock in the area contribute to the vigour of the city	0 (0%)	6 (18%)	9 (27%)	18 (55%)
(proposed) Activities regarding the housing stock in the area contribute to the quality of the living and	0 (0%)	2 (6%)	15 (45%)	16 (48%)

working environment.				
(proposed) Activities regarding the housing stock in the area ameliorate liveability.	0 (0%)	2 (6%)	12 (36%)	19 (58%)
(proposed) Activities regarding the housing stock in the area attract business activity	3 (9%)	19 (58%)	10 (30%)	1 (3%)
(proposed) Activities regarding the housing stock in the area serve the business/economical interests of the housing association	1 (3%)	19 (58%)	10 (30%)	3 (9%)
Rational planning				
(proposed) Activities regarding the housing stock in the area are the result of a process in which alternative means to reach the formulated goals are balanced against each other.	0 (0%)	8 (24%)	21 (64%)	4 (12%)
(proposed) Activities regarding the housing stock in the area are influenced by the analyses of policy advisors.	1 (3%)	8 (24%)	16 (48%)	8 (24%)
There is a clear relationship between de (proposed) activities regarding the housing stock in the area and the goals that are formulated for this area.	0 (0%)	3 (9%)	15 (45%)	15 (45%)
(proposed) Activities regarding the housing stock in the area are based on objective knowledge.	0 (0%)	1 (3%)	21 (64%)	11 (33%)
Incremental planning				
In the decision-making on (proposed) activities regarding the housing stock in the area ends and means are intertwined.	4 12%	17 52%	11 33%	1 3%
(proposed) activities regarding the housing stock in the area are based on the personal knowledge and experience of the professional concerned	1 3%	8 24%	19 58%	5 15%
(proposed) activities regarding the housing stock in the area are the result of a repeating process of little steps in the right direction	0 0%	15 45%	17 52%	1 3%
(proposed) activities regarding the housing stock in the area are adapted to changed circumstances	0 0%	11 33%	18 55%	4 12%
Collaborative planning				
(proposed) activities regarding the housing stock in the area are collaboratively planned by the housing association and its stakeholders	0 0%	6 18%	17 52%	10 30%
(proposed) activities regarding the housing stock in the area are based on practical knowledge about the situation of the local community	0 0%	3 9%	20 61%	10 30%
There is consensus on the (proposed) activities regarding the housing stock in the area by all parties	0 0%	9 27%	19 58%	5 15%
(proposed) activities regarding the housing stock in the area take the wishes and interests of all stakeholders into account	0 0%	4 12%	22 67%	7 21%
Political planning				
Power is of overriding importance within the decision-making of the (proposed) activities regarding the housing stock in the area	8 24%	16 48%	6 18%	3 9%
(proposed) activities regarding the housing stock in the area are established top-down.	5 15%	15 45%	11 33%	2 6%
(proposed) activities regarding the housing stock are the result of a negotiating process in which an exchange of means and interests of different persons, parties or departments takes place	2 6%	13 39%	15 45%	3 9%
Knowledge is used selectively/strategically to legitimize (proposed) activities regarding the housing stock in the area	3 9%	15 45%	12 36%	3 9%
Social Movement				

(proposed) activities regarding the housing stock in the area are being influenced by internal and/or external groups which are not being represented in the formal planning process	9	27%	14	42%	7	21%	3	9%
Alternative plans from outside the formal planning process are influencing the (proposed) activities regarding the housing stock in the area	6	18%	17	52%	7	21%	3	9%
(proposed) activities regarding the housing stock in the area are being influenced through opposition of internal and/or external parties outside the normal planning process. For example via the media, lawsuits, demonstration, strike, whistle-blowers	14	42%	17	52%	2	6%	0	0%
Substantive arguments which support the interest of a group influence the (proposed) activities regarding the housing stock in the area. The group can for example be a Group of residents, the project development department, a local environmentalist group or a school board	0	0%	15	45%	14	42%	4	12%

In the process of coming to (proposed) activities regarding the housing stock in the area, the following actors are decisive (order)	*1*		*2*		*3*		*4*		*5*	
(policy) advisors	2	6%	8	25%	9	28%	6	19%	7	22%
staff	6	19%	3	9%	1	3%	8	25%	14	44%
management	11	34%	6	19%	5	16%	7	22%	3	9%
stakeholders	11	34%	9	28%	7	22%	3	9%	2	6%
special interest groups	2	6%	6	19%	10	31%	8	25%	6	19%
Rank the following types of information										
scientific/objective	1	3%	5	15%	7	21%	12	36%	8	24%
personal experience/common sense	3	9%	14	42%	9	27%	5	15%	2	6%
strategic/selective information	6	18%	6	18%	8	24%	5	15%	8	24%
local knowledge	21	64%	5	15%	2	6%	1	3%	4	12%
logic/legal arguments	2	6%	3	9%	7	21%	10	30%	11	33%
Rank the following concepts										
Ratio	2	6%	8	26%	6	19%	11	35%	4	13%
Experience	7	23%	11	35%	7	23%	5	16%	1	3%
Power	3	10%	3	10%	1	3%	5	16%	19	61%
Consensus	14	44%	6	19%	7	22%	2	6%	3	9%
(collective) Action	6	19%	4	13%	10	31%	8	25%	4	13%
Rank the following activities										
Analysing/Researching	4	12%	6	18%	9	27%	9	27%	5	15%
Piecemeal adjusting activities/plans to changing circumstances	3	9%	14	42%	6	18%	9	27%	1	3%
Exchanging means/interests/positions and deal making (negotiating)	3	9%	7	21%	15	45%	7	21%	1	3%
Consulting and collaborating with other parties.	21	64%	5	15%	2	6%	3	9%	2	6%
Agitating against other plans / developing alternative plans.	2	6%	1	3%	1	3%	5	15%	24	73%

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EXPLORING ROBUSTNESS OF ENERGY PERFORMANCE OF DWELLINGS TO OCCUPANT BEHAVIOUR: RENOVATION AND POST OCCUPANCY

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Abstract
In this paper, we focus on the influence of occupant behaviour on the energy performance of dwellings, before and after renovation process. In this context, 'ventilation control pattern', 'maintenance', and 'heating energy demand' are selected as the key parameters of the study. The aim is to reveal the sensitivity of energy performance of a dwelling to occupant behaviour, considering the pre and post-renovation process. Sensitivity of dwelling energy performance to occupant behaviour is analysed using Monte Carlo method. This method is one of the most commonly used methods to analyse the approximate distribution of possible results on the basis of probabilistic inputs. The inputs are selected as: window and grid operation, and mechanical ventilation set for ventilation control. The data used about occupant behaviour is gathered from OTB Survey [2008]. The Dutch reference building is used as a generic building to test the behavioural patterns. The result shows that a renovated [maintenance] dwelling is more robust to ventilation behaviour of the occupant.

Keywords: occupant behaviour, ventilation, renovation, energy performance, sensitivity analysis.

INTRODUCTION

It has long been known that energy efficiency improvements in the building stock cannot be furthered, unless strategies for renovation of existing dwellings are developed. Moreover, occupant behaviour has been a growing research interest, since the expected energy performance levels have not been achieved with low energy design, and occupant behaviour could be a reason [GuerraSantin and Itard, 2010]. This study focuses on the behavioural aspects of energy performance in renovation of dwellings. The aim is to reveal the sensitivity of occupant behaviour to the energy performance of a dwelling, considering the pre and post-renovation process. Main research question is: Is there an occupant behaviour threshold that defines a significant difference on the energy performance, considering renovation process?

Following, this paper's approach towards the domains of 'renovation' and 'behaviour' are explained:

Kohler defines 'simple renovation' such as insulating walls or replacing single glazing with double glazing, and states that this is only possible if the quality of the existing dwelling is sufficient to fulfil current needs [Kohler, 2006; Itard and Klunder, 2007] redefines simple renovation as 'maintenance'; and furthermore, provide the terms 'consolidation' and 'housing transformation' as steps between simple renovation, demolition and new construction [redevelopment]. In their paper, consolidation is explained as improvements of the building shell [such as insulation, without any change in the floor plan of the house or housing block]. Transformations are improvements or interventions in a housing block or complex that go beyond an individual house. Examples of this are joining houses together horizontally or vertically. Housing transformation requires that at least the loadbearing structure will be preserved when the remaining components are renewed. The scope of this study includes 'maintenance', namely the improvements in the building shell.

In this paper, occupant behaviour is considered as: presence patterns in a space, together with the actual heating [thermostat setting and radiator control] and ventilation patterns [operation of windows, grids, and mechanical systems], and the use of lighting and appliances.

METHODOLOGY

Method

The research methodology is based on sensitivity analysis, which is the study of how the variation in the output of a model can be apportioned, qualitatively or quantitatively, to different sources of variation. In sensitivity analysis, a mathematical model is defined by a series of equations, input factors, parameters, and variables aimed to characterize the process being investigated. Input is subject to many sources of uncertainty including errors of measurement, absence of information and poor or partial understanding of the driving forces and mechanisms. This uncertainty imposes a limit on the confidence in the output of the model [Hamby et al, 1994; Helton et al, 2006; Saltelli et al, 2006]

There are several possible procedures to perform sensitivity analysis. The most common sensitivity analysis practice works based on sampling. Several sampling strategies are available, including random sampling, importance sampling, and Latin hypercube sampling. In general, a sampling-based sensitivity analysis is one in which the model is executed repeatedly for combinations of values sampled from the distribution [assumed known] of the input factors. There are several examples of the application of sensitivity analysis in building thermal modelling [Spitler et al, 1989; Corson, 1992; Lam, 1996; Fulbringer and Roulet, 1999; McDonald, 2004; Westphal and Lamberts, 2005; Harputlugil et al, 2009]. For sensitivity of energy simulation models, a set of input parameters and their values are defined and applied to a building model. The simulated energy consumption of the model is used as a base for comparison to determine how much the output [here measured in terms of energy use per year] changes due to particular increments of input values [Corson, 1992]. Consequently the results show which parameters can be classified as "sensitive" or "robust". Sensitive parameters are the parameters that by a change in their value cause effective changes on outputs [in this case heating energy demand]. Contrarily, change of robust parameters causes negligible changes on outputs.

The sensitivity of occupant behaviour; which is considered here as factors influencing energy use by behaviour; are analysed using Monte Carlo method. The Monte Carlo method is one of the most commonly used methods to analyse the approximate distribution of possible results on the basis of probabilistic inputs [Lomas and Eppel, 2007; Hopfe et al, 2007]. In this research, the inputs [parameters] include use of ventilation system, and resulting air change rates. The steps of the analysis are as follows [Figure-1]:

- Pre-processing survey data [see next section] within statistical analysis program [the mean and standard deviations [SD] of the input parameters are determined]
- Gathering Latin-Hypercube samples from SimLab [SimLab] pre-processor
- Simulating each sample by a dynamic simulation program to collect output data. The simulations are made with 'one at a time' approach. Each input is perturbed in turn while keeping all other inputs constant at their nominal value.
- Combination of inputs and outputs in post-processor of SimLab to get Monte-Carlo
- Interpretation of the results

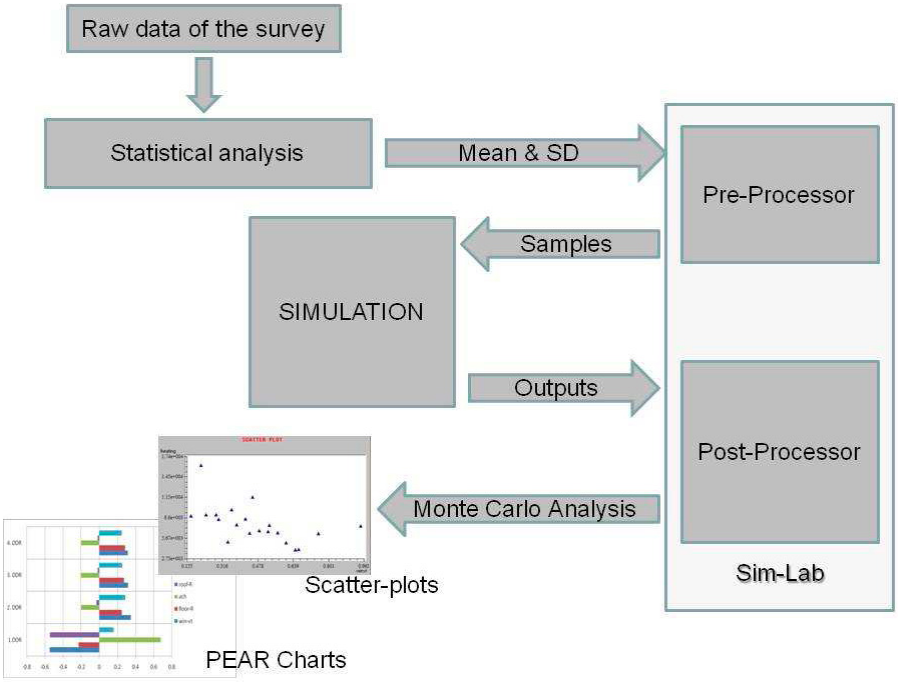


Figure 1. *Experiment/Computation/Observation*

Data

Dutch reference row house [Referentie woning, 2010] is modelled using the simulation software. The characteristics of the dwelling is explained below.



Figure 2. *Plans and sections of the reference row house*

Envelope properties of the non-renovated case [common row house of 1946 [Itard, 2006]] and the renovated case [contemporary row house [NEN 5128]] are displayed in Table 1.

Table 1. *Envelope characteristics and Energy use of sample dwellings*

Characteristics		Row house [contemporary] [renovated]	Row house [1946] [non renovated]
Dimension	Width [m]	5,1	
	Depth [m]	8,9	
	Height [m]	2,6	
	Floor area [m^2]	45,4	
	Volume [m^3]	118,0	
Envelope properties	Rc façade [m^2K/W]	3,0	0,58
	Rc roof [m^2K/W]	4,0	0,42
	Rc ground floor slab [m^2K/W]	3,0	0,38
	U window [W/m^2K]	1,8	5,1
	U front door [W/m^2K]	2,0	3,5
Energy use	EPC value [NEN 5128]	0,78	-
	Yearly energy use	359 MJ/m^2 [NEN 5128]	596 MJ/m^2 [Itard, 2006]

For calculating the *total ventilation rates*, Dutch standard for ventilation: NEN 1087 values are assumed [Table 2].

Table 2. *Dutch standards for ventilation*

	Living room	Bedroom	Kitchen	Bathroom +WC	WC only
Netherlands [NEN 1087]	1,0 $dm^3/s/m^2$ floor area	1,0 $dm^3/s/m^2$ floor area	21 dm^3/s	14 dm^3/s	7 dm^3/s

The following formula and the physical descriptions of the dwelling model provide the air change values for each room, listed below.

Supply Air Rate [AC/h] = Volume Flow Rate [m^3/h] / Room Volume [m^3]

Living room: 1,25 ach	Bathroom: 1,26 ach
Attic: 1,47 ach	Bedroom 1: 1,26 ach
Bedroom 2: 1,26 ach	Bedroom 3: 1,15 ach
Entrance: 1,26 ach	Circulation: 1,26 ach

Data about *ventilation behaviour* is collected in two neighbourhoods, that began to develop in 1996, in the Netherlands. The survey was conducted in Winter 2008, in 319 dwellings. Number of row houses in the sample is 117 [37%]. The data collected through the survey is about dwelling characteristics, household characteristics, energy consumption figures, actual behaviour about heating and ventilation behavioural patterns and use of lighting and equipments. In the scope of this research, data used about behaviour from the survey include: hourly ventilation behaviour changes: use of windows, and grids in each room, and hourly set point adjustment of mechanical ventilation.

In the survey, respondents were asked to fill in tables, mentioning if they open/don't open windows and grids in each room, each hour; and if they turn on/off mechanical ventilation each hour, during the week and the weekend. These tables are converted to values for further mathematical calculations [1: open window/grid, mechanical ventilation on, 0: closed window/grid, mechanical ventilation off]. Then, these values are used to calculate the air change per hour values [ach] of each room, when there is/not natural and/or mechanical ventilation present.

All 117 dwellings from the survey database have open kitchens. Therefore, reported data on ventilation behaviour in living room and in kitchen is combined. In addition, entrance, bathroom and circulation zones' natural ventilation patterns reported in the survey database are not simulated, because the reference dwelling model did not propose natural ventilation through windows, in these rooms.

Using the ach value assumptions calculated from the NEN standard and the reference row house, and the converted/quantitative ventilation behaviour data [from the survey database], air change rates of each room during the day are calculated. Afterwards, descriptive statistical analysis is applied to be able to obtain the mean and the standard deviations of ventilation patterns. These values [Table 4] are processed in SimLab pre-processor for gathering the generic 50 samples of ventilation patterns [see Pre-processing survey data step, in previous section]. As this study only focuses on ventilation behaviour, the remaining behavioural patterns are kept constant and taken from the NEN 5128 [Table 3].

To calculate average internal heat-gain from lighting, assumption for 1 m^2: 6,0 W For this study, 50 samples of ventilation rates are generated with SimLab.

Table 3. *Indoor temperature settings [NEN 5128]*

	07.00-17.00		17.00-23.00		23.00-07.00	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Living area thermostat setting	19 °C	19 °C	21 °C	21 °C	16 °C	16 °C
Sleeping area thermostat setting	16 °C	19 °C	16 °C	21 °C	14 °C	16 °C

Table 4. *Mean and Standard deviations of ach values per hour*

	Living room		Attic		Bathroom		Bedroom 1		Bedroom 2		Bedroom 3	
Hours	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
01.00-02.00	1,12	0,56	0,49	0,70	0,23	0,11	0,87	0,58	0,76	0,62	0,59	0,58
02.00-03.00	1,12	0,56	0,49	0,70	0,23	0,11	0,87	0,59	0,77	0,62	0,58	0,58
03.00-04.00	1,12	0,56	0,49	0,70	0,23	0,11	0,87	0,59	0,77	0,62	0,58	0,58
04.00-05.00	1,12	0,56	0,49	0,70	0,23	0,11	0,87	0,59	0,77	0,62	0,58	0,58
05.00-06.00	1,12	0,55	0,49	0,70	0,24	0,14	0,88	0,58	0,78	0,61	0,58	0,58
06.00-07.00	1,15	0,58	0,49	0,70	0,27	0,18	0,89	0,58	0,79	0,61	0,58	0,58
07.00-08.00	1,21	0,54	0,49	0,70	0,30	0,19	0,99	0,52	0,89	0,58	0,62	0,58
08.00-09.00	1,21	0,54	0,52	0,71	0,27	0,18	1,03	0,49	0,94	0,55	0,62	0,58
09.00-10.00	1,18	0,54	0,53	0,71	0,25	0,14	1,05	0,47	0,94	0,55	0,63	0,57
10.00-11.00	1,19	0,52	0,56	0,72	0,24	0,12	1,03	0,49	0,96	0,54	0,64	0,57
11.00-12.00	1,18	0,53	0,57	0,72	0,24	0,12	1,04	0,48	0,94	0,55	0,64	0,57
12.00-13.00	1,20	0,52	0,56	0,72	0,24	0,12	1,03	0,49	0,92	0,56	0,64	0,57
13.00-14.00	1,19	0,52	0,56	0,72	0,24	0,12	1,05	0,47	0,94	0,55	0,64	0,57
14.00-15.00	1,19	0,52	0,56	0,72	0,24	0,12	1,04	0,48	0,94	0,55	0,64	0,57
15.00-16.00	1,18	0,54	0,55	0,71	0,25	0,14	1,04	0,48	0,94	0,55	0,64	0,57
16.00-17.00	1,21	0,55	0,55	0,71	0,30	0,21	1,05	0,47	0,96	0,54	0,65	0,57
17.00-18.00	1,34	0,61	0,53	0,71	0,40	0,29	1,05	0,48	0,94	0,55	0,65	0,57
18.00-19.00	1,34	0,61	0,55	0,71	0,45	0,31	1,00	0,51	0,86	0,59	0,62	0,58
19.00-20.00	1,16	0,61	0,53	0,71	0,33	0,24	1,00	0,51	0,84	0,60	0,61	0,58
20.00-21.00	1,07	0,61	0,52	0,71	0,29	0,20	1,00	0,51	0,82	0,60	0,60	0,58
21.00-22.00	1,07	0,59	0,51	0,70	0,27	0,17	0,97	0,53	0,81	0,61	0,59	0,58
22.00-23.00	1,08	0,58	0,49	0,70	0,26	0,17	0,95	0,55	0,81	0,61	0,59	0,58
23.00-24.00	1,10	0,58	0,51	0,70	0,24	0,13	0,89	0,58	0,78	0,61	0,59	0,58
24.00-01.00	1,10	0,57	0,51	0,70	0,23	0,11	0,87	0,59	0,76	0,62	0,58	0,58

Based on the 50 samples generated from pre-processor of SimLab, heating energy demand for each sample during the Dutch heating season [assumed as 01.October-01.April] is calculated with 'one at a time' approach [see previous section], using a dynamic building simulation program. Both renovated and non-renovated reference building models are simulated with the 50 samples of ventilation behaviour, and the analysis of the results is conducted using the Monte Carlo statistical analysis method, in the post-processor of SimLab. Results are discussed in the next section.

RESULTS AND DISCUSSION

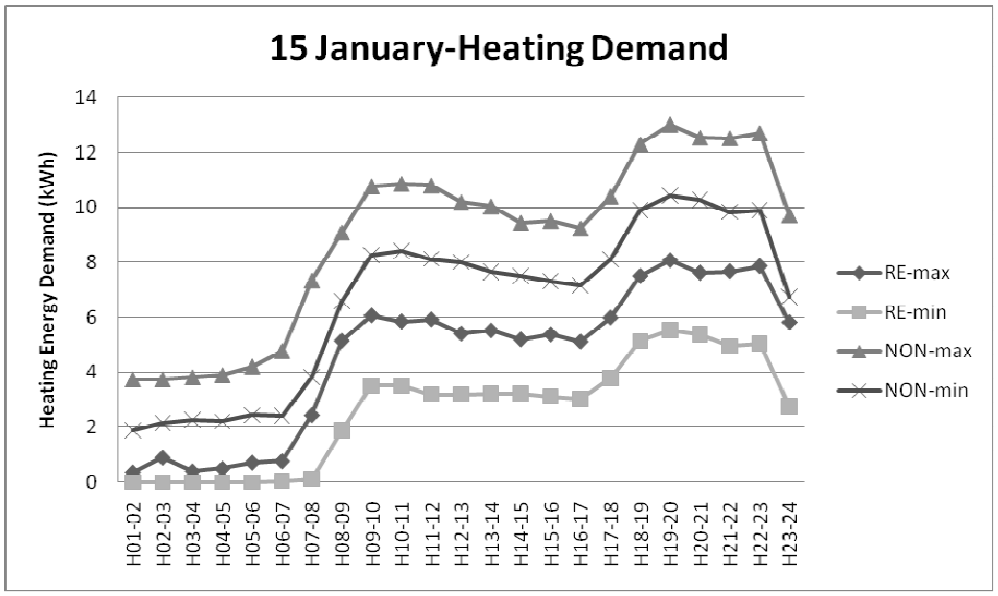
Considering the great amount of hourly input and output data produced, representative days within the heating season are selected to facilitate interpretation of the results: 15.October, 15.January and 15.March. Discussion of the results, focusing on the comparison of the renovated and the non-renovated, is covered through: [1] comparison of the influence of the variations in daily ventilation behaviour on daily heating energy demand, and [2] on seasonal heating energy demand.

Daily heating energy demand of both renovated and non-renovated cases, regarding hourly ventilation behaviour of the occupants in each room showed that: On 15.January [Figure 3] heating energy demand of the non-renovated case is much higher than the renovated one. However, the changes in ventilation patterns seem not to be directly related with the resulting heating energy demand, occurring each hour. Similar non-relation could be seen on 15.March [Figure 4] and 15.October [Figure 5].

Heating energy demand of the renovated case displays the inference of heat conservation during early hours of the day, when occupants are present. However, this should not be interpreted as heating energy demand would be less during occupancy, than non-occupancy,

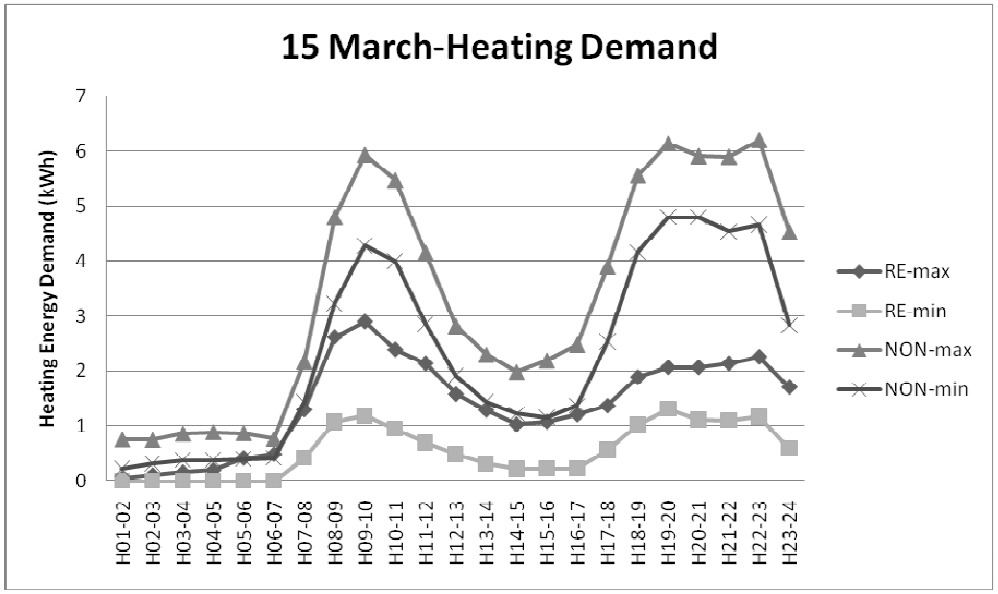
because during evening hours presence results in increasing heating energy demand. For further evaluation, Monte Carlo analysis was conducted over the outputs of 50 samples. The results of Monte Carlo showed that:

Based on the ventilation behaviour of 24 hours in living room, the hours that have the biggest impact on heating energy demand on 15th January, 15th March and 15th October differ in renovated and non-renovated cases. In non-renovated cases the biggest impact period is between 8 and 9 am. However, in renovated cases, the biggest impact periods are 11 and 12 am for 15 January, 8 and 9 am for 15 March, and 9 and 10 am for 15 October [Figure 3,4,5-Table 5].



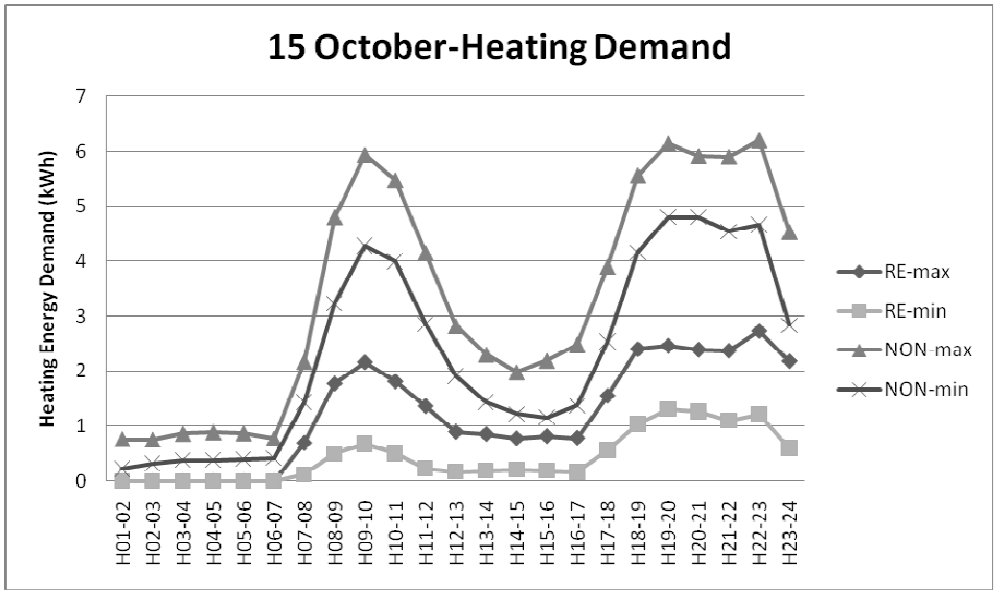
[Re-: Renovated case, NON-:Non-renovated case]

Figure 3. *15.January daily heating energy demand change*



[Re-: Renovated case, NON-:Non-renovated case]

Figure 4. *15.March daily heating energy demand change*



[Re-: Renovated case, NON-:Non-renovated case]

Figure 5. *15.October daily heating energy demand change*

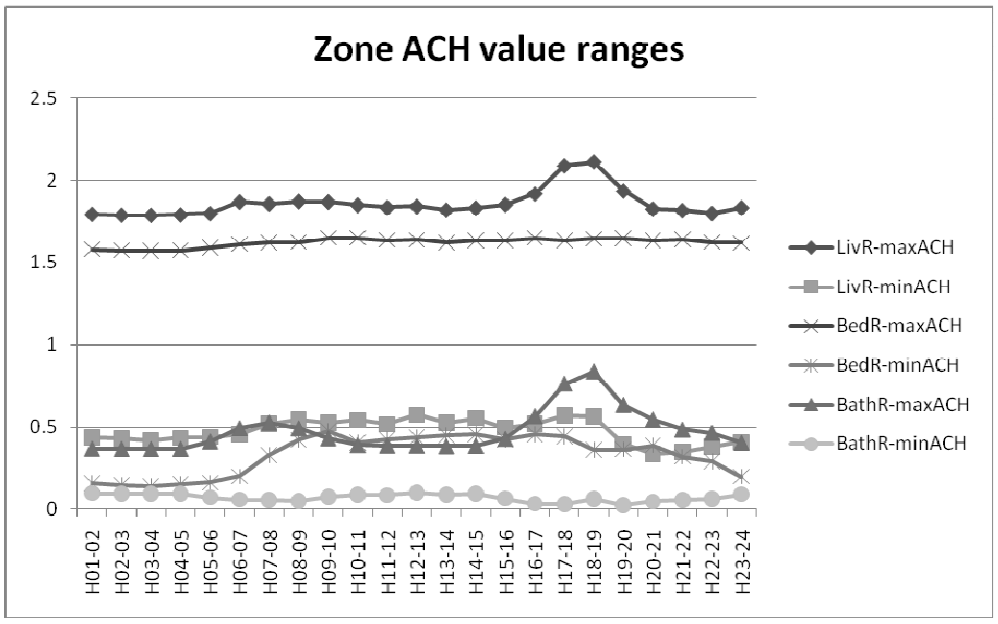


Figure 6. *Room ach values, minimum and maximum*

The seasonal heating energy demand analysis has been executed as well [Figure 7-8, Table 5]. The hours, that the ventilation behaviour influences the heating energy demand most are the same with the non-renovated case daily values, namely 8:00AM and 9:00AM. On the other hand, the values of correlation coefficients [PEAR] are closer to each other in the renovated cases than the non-renovated cases. This shows that, non-renovated dwellings are more sensitive to ventilation behaviour, considering the heating energy demand.

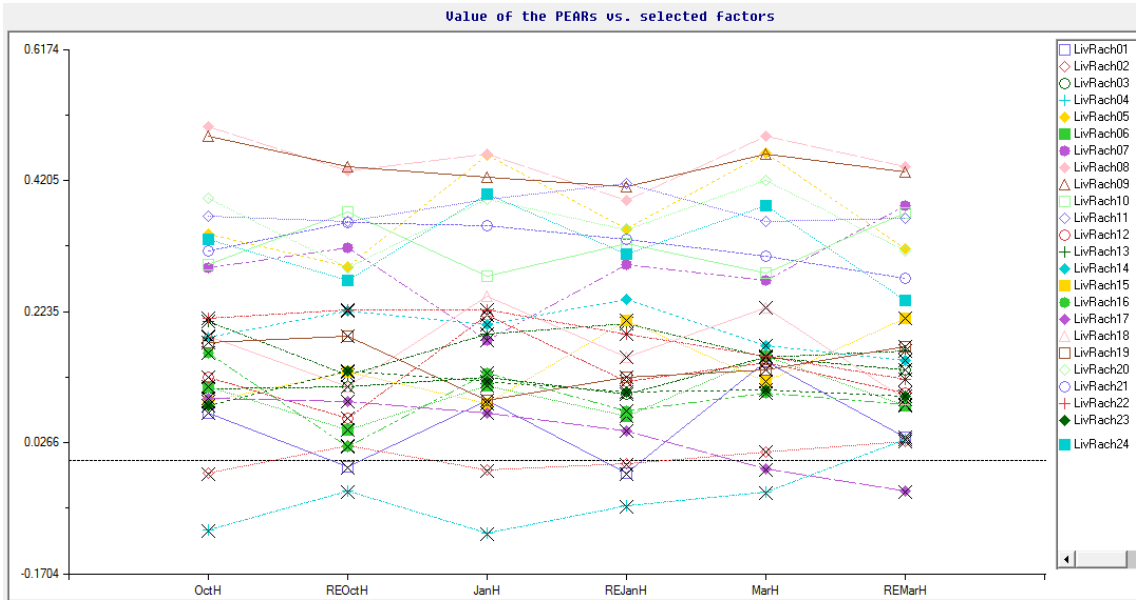


Figure 7. *PEAR factors for seasonal heating energy demand [non-renovated case]*

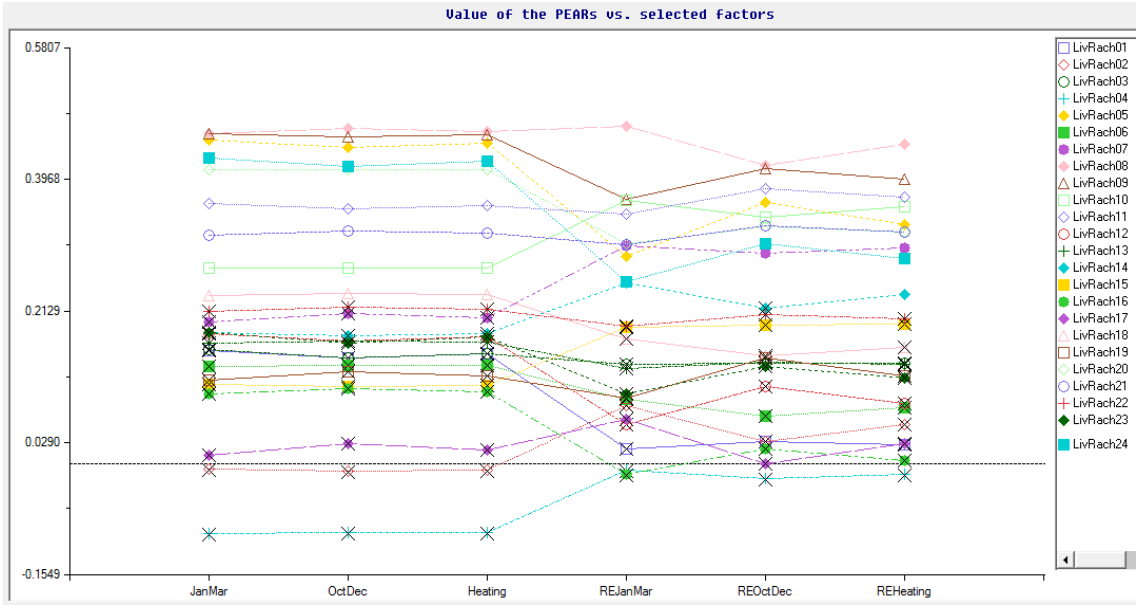


Figure 8. *PEAR factors for seasonal heating energy demand [renovated case]*

Table 5. *First five hours, ventilation behaviour is most influential on heating energy demand*

Rank	Non-Renovated Case						Renovated case					
	Daily heating energy demand PEAR values and related hours											
	15 October		15 January		15 March		15 October		15 January		15 March	
	Hours	PEAR	Hours	PEAR	Hours	PEAR	Hours	PEAR	Hours	PEAR	Hours	PEAR
1	08-09	0,502	08-09	0,461	08-09	0,487	09-10	0,441	11-12	0,417	08-09	0,442
2	09-10	0,487	05-06	0,460	05-06	0,463	08-09	0,435	09-10	0,411	09-10	0,435
3	20-21	0,394	09-10	0,425	09-10	0,460	10-11	0,374	08-09	0,390	07-08	0,383
4	11-12	0,368	24-01	0,401	20-21	0,421	11-12	0,359	05-06	0,348	10-11	0,373
5	05-06	0,341	11-12	0,393	24-01	0,384	21-22	0,358	20-21	0,346	11-12	0,364
	Heating season, heating energy demand PEAR value											
	Hours			PEAR			Hours			PEAR		
1	08-09			0,465			08-09			0,446		
2	09-10			0,459			09-10			0,397		
3	05-06			0,448			11-12			0,372		
4	24-01			0,422			10-11			0,359		
5	20-21			0,411			05-06			0,334		

CONCLUSION

In this paper, we focused on exploring the sensitivity of energy performance of a dwelling to occupant ventilation behaviour, considering the pre and post-renovation process. Results of this preliminary study showed that there is a correlation between occupant behaviour and heating energy demand of dwellings, and the more energy conservative the dwelling gets, the less it is sensitive to occupant behaviour.

However, this conclusion covers only ventilation behaviour, and it is necessary to include presence, and heating behaviour in further analysis. Energy performance simulations are conducted with one-at-a-time approach. In this case, only ventilation behaviour for each hour of the heating season was changed, while the rest of the behavioural variables left constant. This conclusion also directs us for further investigation.

In order to reveal the interrelations among different behavioural patterns, and their influence on the heating energy demand of dwellings, a further analysis is still under progress with 250 samples and three behavioural variables as presence, ventilation, and thermostat settings.

ACKNOWLEDGEMENT

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AN EVALUATION OF CONSTRUCTION SPEED PERFORMANCE FOR BUILDING PROJECTS IN UK AND GERMANY

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Abstract
It is aimed to design a study that facilitates a fair comparison of construction speed performance for residential and office developments in UK and Germany. The definitions of the populations are restricted hence there is a necessity to construct a common basis for two different data sets. Subsequent to data base filtering, random sampling was performed via computer algorithm and 200 observations from each location were retained in the samples. Available quantitative variables were utilized to create factors and the response variable. 2 sample t-test was designed to test the group differences between two samples resulted in no substantial variation exists between population means. Limitations applied to 2 sample t-test forms a motivation for further investigation and in this context a factorial study is designed. This enables to observe the effect of not only the location factor but also the hypothesized factors that may influence the mean response. The analysis yielded that project location causes a significant variation in the mean response when factors regarding facility, standard and height are taken into account. Consistent with the complexities involve in construction projects, it is concluded that neglecting the effect of construction speed related factors and only taking project location into account would not be an appropriate approach for a post ex facto research where observations can not be controlled.

Keywords: Construction speed performance; 2 sample t-test; factorial design; international benchmark.

INTRODUCTION

As of January 1993, the Single European Market, which enables the end of trade barriers, a relaxation of customs regulations and free movement within the European Union (EU), was introduced (Proverbs *et al.*, 1998). Consequently, competition of the counterpart sectors in EU roses. In a time of globalisation and an increasingly competitive environment, measuring performance has become critical to business success, spread to many industries including construction (Bassioni *et al.*, 2004). Current statistics presents EU construction investments has reached to 1,173 billion C which corresponds to 9.9% of GDP in EU (FIEC, 2009). The figure demonstrates that the industry is too important to be allowed to stagnate (Egan, 1998).
The construction industry is project oriented where each project is referred to be as unique (Ofori, 1990). Although similar production methods and sequences are employed in every project, each project is considered as a prototype (Wegelius-Lehtonen, 2001). Therefore, performance measurements mostly focus on factors associated with project levels rather than organisational ones (Love & Holt, 2000; Kagioglou *et al.*, 2001). In today's fast paced construction environment, the clients stipulate for fast track construction in order to enhance

their competitive positions by entering the market first and capitalise high profitability until other rivals penetrate the market (Kog *et al.*, 1999). To contractors increased construction speed enhances the profitability and provides competitive advantage, too (Walker, 1995). In addition, ability of constructing faster and completing projects on time objectively reflects the capacity to organise and control site operations, to optimally allocate resources and to manage the information flow between design team and among subcontractors (Murray, 2003).

In this context, it would be a valuable contribution to evaluate and benchmark one of the key performance indicators, construction speed, between Germany and UK based on projects executed during the last three decades. Although international alterations involve in construction industry such as economical, cultural, and environmental as well as industry specific ambiguities make comparisons arduous, conducting a comparison is not impossible (Xiao & Proverbs, 2002). An intervention study was designed aims at determining group differences between two locations. In addition, it is aimed to assess the variations in construction speed influenced by not only the location but also the other factors that were established by theory and intuition.

THEORETICAL BACKGROUND

Construction speed was utilized as a response variable by Love *et al*. (2005); Stoy *et al*. (2007). While Stoy *et al*. (2007) defines the term as executed gross floor area per month, Love *et al*. (2005) describes it as the time necessary to execute a unit gross floor area. This study adopts the definition provided by Stoy *et al*. (2007). The review of the literature reported many studies intended to determine the factors affecting construction time performance and/or to provide predictive models (e.g.(Bromilow, 1974; Ireland, 1985; Walker, 1995; Kumaraswamy & Chan, 1995; Love *et al*., 2005; Stoy *et al*., 2007)). The findings of relevant studies indicated numerous factors including project level macro factors such as construction cost and gross floor area (Chan & Kumaraswamy, 1995), number of storeys (Ireland, 1985; Love *et al*., 2005), project location (Nkado, 1995; Dursun & Stoy, 2011), building height (Chan & Kumaraswamy, 1999), type of facility (Ng *et al*., 2001); and organisational level factors like managerial control (Sidwell, 1982), client objectives and communication (Walker, 1995). Moreover, Chan & Kumaraswamy (1999) analyzed the influence of special factors within the construction process (micro factors), such as construction site productivity, external wall surface, and frame type. Limited number of studies (Proverbs *et al*., 1998; Xiao & Proverbs, 2002) made an attempt to compare construction time performance in international context. Proverbs *et al*. (1998) perform a comparison between UK, French and German building construction sectors on the basis of a hypothetical project. The respondents from 3 locations were asked to estimate the construction duration of the property designed by research team and the results were compared via ANOVA test. The results demonstrate that substantial variations occur in average construction duration. It was concluded that French companies are superior to German counterparts while UK companies remains the slowest (Proverbs *et al*., 1998). Proverbs *et al*. (1998) also investigated the factors reported in early studies that may influence the duration such as labour utilisation, reinforcement fabrication, formwork solutions and scaffolding systems. Another relevant study was conducted by Xiao & Proverbs (2002) and it utilized a hypothetical project (a six-storey concrete frame speculative office building) to collect data from USA, UK and Japan contractors. The results revealed that average anticipated duration to execute the project is the shortest for Japanese firms followed by UK and USA, respectively.

THE SAMPLE

The *ex post facto* research which is designed to perform an international benchmark incorporates several problems when two historical data sets from the distinct locations are employed. The problem arises hence the standardisation in data collection, the structure of the data sets and definitions of available variables do not present a perfect match. Particularly for cost information, UK data base employs definitions in accordance with British Cost Information Service (BCIS) standards, while German data set classifies them according to DIN norms. Consequently, descriptions of the cost related variables must be examined attentively to figure those that correspond to each other. European Council of Construction Economists (CEEC) published Code of Measurement for Cost Planning (Wright *et al*., 2008) that emerges to determine cost group descriptions and presents a comparison basis between Germany and UK, exhaustively (table 1). Accordingly, the term "construction cost" or "cost" corresponds to the equation given below in this study.

UK (substructure + superstructure + internal finishes + fittings) = DE (300 – 327 – 390)

Another aspect of cost information involves in time value of money. Hence sampled projects executed in a wide span of time, all cost information are rebased to 2005 market prices via construction price index provided by BKI in Germany, and BCIS in UK. Last issue regarding cost related variables is the problem of different currencies. Subsequent to index the cost information to 2005, all German cost information was converted to British Pounds with the average exchange rate in 2005.

This study enjoys working with large number of observations when compared to relative studies in the literature cited in the previous section. UK data set comprises more than 15,000 observations where German one consists of approximately 2000 objects. The intervention study is designed to assess the affect of an explanatory categorical variable - in this case: location of the project. To form a common base between two data sets filtering shall be performed. Filtering observations to determine those that will retain in the sample involves in several steps. First, it is crucial to set the boundary years. In this regard, the sample is limited to the projects which were commenced after 1980 and completed before 2004. Also, it is expected to have large variations between different type of construction works. Therefore, the second limitation is applied for the type of construction works and only new construction jobs are included in the sample. There exists no common foundation for the descriptions of type of facilities in two distinct data sets. In addition, while one data set consists of some type of facilities the other does not. Thus, a decision regarding the type of facility to be included in the sample was made and only residential and office building projects were retained. The last

Table 1: CEEC cost planning cost codes and their corresponding definitions in UK and German standards

CEEC code	UK cost group (BCIS)	German cost group (DIN 276)
Substructure	Substructure	311, 312, 313, 319, 321, 322, 323, 324, 326, 329
External superstructure	Roof, external walls, windows and external doors	331, 332, 333, 334, 335, 337, 338, 339, 361, 362, 363, 369
Internal superstructure	Frame, upper floors, stairs, internal walls and partitions, internal doors	341, 342, 343, 344, 346, 349, 351, 359
Internal finishings	Wall finishes, floor finishes, ceiling finishes	325, 336, 345, 352, 353, 364

Table 2: Quantitative variables retained and derived

Variable description	Abbreviation	Unit
Number of storeys	NoS	nominal numbers
constrution duration	Dur	months
gross floor area	GFA	m^2
construction cost	cost	£
construction speed	speed	m^2/month
standard of the building	standard	£/ m^2

restriction applies to the scope of a project. According to Bromilow (1974) construction cost does not only indicate the project size but also reflected the work's complexity and quality. Therefore, the projects that has construction costs below 200k £ and above 20 million £ are excluded from the data set. Subsequent to filtering process the numbers of observations that were retained in the German and UK data set are 347 and 901, respectively. The last step is the random selection of properties to be included in the sample. 200 random observations from each country were selected via a computer algorithm that generates the list of projects to be included from given data sets. This avoids any judgemental selection that may manipulate the results of the analysis in favour of the hypotheses.

The final sample consists of 4 quantitative variables which are number of storeys (nominal scale), construction duration in months (nominal scale), gross floor area (ratio scale) in square meters, construction cost in £ (ratio scale) (table 2); and 2 factors each with 2 levels that are associated with the location of the project and the type of the facility (table 3). Via employing those variables 2 more quantitative variables are derived: construction speed (ratio scale) defined as the average amount of constructed gross floor area per construction duration unit and standard of the building (ratio scale) that is measured by construction cost per gross floor area unit (table 2). Finally this leads obtaining 2 more factors identified as height and standard of the building. Creation of factors associated with height and standard was performed based on investigation of descriptive statistics for the corresponding quantitative variables. Principally, the threshold values of levels were obtained from minimum, first quartile, median, third quartile and maximum values of the variables associated. Please see table 3 for exhaustive information of factors retained and derived.

METHODOLOGY

Bi variate and multivariate statistical analysis are employed to draw and verify conclusions. Two sample t-test is a bi variate statistical procedure suggested to compare means of two distinct population sample. It determines if the difference in two sample means (if any) is

Table 3: Factors retained and/or derived

Factor name	Levels	Abbreviation	Description
building location	2	f_loc	1=Germany, 2=UK
building height	4	f_hei	Based on number of storeys: 1=low (0-2), 2=medium (3-5), 3=med-tall (6-8), 4=tall (9-12)
building standard	4	f_std	Based on standard: 1=low (250-451), 2=medium (451.01-649.86), 3=med-high (649.87-997.26), 4=high (997.27-3500)
type of facility	2	f_tf	1=office, 2=residential

caused by the random chance or not, under given circumstances (Tabachnick *et al.*, 2001). Certain assumptions must be fulfilled prior to conducting the test. The first one involves in sampling procedure that the analysis shall be based on data from two independent, random samples. The sampling procedure was presented in detail at previous section and therefore the assumption related to randomisation of sampling was considered to be fulfilled. Hence, the observations located in different countries there is no reason that why dependencies between observations would occur. Since t-test is a parametric one, the second restriction of the test assumes that both samples are normally distributed. Parametric tests assume that the distribution is known, or that the sample is large, so that a normal distribution may be assumed (Fellows and Liu, 2008). The test statistics is given as follows

$$t = \frac{\overline{x_1} - \overline{x_2}}{standard\ error\ of\ the\ difference\ in\ means}$$

where $\overline{x_1}$ is the mean of sample from Germany and $\overline{x_2}$ is the mean of sample from UK. The significance of the results will be evaluated according to *p* value of the test that is derived from *t* distribution. The null hypothesis will be rejected in case *p* value is less than 5% ($p(t) \leq 0.05$). This indicates the level of risk one is willing to accept of making the opposite of above conclusions (null hypotheses) when it is not true.

It is crucial to report a shortcoming of the test that also stands for the main motivation to construct a factorial design for further investigations. 2 sample t-test assumes that utilized samples are identical to each other and only receive different treatments (in this case: project location). Then it is powerful instrument to draw a conclusion regarding the effect of treatment under given circumstances, where control and treatment group only differs in intervention. Observational studies of single groups are rarely useful for evaluation because the characteristics of the populations to be compared may differ in ways that affect the outcomes being measured-characteristics other than the interventions being compared (Grimshaw *et al.*, 2000). Every construction project (each observation in the sample) is referred to be as unique and therefore, construction related researches can not be evaluated such as controlled experiments performed in laboratory conditions.

Commonly the term "factorial design" is utilized to describe situations where two or more factors are assumed to have effect on dependent variable. A factor is a categorical variable with two or more nominal values referred to as levels (recall table 3). Factorial design is a powerful multivariate instrument to field scientists as a preliminary study, allowing them to judge whether there is a link between variables, whilst reducing the possibility of experimental error and confounding variables. For instance, intuitively one can argue that the standard of a building may vary within different locations also effects the construction speed alongside. In this context, the study constructs 2×2×4×4 factorial design that addresses two aims. The first one is to verify the result obtained by two sample t-test and the second one is to monitor the main effects and interactions of hypothesized factors on the construction speed. Each multiplier element of the study design is derived from the number of levels by the factors created. The method can be assumed as an extended version of ANOVA (analysis of variance); evaluating the effect and interactions of more than one factor simultaneously on mean response from various samples. The underlying principle applies to many cases in construction related researches hence various factors are interdependent to each other. For instance, intuitively one can argue that the standard of a building may vary within different locations for a given type of facility, also affects the construction speed alongside. The test routine incorporates calculation of *F* statistics which corresponds to the ratio of estimated

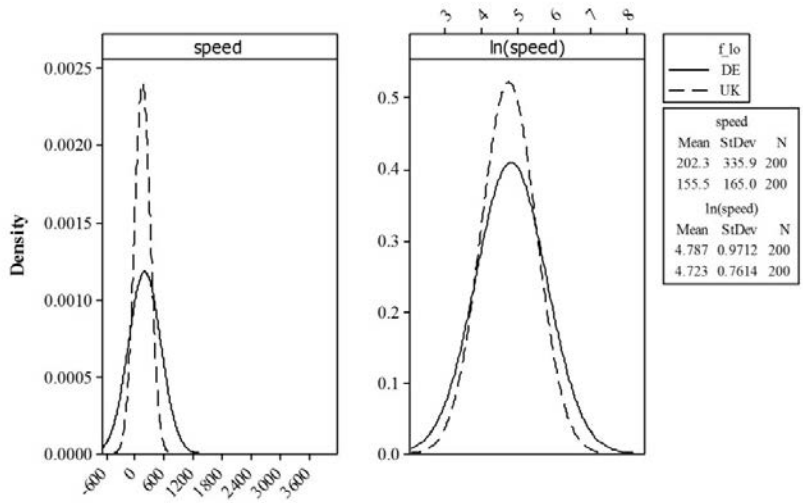


Figure 1: Distribution function of the response variable with respect to project location

variance between groups to estimated variance within groups. Accordingly, the null hypothesis is rejected if probability of the statistic computed is less than 5%.

ANALYSIS AND DISCUSSION

Exploratory Data Analysis

Prior to the commencement of analysis careful investigation of the data shall be performed due to verification of the assumptions outlined in the last section. In addition, to demonstrate the properties of the data shall ease the readers' ability to interpret the results. Hence the analysis involves in parametric tests the distribution function of the response variable plays a vital role. The histogram of the response variable presents that the distribution function is positively skewed (figure 1). Natural logarithm transformation is applied to the response which results in inducing symmetry and reducing skewness (figure 1). Subsequent to variable transformation, one outlier in each sample was detected visually by investigating the box plot of the *ln(speed)* with respect to project location (figure 2). Those observations were excluded from samples and therefore will not be retained for the analysis.

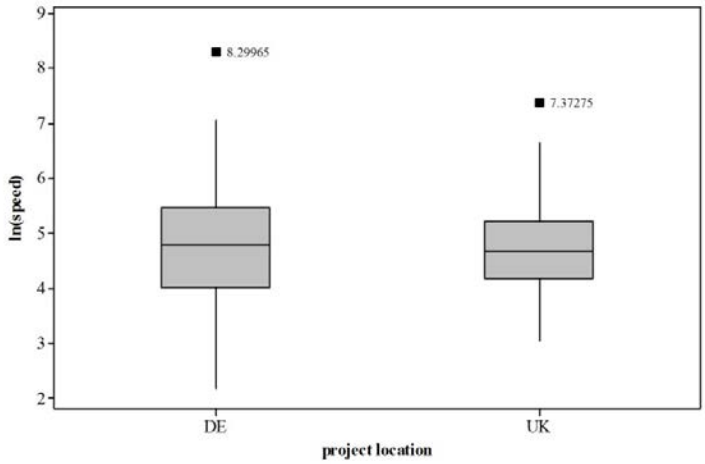


Figure 2: Box plot of *ln(speed)* with respect to project location

Table 4: Descriptive statistics of quantitative variables by means of project location

Variable	Location	N	Mean	SE Mean	St Dev	Median
NoS	DE	199	4.005	0.111	1.565	4
	UK	199	2.899	0.105	1.477	3
dur	DE	199	14.729	0.541	7.633	13
	UK	199	12.417	0.286	4.034	12
GFA	DE	199	2551	206	2912	1564
	UK	199	1915	136	1913	1282
cost	DE	199	1264951	121892	1719495	672240
	UK	199	2056515	190600	2688738	1154075

Table 4 presents descriptive statistics of the quantitative variables: number of storeys, construction duration, gross floor area and construction cost. One can see that, average height of German buildings - function of number of storeys - is greater than UK ones. It is also observed that mean duration to complete construction works of residential and office properties in Germany is slightly greater than those in UK. While average gross floor area of the sample is greater in Germany, construction cost shows a strong opposite trend. The figure might be caused by different factors such as national standards; cost of labour, material and machine; market conditions; site conditions; and so on. It should also be noted that, the argument is also supported by Construction Statistics Annual Report published by Department of Trade and Industry (DTI) in 2006. According to DTI (2006), although the average labour cost is more expensive in Germany, to construct a square meter of residential and office buildings in UK is significantly more expensive than in Germany.

Table 5 acknowledges location as the main factor and presents descriptive statistics of the other factors created. In both locations mean response of construction speed in office buildings are greater than in residential buildings. One can see in table 5 that the spread in

Table 5: Descriptive statistics of *ln(speed)* with respect to factors defined

Location	Factor	Level	N	Mean	SE Mean	St Dev	Median
DE	f_tf	office	37	5.15	0.16	0.95	5.2
		residential	162	4.68	0.072	0.921	4.69
UK	f_tf	office	77	5.05	0.095	0.83	5.03
		residential	122	4.495	0.053	0.585	4.52
DE	f_std	low	93	5.12	0.076	0.733	5.11
		mid-low	62	4.57	0.126	0.992	4.45
		mid-high	37	4.232	0.164	0.996	3.92
		high	7	4.638	0.355	0.94	4.60
UK	f_std	low	7	4.907	0.159	0.421	4.93
		mid-low	38	4.703	0.105	0.646	4.62
		mid-high	62	4.69	0.0908	0.714	4.69
		high	92	4.71	0.085	0.81	4.64
DE	f_hei	low	27	4.14	0.185	0.961	4.09
		mid-low	148	4.76	0.072	0.88	4.84
		mid-tall	21	5.54	0.142	0.651	5.59
		tall	3	5.49	0.811	1.404	4.98
UK	f_hei	low	98	4.53	0.066	0.651	4.51
		mid-low	85	4.81	0.084	0.773	4.69
		mid-tall	16	5.32	0.172	0.687	5.35
		tall	0	*	*	*	*

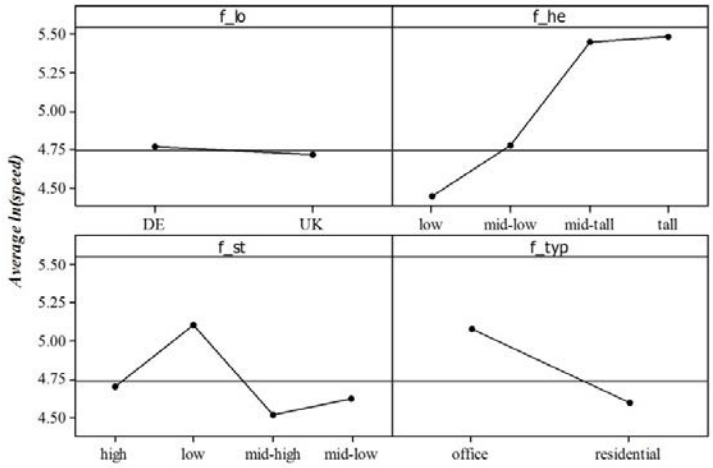


Figure 3: Main effects plot for *ln(speed)* by means of factor defined

number of observations for defined standards shows an opposite pattern. While low and mid-low levels of projects are dominating the German sample, UK sample is dominated by mostly mid-high and high levels of projects. The motivation stands for this figure is no different than the motivation for "cost" variable and has already been outlined in paragraph above. In addition, both in Germany and UK low standard buildings leads the construction speed. Lastly, one can observe in table 5 that the average speed roses as the height of the building increase. Main effects plot presents the changes in average response with respect to the factors defined (figure 3). This in turn may illustrate the behaviour of the *ln(speed)* by means of single factors.

Inferential Statistics

The first test to be conducted aims to assess the significance of group differences in mean response assuming that both samples have identical properties except the intervention: project location. Minitab 16 statistical software was employed to perform 2 sample t-test. 3 assumed conditions will be tested through the analysis (null hypotheses):

- $H_{1,N}$ = the mean response of German sample is not significantly different than UK
- $H_{2,N}$ = the mean response of German sample is not significantly less than UK
- $H_{3,N}$ = the mean response of German sample is not significantly greater than UK

The statistics of the hypotheses tests are given in table 6. CI stands for confidence intervals and it quantifies the uncertainty associated with estimating the difference from sample data. It indicates one can be confident 95% that the true difference of sample means lies between -0.10769 and 0.22594. *p* values can be observed in table 6 and consequently none of the null hypotheses can be rejected. Therefore, based on the 2 sample t test results there is not enough evidence to conclude that the means differ at 5% level of significance. Besides, it is concluded that construction speed of German residential and office buildings neither fast, nor slower when compared to UK counterparts. The test diagnostics are investigated carefully mainly focusing on determining possible outliers that may influence the results dramatically. No violations or outliers are detected.

Second stage of the inferential analysis involve in validating the results provided by 2 sample t-test as well as evaluating the influence of other factors created on the construction speed

Table 6: Two sample t-test and confidence intervals for $ln(speed)_{DE}$ and $ln(speed)_{UK}$

Hypothesis	Statistics	$ln(speed)_{DE}$	$ln(speed)_{UK}$
	Sample Size	199	199
	Mean	4.769	4.7099
	95% CI	(4.63 , 4.90)	(4.61 , 4.81)
	St Dev	0.941	0.7396
	difference between means	0.059122	
$H_{1,N}$	95% CI	(-0.10769 , 0.22594)	
	$p_{1,N}$	0.486	
$H_{2,N}$	90% CI	(-0.080768 , 0.19901)	
	$p_{2,N}$	0.757	
$H_{3,N}$	90% CI	(-0.080768 , 0.19901)	
	$p_{3,N}$	0.243	

Table 7: Analysis of variance for *ln(speed)*

Source	*d.f*	Seq SS	Adj SS	Adj MS	*F*	*p*(*F*)
f_loc	1	0.3478	7.387	7.387	13.85	≤ 0.000
f_tf	1	20.8714	22.8817	22.8817	42.91	≤ 0.000
f_std	3	31.6204	30.5766	10.1922	19.11	≤ 0.000
f_hei	3	23.6181	23.6181	7.8727	14.76	≤ 0.000
Error	389	207.479	207.479	0.5334		
Total	397	283.937				

along with project location. The task will be performed via 2×2×4×4 factorial study as indicated in the methodology section. It is aimed to test the following null hypotheses:

- $H_{4,N}$ = Project location affects no significant difference in mean *ln(speed)*
- $H_{5,N}$ = Type of facility influences no significant difference in average *ln(speed)*
- $H_{6,N}$ = Level of building standard cause no significant difference in mean *ln(speed)*
- $H_{7,N}$ = Level of building height affect no significant changes in average *ln(speed)*

The computation of the analysis is performed with the general linear model routine. The results are outlined in table 7. One can observe that all *F* values are statistically significant. Therefore, the null hypotheses, $H_{4,N}$ $H_{5,N}$ $H_{6,N}$ $H_{7,N}$ were rejected. The result of the general linear model concludes that there is a significant difference in construction speed by project location, type of facility, standard and height of the building.

Discussion

On top, the study shall address to discuss the reasons that the analyses present contradictory results. Although identical samples were employed; 2 sample t-test argued German and UK construction speed performance is not significantly differ from each other on the basis of test statistics that were shown in detail, while general linear model presented project location as a significant factor and it causes substantial variations in the mean that can not be explained by chance. The reason of this disparity lies in the design of the research and the methodologies employed to test the hypotheses. While 2 sample t test assumes that random observations in samples are identical except the intervention (project location) and therefore neglects the effect of any factor that may influence the construction speed; general linear model takes

other factors (derived from theory, intuition, common sense and field experience) into account that may cause variation in the response mean. Consistently, the effect of location

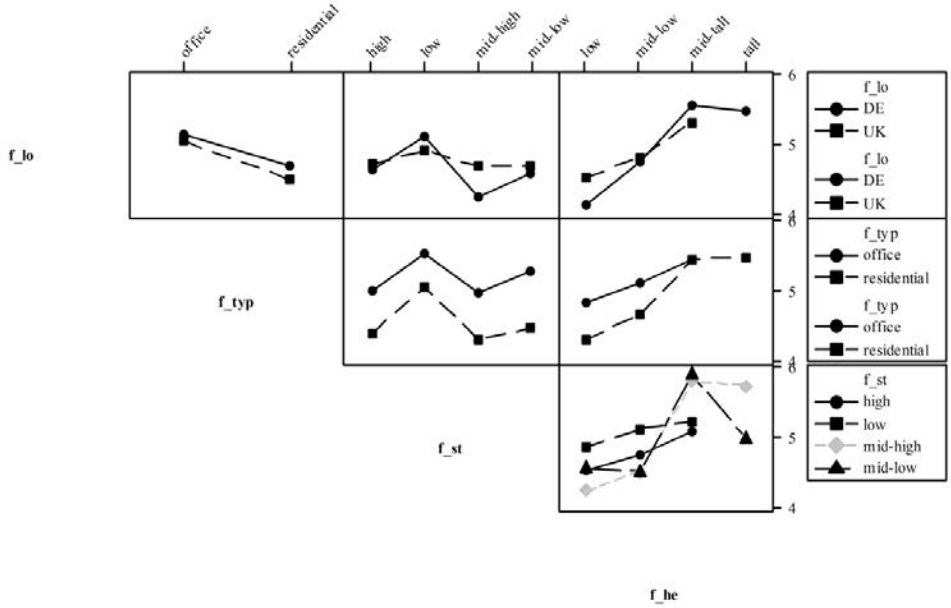


Figure 4: Interaction plot for *ln(speed)*

factor on construction speed becomes insignificant similar to 2 sample t test when general linear model applies to only one factor: project location.

On the other hand, interactions between defined factors may influence the results. The interaction plot of the factors (figure 4) illustrate the pair wise factors and corresponding mean of *ln(speed).* It is observed that in both locations for the given type of facility*, ln(speed)* shows an identical trend: speed of office buildings is superior to residential ones. This indicates there is no interaction between project location and type of facility. However, for the given location and standard ln(speed) presents different properties resulted in two lines intersecting each other (figure 4). It can also be observed that ln(speed) presents more sensitivity for a change in standard in UK when compared to Germany. This indicates a strong pattern of interaction between factor of location and standard. One can also see at the top right corner of the figure 4, given factor of height and location the mean response present two intersecting lines. Thus, it can be concluded that interaction is also present between factors of location and height. Similarly, another interaction can also be monitored between the standard and height of the building according to figure 4. However, one must bear in mind that visual inspections do not provide sufficient evidences regarding significance of interactions.

It is vital to note that perception of a researcher regarding the construction project environment plays a major role to interpret the results of the analysis and draw conclusions out of them. Therefore, consistent with the reasons outlined above, the results from general linear model are accepted and the results from 2 sample t test are declined. It is concluded that 2 sample t test is not an appropriate instrument to execute a post ex facto research because of the construction project specific complications. It is argued that multi variate design of a research that enables to take more than one factor at the same time into account is superior to bi variate design when utilized sample consists of uncontrolled observations. According to the results derived by factorial design it is concluded that factor of project location, type of facility, standard of the building and building height causes significant difference in construction speed.

The findings of this study supports the arguments postulated by Ireland (1985); Nkado (1995); Kumaraswamy and Chan (1995); Chan and Kumaraswamy (1999); Ng *et al*. (2001); Love *et al*. (2005); Dursun and Stoy (2011) and others that project location, standard as an indicator not only for project cost and size but also for the complexity involves in the project, type of facility, and building height as a function of number of stories are significant factors of construction time performance. However, it fails to evaluate the effect of organisational level factors such as communication and management, due to availability of data. Hence compared samples and methodologies employed do not match each other, the results are not sufficient to remark a discussion regarding the study conducted by Proverbs *et al*. (1998). Yet, one can observe at the left top corner of figure 4 that the average construction speed of German office developments are slightly greater than those in UK.

CONCLUSION

The study is designed to enable a fair comparison for construction speed performance of residential and office developments in UK and Germany. The definitions of the populations are restricted hence there is a necessity to construct a common basis for two different data sets. In this context, the populations are limited to projects that are executed between 1980 and 2004. Another restriction is applied to the scope of construction works measured as construction cost. In this regard, only projects between 200 k and 20 million pounds (indexed to 2005 prices) were included in the data sets. Subsequent to data base filtering, random sampling was performed via computer algorithm and 200 observations from each location were retained in the samples. Available quantitative variables were utilized to create factors and the response variable. 2 sample t-test was designed to test the group differences between two samples resulted in no substantial variation exists between population means. Limitations applied to 2 sample t-test forms a motivation for further investigation and in this context a factorial study is designed. This enables to observe the effect of not only the location factor but also the hypothesized factors that may influence the mean response. The analysis yielded that project location causes a significant variation in the mean response when factors of facility, standard and height are taken into account. Consistent with the complicated issues involve in construction projects, it is concluded that neglecting the effect of construction speed related factors and only taking project location into account would not be an appropriate approach for a post ex facto research where observations are not controlled. Therefore, the conclusions of factorial design are considered to provide superior results and accepted as the outcomes of the study. To sum up, it is concluded that project location along with type of facility, standard of a building defined as construction cost per square meters, and height of the building - a function of number of storeys - cause substantial variations in construction speed. It has to be noted that the conclusions are strictly limited to populations described.

This research also demonstrates how the design of a study may play a crucial role to reach the realistic responses to the research questions. Particularly, a research involves in an international investigation may face to various problems regarding availability of the data. Moreover, when the data is available, one has to deal with compatibility of the variables caused by different methods and definitions of storing the data. The research community shall consider developing international standards to create mass data bases. The authorities such as government representatives, parliament members, politics and etc. shall be informed regarding the benefits that can be earned in case such developments are supported by laws. Only then, the developed standards can be dictated to the industry practitioners. Further research shall focus on setting international standards for collecting the data. On the other

hand, setting international construction performance indicators and determining the standard methodologies to be employed is crucial to generate objective results.

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ORGANIZING COLLABORATION IN CONSTRUCTION PROJECTS – FORMAL MODELS MEETING PRACTITIONER PERSPECTIVES

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Abstract
There is a call for new project management approaches that are able to deal with increased flexibility and put people aspects more in focus. In construction projects, formal models for relationship management are increasingly being used. Based on a case study of a Swedish hospital partnering project, this paper discusses how project managers approach this new challenge of integrating systems for relationship management with core project processes, and if the partnering systems are effective in supporting collaboration and knowledge integration in a multiparty partnering environment. The findings indicate that partnering processes influence project processes in a favourable way, but that project managers also rely strongly on their personal experience in managing collaborative processes. The practices they introduce are often successful, but also tend to be patchy and related to collaboration problems in traditional contracts. The formal partnering processes, on the other hand, seem to be important in providing a basic structure for collaboration and to communicate collaborative intents, but are too general and infrequent to address more specific and pressing problems of process design and organization. Bringing in professional behavioural knowledge may be needed to achieve a more consistent and adequate relationship management that makes use of both formal partnering processes and core project processes.

Keywords: Partering, collaboration, knowledge integration,

INTRODUCTION

In many countries, the construction industry is criticized for being adversarial and inefficient (Latham, 1994; Egan, 1998; Byggkommissionen, 2002; PSIB, 2003). Resulting from dissatisfaction with the cost increases, delays and conflicts associated with the traditional methods, there is an international trend to develop contracting and management models which both make better use of project competences and allow for a greater flexibility in decision-making. Removing barriers of distrust that hinder collaborative problem-solving is believed to create opportunities for knowledge integration, learning and improvement. A key goal in these models is therefore to develop more collaborative relationships between the numerous specialist firms that participate in a construction project.

In the discipline of project management, there is and has been a strong emphasis on skills and techniques related to project planning and control. However, there is growing concern that when uncertainty is high, traditional techniques-based project management may not be sufficient and, if too rigorously applied, can impede the fulfillment of fundamental project goals. Thus, there is a call for more knowledge and new strategies for managing uncertainty and flexibility in cases when this is desired or necessary (Williams, 1999; Dvir and Lechler, 2004; Olsson, 2006; Pollack, 2007). That project managers focus more on establishing an environment that facilitates collaboration and knowledge exchange between highly skilled

individuals is seen as a key element (Fernie et al., 2003; Sense, 2008). A recent survey of management practices and procurement methods in 15 major European infrastructure projects (Hertogh et al., 2008) found that the "hard" aspects of project management (risk analysis, cost control, contracts) were generally more professionally managed than the relationships with both external and internal stakeholders.

Some project managers learn through practice how to create good working relationships and motivate project participants. Thus, also within a traditional regime, many projects are successful with few conflicts and trust-based relations between the principal parties. Partnering relationships differ from such informal collaboration by the emphasis on structure and formalization of relationship management and interaction. Typical key components are workshops for teambuilding and training of collaboration techniques, joint risk management and value management sessions, systems for periodic assessments of relational performance as well as conflict resolution, and a new role of partnering facilitator (see e.g Anvuur and Kumaraswamy, 2007). Consequently, project managers in partnering projects need to more consciously incorporate relational considerations and behavioural knowledge in their planning and execution of project activities and processes. This is especially so in more complex projects, where more parties are involved and the goals are more ambitious regarding knowledge integration and joint learning. Further, the integration of disciplines is likely to call for changes in established ways of working, such as roles, task sequencing and decision processes.

Against this background, this research project examines more in depth how new goals of collaboration and formal partnering mechanisms influence and interact with the more traditional and technically focused project management roles and routines. How do project managers and other actors approach these new ideas of formal relationship management and knowledge integration? How do project processes and aspects tend to be affected by partnering arrangements? Which are the implications for project management and future developments in partnering? These questions are addressed by an interview-based case study of a large Swedish partnering project in the hospital sector.

DEVELOPMENT OF COLLABORATIVE PRACTICE IN SWEDEN

In Sweden, it is only the in the last five years or so years that explicit and formal partnering has become more widespread. Although partnering has not been supported or explicitly encouraged by any official policy initiatives or industry change programs as has been the case in the UK, Denmark and the Netherlands, there has been a growing use of partnering arrangements. The Swedish construction contractor NCC has brought their partnering model from their Danish subsidiary, and the Swedish Construction Clients' Federation has organized courses in partnering for all actors, often using consultants from the UK. However, there are still few partnering guidelines in Swedish and few experienced partnering consultants. A survey of the practices and experiences of 39 partnering clients (Andersson and Johansson, 2008) showed that nearly all of them had used workshops with teambuilding practices and continuous evaluations of participants' views of the working relationships. Systems for conflict resolution, partnering facilitators and target cost contracts were also very common. Another recent survey of NCC partnering projects (Appelgren and Hellsing, 2009), indicated that when clients use partnering for the first time, the collaboration primarily involves the client and the building contractor. In their second project, however, clients tend to include also consultants and sub-contractors in a more formal way. In the survey by

Andersson and Johansson (2008), consultants and subcontractors were formal partners in around 50% of the projects. However, it was still unusual that other parties except the building contractor were involved in a gainshare-painshare arrangement. Thus, formalization is increasing, but experiences of organizing collaboration and knowledge integration in a larger group of actors are still scarce.

KNOWLEDGE INTEGRATION AND RELATIONSHIP MANAGEMENT

In contingency theory (Thompson, 1967; Galbraith, 1973), the need for communication and coordination is seen as the main determinant of organizational design. Available means of coordination are managerial hierarchy, plans, standardization (of routines, outputs or roles) and mutual adjustment. Different coordinating mechanisms are more or less costly, but they may not be used interchangeably in all contexts. Thus, standardization of rules and outputs is cheap, but sequentially interdependent tasks require planning. Hierarchy may handle many unique and exceptional situations, but is inefficient when the knowledge needed is held by subordinate experts only. Then, mutual adjustment between individuals, which is the most resource-demanding coordination mechanism, is needed.

One reason why mutual adjustment is resource-demanding is that different specialists belong to distinct communities of practice (Wenger, 1998), each with their own culture and terminology. Knowledge integration is not trivial even in the absence of goal conflict (Dougherty, 1992) and integrating tacit knowledge of different individuals requires direct personal interaction (Grant,1996). The more complex tasks, the more important are personal and communication-intensive forms of integration. Social processes, as opposed to routines and systems, are seen as particularly important in project settings with temporary relationships (Bresnen et al., 2003; Sense, 2008).

So how does coordination differ between traditional construction and partnering projects? Construction projects are temporary and unique organizations, consisting of a large number of specialized firms. The coordination needs are immense, but are (apart from the usual project planning and control systems) to a great extent resolved by a high and partly formalized industry level institutionalization of processes and technical components (Kadefors, 1995). A limited number of procurement routes are defined in standard contracts, further acting to standardize roles, responsibilities and risks of different parties. Companies are designed to fit into specific “slots” in the project organizations and building process, and individuals and firms to a considerable extent perform similar tasks in all projects (Koch and Bendixen, 2005). The same types of meetings with similar agendas are held in most projects, both during design and construction. In this way, the need for mutual adjustment in the form of project level communication and negotiation between parties is reduced, and new participants who join a project are expected to quickly start to produce at their full capacity.

In a partnering project, these existing roles, interaction patterns and communication arenas will have to be partly modified, and new practices added. This transition to more collaborative relationships implies that more resources are assigned to coordination by mutual adjustment, potentially enabling a higher level of knowledge integration. Ideally, then, all participants with key knowledge should be able to collaborate and exchange all necessary information face-to-face. However, efficient groups cannot comprise too many members, and needs for knowledge integration can therefore be hard to meet in practice. In effect, total group performance is achieved in interplay between the work done by individuals

on their own, according to their own routines, and group activities such as formalized project meetings and ad hoc problem-solving (Enberg et al., 2006). Thus, achieving an adequate balance between individual and group activity, as well as a balance between width and depth in partner involvement, should be core issues in partnering project management.

Other aspects to consider are trust and control, for example in the form of detailed contracts and formalized control systems. Depending on the circumstances, such control may counteract or complement trust (Klein Woolthuis et al., 2005). In construction, traditional contracts are generally perceived as sources of distrust, entailing conflicts and close supervision (Kadefors, 2004), but in partnering projects the pricing system is often shifted from fixed price to cost-plus or target cost schemes. However, formal contracts and systems also reinforce trust by their influence on communication and learning (Poppo and Zenger, 2002; Mahama, 2006; Vlaar et al., 2006, 2007). By forcing parties to scrutinize potential problems and formulate responses, contracting processes, just as other forms of knowledge codification, can support mutual understanding (Vlaar et al., 2006, 2007; Zollo and Winter, 2002). Organizational systems that are primarily designed for other purposes also interact with trust production (Madhok, 2006). Thus, performance measurement can bring about new arenas for communication and provide input to discussion, and a meeting that is organized to solve problems and enable coordination will inevitably lead to the development of personal relationships between participants. Thus, relationship quality is – in a positive or negative way – influenced by all communication and interaction in a project, not only by specific partnering activities.

Finally, there are some general social norms that are associated with positive relationships, trust and collaboration. Important in all types of exchange relationships is the norm of reciprocity (Gouldner, 1960; Berg et al., 1995). This norm is reflected in perceptions of fairness, in a preference for equal shares, fair processes and respectful treatment (Folger and Cropanzano, 1998).

METHODOLOGY

The study reported in this paper is a part of a larger research project focusing on collaborative contracting as an emerging practice. The project involves several case studies and the criteria for selection are that consultants and sub-contractors should be involved in the collaboration and that there are ambitions for closer collaboration between a wider range of participants. Most cases that meet these criteria have a contract sum of more than 10MEUR and a complex technology or social setting.

The project wss a new hospital building. Interviews were carried out during late stages of construction and shortly after the completion of the project with the client project manager, the user representative, the design manager, the building contractor, three architects, the mechanical engineer, one subcontractor and the partnering facilitator. Interviews lasted between one and three hours. Detailed notes were taken and transcribed within a day or two and the transcription was subsequently sent to the respondents for checking. The interviews were semi-structured and the interview guideline comprised questions about project history and development, partnering experience of the company and individual, project processes and organization, perceived differences to general practice, and personal views and experiences relating to collaboration and knowledge integration. With the client and the building contractor follow-up interviews were made, and with several other respondents comments to

transcriptions were clarified by phone conversations. The case study focused primarily on the design stage, where complexity and novelty of processes are highest.

THE HOSPITAL PROJECT

Background and choice of partnering

The new hospital building comprises with wards for various specialties, surgery and some additional functions. The building is 20.000 m2 with a total cost of around 45 MEUR. The client, a public county council, had the goal to achieve low total operating costs over the lifecycle of the building (life-cycle costs, or LCC). This included construction costs, costs for technical operation and maintenance of the building (LCC Building) and costs for hospital core business operations (LCC Hospital). The client project manager was convinced that by increasing costs for pre-design and design and improving the quality and flexibility of the building, both LCC Building and LCC Hospital would decrease significantly, thus saving very much money for the county council in a longer perspective.

To address LCC Hospital, a conceptual design contest for architects was organized. The chosen design envisaged single rooms operated by small care teams. Larger care units are less costly if construction and direct operating costs are considered, but were turned down because of higher risk for infections that delay patient recovery. In the next step, technical consultants were procured based on their competence, also with a special focus on LCC, and the design team developed design to achieve the lowest total operating costs. This way, low costs for heating, lighting, ventilation and cooling were not achieved by reducing window area, since patients recover more quickly in rooms with a view, but by better windows and by using daylight to reduce needs for lighting. Possible future changes in hospital operations were also analysed in order to arrive at an optimal level of flexibility and generality.

Another important project goal was that when the building would be completed, it should have up to date technology and be suited to the user requirement at the time of moving in. The process from start to completion for this type of building takes at the very least five years and often much longer. Using traditional project delivery models, requirements guiding design are formulated early in the process. Then, design is carried out and drawings and specifications form the basis of a procurement contest, resulting in a fixed price contract. Change orders after the contract is signed are expensive. In medical care, however, technological development is rapid and affects facilities in many ways. Political decisions may also change requirements from one day to another.

In this project, the client chose a partnering approach for the construction phase for two reasons: to include construction and cost estimation competence in the LCC analysis, and to introduce more flexibility and enable decisions to be taken later in the process.

Partner selection and contracts

Before commencing the detailed design, contractors were procured, also in quality-based selection. The group of companies involved in the project comprised a mixture of small and large actors. The architect, structural engineer and mechanical engineer were leading consultancy firms. The building contractor was one of the largest in Sweden, while several (nominated) sub-contractors were local firms. Very few of the individuals involved had participated in partnering projects before, although the larger companies had previous

experience of this kind of projects. The building contractor, however, had partnering competence in house, as well as a system for managing partnering projects.

Each consultant had a cost-reimbursable contract with a guaranteed maximum price for their work during the detailed design and construction phases. For the contractors, a target cost arrangement with a gainshare/painshare mechanism was set up, and the consultants would also receive a bonus if the construction cost ended up below the target cost. On top of this, there was a bonus system based on the client's evaluation of the collaboration (partners evaluated as a group) and their performance in reaching quality goals and doing LCC analyses (partners evaluated individually).

Works contracts were used for the contractors. This was very important to the client, who was convinced that the contractor would get a too strong influence in a design-build environment, and that it then would be difficult to prioritize long term performance and quality before construction costs.

Partnering model and processes

After the contractors had been procured, a start-up partnering workshop was held. About 30 people representing the partners participated: the client, the architect, the structural engineer, the electrical engineer, the mechanical engineer, the building contractor, the ventilation contractor, the piping and plumbing contractor and the electrical contractor. A partnering facilitator from the building contractor led the workshop. Joint goals were formulated in a partnering declaration and an action plan for how to reach each goal was developed.

Every 6 months, there were follow-up partnering workshops. Before each one of these, a questionnaire was sent out to all participants, asking them how they perceived the working climate. The results from the questionnaires were discussed at the workshops. 4-5 times during the project, consultants and contractors were evaluated by the client as a basis for judging compliance with the soft bonus criteria. These evaluations led to discussions about problems and needs and possibilities for improvement.

The design process

There was no joint project office at the hospital and the consultants worked at their respective offices. The project was not considered large enough to require the continuous presence of many consultants, and much of the design was done before the contractors were procured.

The client appointed an external consultant to manage the detailed design process. He had no previous experience from partnering projects, but had managed projects with high integration between design and construction in industrial settings. When deciding the structure of meetings and participants, he used a model from one of these. Although the explicit partnering system was supplied and administered by the building contractor, their partnering facilitator was not involved in planning such other project activities. Design meetings involved both consultants and contractors, and there was a whole day meeting every fourth meetings were organized to enable both week. The meetings combined large and small group to enable both overview and specialized discussions. The first two hours there was a design meeting where the whole group, about 20 people, was present. Then, the participants split up in three technical subgroups: building, mechanical (heating, ventilation, sanitation) and electricity. These included the consultant, the contractor and one client "quality leader", who also led the meetings. At the end of the day, the whole group assembled again. The technical

subgroups, the contractor group and the consultant group also met separately in between, on other Tuesdays.

The design manager was concerned that all meetings should be meaningful for all parties. Also, contractors are not used to contribute to design and he considered "bringing the contractors' knowledge to the drawing table" to be one of the most important challenges in the project. Splitting up the group, then, was a way both to reduce the time spent passively listening to other parties' problems and to create an environment where also sub-contractors would feel compelled to actively contribute to decision-making. Also important for meeting style was that the client project manager expressed a strong belief that decisions should be reached in consensus in order to increase initiative and commitment among participants. This implied that he very seldom intervened to make explicit decisions.

At the beginning of each design meeting, half an hour was spent on discussing two of the 17 partnering goals defined in partnering declaration and further developed in the action plan. Some of the goals concerned attitudes and behaviour (for example: putting the project first, sharing competence, joint responsibility for problem-solving) and others were more technical (work with LCC analyses, low energy consumption, a good environment for the patients, high flexibility, etc). Before each meeting, all participants had been instructed to prepare and think about the implications and meanings of a specific goal, and at the start of the meeting two of them were randomly selected to present their thoughts. According to interviewees, many participants initially considered these general discussions as being a waste of time, but successively discovered that they were of great help in preventing disagreements. The parties could refer to the mutual goals when they felt that somebody was acting too much in their own self-interest. Especially patient-related goals were influential.

Apart from the new structure and action plan discussions, the meeting agenda was rather traditional. Thus, building issues were always discussed before issues related to the building services systems. The design manager and client quality leaders had also decided the agenda of the technical group meetings beforehand. As a consequence, other participants had only a limited influence on which aspects should be brought up. One reason for controlling the meeting agenda was that the design manager saw a risk that some participants (mainly consultants) became to dominant while others (sub-contractors) would remain passive. The design manager stressed that the parties had to be equally strong to achieve a good collaboration, and it was therefore necessary to encourage some and hold back others.

Experiences and relational aspects

The project was perceived as successful by all participants, and especially the client and the architect were pleased. All parties expressed that the relational climate had been much better than in a traditional project and that the partnering relationship in combination with the cost transparency has allowed for more informed decisions. Quality, investment costs and maintenance cost have all been considered and more alternative solutions investigated. Due to the advanced LCC assessments, the estimated energy consumption is among the lowest in Sweden for this type of building. Several examples of over-design, where consultants play safe and choose excessively high quality and expensive design, have been eliminated. Many changes improving the usability of the building have been made during the construction process, some of them only months before completion. The quality of details is perceived as significantly higher than normal for hospital facilities. The target cost has only been adjusted marginally, and there was a gain to share since the costs were about 5% below the target cost.

However, despite that the participants generally saw the partnering model as preferable to traditional contracting there were also criticism and disappointment with certain aspects. The most problematic part, then, was the early phase with the joint design process. The design team had been working closely during the design process, and had made joint study visits to other hospitals. After the contract had been signed, the contractors had to be introduced to the project and relationships between the new partners established. The client representatives and design consultants thought that the building contractor behaved in a rather traditional way in the beginning, but already during the start-up workshop they saw a change in attitude. The role of the contractors in the design process was to identify and propose more cost-efficient solutions. However, the focus was on lifecycle costs and not construction costs. This was a new perspective for most contractors which also required some mathematical skills to understand. In the beginning, the building contractor often suggested cheaper alternatives of lower quality. However, as the proposals repeatedly met resistance from others, often with reference to the partnering goals and action plan, the contractor managers began to change focus. At the end of the project, the other participants perceived the contractor as a committed to delivering value for money for the hospital and the contractor employees were highly enthusiastic about this role.

Thus, attitude problems relating to costs and quality were not so important and did not take long time to overcome. However, the building contractors were strongly focused on the construction phase, and early in the project they suggested that it would be better to start construction earlier than the client had initially planned. Thereby, said the contractors, there would be more time in the important and usually messy later stages, an argument that the client accepted. This decision, however, had significant impact on the design process, since the design team had to start with the foundation details instead of systematically reviewing the design together with the contractors. As a result, the design process became disorganized and significantly delayed.

There was also some confusion regarding the relative influence of various partners in the design process. Due to the high energy requirements, the mechanical engineer had a more central role than normal. He was in charge of the LCC calculations for the heating, ventilation, lighting and AC systems, giving him a strong position also in traditional contractor domains of cost estimation. However, he found the participative but still hierarchical design process frustrating, since there was seldom time to resolve the issues that he perceived as most pressing. Also, he did not intervene with other parties' work as much as he would have from a purely technical point of view, since he thought that it would have threatened relationships.

The client's belief in consensus engendered mixed views in the partner group. This strategy was appreciated, but it also led to confusion as to when a decision was actually made. As the client did not make explicit decisions and the meeting minutes just said that questions were discussed, not decided, the same question tended to come up again and again. Despite that one of the partnering goals was to establish a clear decision process, this problem persisted more or less during the whole project.

An important purpose of the partnering questionnaires and follow-up workshops was to assess performance, especially in terms of working climate, to improve and fine-tune processes. However, these measures were only partially successful in this respect. Workshop participants were too many and questions too general to efficiently address more specific issues. Also, follow-up workshops were not held often enough to address problems when

they arose. The client found the bonus discussions to be more useful, much because they felt that is was easier to bring up problems in partner performance when there was a formal system. Still, the system was one-sided, since there was no similar opportunity for the others to bring up problems in the client organization.

DISCUSSION AND CONCLUSIONS

The focus of this paper is how partnering processes interact with other project processes in partnering projects, and how project managers approach this new challenge. The partnering model chosen in the hospital project with workshops, questionnaires for assessing performance, target cost contracts and quality bonuses was quite typical for recent ambitious Swedish partnering projects described by Andersson and Johansson (2008). The ambitions regarding knowledge integration were however higher due to a focus on life-cycle costs. The project was considered to be very successful by most all participants.

So which were the effects of the formal partnering system? The workshops, especially the start-up workshop, were seen as being of considerable importance for building relations and commitment in early stages. Further, that the action plan for reaching partnering goals was discussed in the beginning of every design meeting contributed to the establishment of shared interpretations of joint project goals and to the parties understanding of each other's situation (Mahama, 2006). The bonus system had secondary effects in providing a context for discussing improvement needs which were probably more important than the direct financial incentives.

However, explicit partnering processes only accounted for a smaller part of the total project communication, and the influence of the toolbox and partnering facilitator on core project processes was small. In deciding the organization of design meetings the client management team used their own personal experiences and beliefs regarding which prerequisites are essential for successful collaboration. A primary concern, then, was to ensure active participation and commitment from all parties by smaller groups, active support and consensus decisions. Thus, norms of equality and reciprocity gained strong influence on decisions about relationship design. To a great extent, project management succeeded in motivating participants to collaborate towards shared project goals. When it came to organizing knowledge integration experiences were more mixed. This aspect seemed to be less in focus; for example the decision to start construction activities earlier than previewed was made without considering the likely impact on design collaboration and on the schedule for design document delivery. There was some ambiguity in this, since the client wanted to give the design team a stronger position than it would have had in a design-build contract but still tended to prioritize contractor involvement and unreflectively accept contractor propositions. One way of understanding this is that the relationships to the design team were already established, while the contractors were new to the project and their commitment needed to be ensured. Further, following rules of reciprocity, this entitled the client to turn down some other, clearly unwanted proposals from the contractor. In effect, that the contractor's attitude changed over time might be partly attributed to this early client concession, although it may also be interpreted as a preoccupation with traditional problems at the expense of solving new ones.

Although committed project managers and members are essential to successful collaboration, so is an ability to make tradeoffs between relational and operational goals and challenge

expectations that may arise when a partnering label is put on a project. Especially in planning early phases of a project, before relationships are established, it is important to consider how relationship development can be reconciled with both knowledge integration and disagreement. Formal partnering tools and processes are too general to be truly helpful in this respect, and have to be adapted and complemented to a specific context. Professional behavioural knowledge may be needed to achieve a more consistent and adequate relationship management, combining formal partnering processes and core project processes.

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BETWEEN MARKETING AND FINANCIAL SUPPORT: DUTCH MUNICIPAL POLICY INSTRUMENTS TO IMPROVE THE QUALITY OF PRIVATE HOUSING STOCK

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Abstract
Dutch municipalities are faced with an ageing private housing stock, of which parts show a diversity of quality backlogs, including their energy quality. Dutch municipalities are in the process of developing a combination of communicative and economic policy instruments to seduce private homeowners to invest in their dwellings' quality. Homeowners' willingness and capability to invest, and their level of organization play key roles here. This paper investigates, if the applied policy instruments to improve the quality of private housing stock in three Dutch municipalities are effective as well as cost-effective for both municipal governments and private homeowners. First results indicate that municipalities are marketing quality improvements to private homeowners by organizations that support and communicate with homeowners, but yet it seems without the hoped-for large-scale improvements. A multi-level policy approach seems to be needed for private dwelling improvement to become successful. This implies an improved playing field shaped by the national government, in which municipalities can make use of their local long-term oriented economic policy instruments more efficiently, such as property taxes and rebates on such taxes for (e.g. energy) quality improvements.

Keywords: Dutch municipal policy instruments; quality improvement of private housing stock.

INTRODUCTION

In 2008, the Dutch housing stock consisted of around 7 million dwellings (CBS, 2011). More than two-thirds (68%) of the Dutch housing stock is privately owned, and almost one-third is owned by housing associations (ABF Research - SysWov, 2010): the owner-occupied share is 57,2%, whereas the private rental share is 10,8%. The social rental share is even diminishing due social rented property, which is sold-off by housing associations. The percentage of owner-occupied housing in the Netherlands and other European countries is growing, as a result of European policies stimulating homeownership.

The private Dutch housing stock is aging and problem parts can be found in the pre-war owner-occupied single family houses, in pre-war private-rented single family houses and in pre-war and early post-war private rented and owner occupied multiple-family dwellings (Meijer and Thomsen, 2006). In addition, there is a large energy saving potential in private housing stock, especially in dwellings built before 1985, where this potential is the largest (Menkveld et al., 2005). Apart from many other factors, such as the spatial quality of a location, housing quality seems to be dependent on the kind of tenure (cf. Visscher and Meijer, 2008; Meijer and Thomsen, 2006).

The national 'Qualitative Housing Survey' KWR (Kwalitatieve Woning Registratie) was a large-scale periodical survey on the 'overall' quality (including its building-, energy- and housing-technical quality) of the Dutch housing stock and its living environments. A diversity of KWR measurements indicated, the quality of this stock has strongly improved since 1990, especially in the pre-war part of the housing stock and in particular in private (and social) rental dwellings (cf. Companen, 2007). The KWR survey was succeeded by the national WoON (WoonOnderzoek Nederland), which until so far, and in terms of quality, has mainly measured the energy performance levels of dwellings in WoON Energie 2006 and WoON Energie 2009.

In the Netherlands, 'More with less' (Meer met minder), the national energy saving plan (2007) and covenant (2008) for the existing building stock were introduced. The plan aims to build up a 'structural market for energy saving' by removing investment- and other barriers for owner-occupiers, private landlords, and others (cf. Tambach et al., 2010). Lessons learned from pilots, workshops, experience and key- and expert-interviews have resulted in a More with less report on approaches, likely to be successful for building-related energy saving in the existing housing stock (Boerbooms et al., 2010). Hypotheses are founded on findings in literature on behavioural economics, focusing on people and their decisions being sensitive to irrational influences of their direct environment, their emotions and short-sightedness (ibid., p.16).

The Dutch municipal government as problem owner

Enforcement possibilities and sanctions (fines) as integrative part of Dutch energy certification regulation are still missing, the current Dutch Building Decree (2003) does not contain a minimum energy performance standard for existing dwellings, and Dutch dwellings are mostly no municipal property (cf. Tambach et al., 2010; Tambach, 2009). This playing field makes it difficult for municipal authorities to improve the energy performance of housing stock, also with regard to international agreements, such as the Kyoto Protocol (1997), entering into force on 16 February 2005, setting binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions. In addition, municipalities are faced with a decline in the social and economical value and the liveability of neighbourhoods, where maintenance backlogs of private homes become visible.

Despite the fact that a rising number of municipalities is formulating high-ambitions local climate policies (Tambach, 2009), the improvement of private housing stock is seldom to be found on the municipal political agenda due to missing insight into this stock's quality (Goudriaan and Ten Napel, 2004).

In this research, and with regard to the above playing field, the Dutch municipal government, is regarded as 'problem owner', trying to realize quality improvements in an aging private housing stock. In-depth insight of Dutch municipalities in the local housing stock's overall

condition is diminishing and is limited to ad-hoc quality registrations in (long-term) maintenance reports, and in reports, giving tailored advice on energy saving measures for a certain property ('Maatwerkadviezen Energiebesparing'). An Energy Performance Certificate (EPC) is also included in such a tailored energy-saving retrofit report (abbreviated as tailored retrofit report or advice, hereafter). An EPC is related to Directive 2002/91/EC, also known as the Energy Performance of Buildings Directive (EPBD, 2003), which intends to promote the improvement of the energy performance of buildings within the European Community.

The signatory parties of the Climate Agreement, the VNG (the Association of Dutch Municipalities) and several ministries (VNG et al., 2007), promote that the national government and municipalities realise considerable energy saving in the built environment. One of the ambitions is a reduction of dwelling's and building's energy consumption with more than 50% by 2020 (paragraph 6, article 10/1.). Signatory parties also agreed to promote, in dialogue with More with less programme parties, that municipalities actively contribute to the execution of the programme by the organization of 'target-group-oriented' (cf. Gladwell, 2002; Godin, 2002 and Ariely, 2009) communication and information campaigns, and other local stimulus to organize 'to let private owners and companies take energy saving measures for their property'.

Homeowners' barriers to dwelling improvement

Homeowners are responsible for the maintenance of their dwellings and Dutch owner-occupiers generally make more investments in the maintenance of their dwellings than any other owner category. Despite this fact, there remain financial, organizational and other constraints to work away maintenance backlogs, also encountered in private rental and owner-occupied, pre-war and early post-war apartments, mainly situated in (greater) urban areas, combined with mostly individually sold off flats (Meijer and Thomsen; 2006).

Case study research

This case study research makes part of a PhD project, focusing on municipal policy instruments for quality improvement of private housing stock, conducted in the framework of the research project 'Quality impulse for private housing stock' (see acknowledgements). The research question of this paper is:

Have the municipal policy instruments that were applied in three different urban areas (cases) been effective and cost-effective for both the municipal government and homeowners to improve the quality of private housing stock?

This case study research included literature and documentary studies, and interviews with municipal officials, aldermen, management board members of homeowners' associations (HOAs), owner-occupiers and private landlords. The cases were selected according to the severeness of quality backlogs of private dwellings in three urban areas (neighbourhoods or districts) and case studies were conducted and analysed by making use of literature on policy instruments, behavioural economics and marketing.

First, the role, policy and instruments of the Dutch municipal government are described. Second, municipal policy approaches and instruments in three of seven conducted case studies will be elaborated in this paper as well as the effectiveness and cost-effectiveness of the instruments. Third, the findings will be discussed. Fourth, brief conclusions will be drawn from this case study research.

THE DUTCH MUNICIPAL GOVERNMENT

The Dutch national Housing Act (1901), revised in 1991 and 2007, refers to the national Building Decree (2003) which contains technical building regulations for both new and existing buildings and for various building functions. It also includes minimum requirements in the areas of safety, health, usability, energy efficiency and the environment. Based upon the Housing Act, Dutch municipal authorities have to inspect the quality of the housing stock, which must not decrease below the minimum level according to quality requirements for existing dwellings of the Building Decree.

In the first Dutch National Environmental Policy Plan (NEPP, 1989) and first white paper on energy saving (1990), municipalities were given a role as co-executor of energy policy, linked to sustainable development. Dutch municipal authorities are the tier of government, which stands closest to the citizen. They possess an important informative role to point out the EPC to citizens (Agentschap NL, 2010). They can advise house-buyers to ask for an EPC to gain insight in a dwelling's energy quality or advise homeowners to think about energy efficiency measures at the moment of dwelling improvement and guide them to a diversity of subsidy options, for example the national subsidy for a tailored retrofit advice ('Subsidie Maatwerkadvies Energiebesparing'), which ran from 1 July 2009 till the budget stopped at the end of 2010.

Local authorities in the Netherlands have relatively limited own tax revenues and depend largely on the national government for their resources: about half of this national funding takes the form of a specific transfer, or ear-marked funding - the rest is in the form of a Municipal Fund (an open-budget system with a budget ceiling, with its distribution depending on criteria like the number of inhabitants) (Coenen and Menkveld, 2002). But compared to other European countries like Sweden, Belgium and the United Kingdom, the Netherlands has the lowest revenues from own local taxes (cf. Koopmans et al., 2005). For Dutch municipalities, OZB ('onroerendezaakbelasting') property taxes are an important revenue source, and they gain more than 90% of their fiscal revenues from OZB taxes (ibid.).

Municipal policies and instruments

Municipal authorities can force, seduce and/or persuade homeowners to improve the quality of their dwelling by sticks, carrots and/or sermons (Thomsen and Van der Flier, 2008; Bemelmans-Videc et al., 2003). This research distinguishes three types of policy instruments, municipal authorities can make use of, based on a distinction by Itard and Meijer (2008), Ürge-Vorsatz et al., (2007), and Derksen and Schaap (2007), which are: (1) Regulatory instruments, (2) Economic instruments, and (3) Communicative instruments.

For private dwelling improvement, local authorities often combine 'carrots', such as subsidies and preferential loans with 'sermons' by communication bodies, functioning as a medium and 'extension' (cf McLuhan, 1997) of the municipality towards homeowners. Force is applied to enforce the law or protect public interest, common good, civil right or basic private concern (Thomsen and Van der Flier, 2008). Regarding property rights, owners cannot easily be forced to serve public interests or suit governmental policies (ibid.). Thomsen and Van der Flier (2008) state that in today's western democracies, a shift from public force to civil responsibility can be noticed, and force (the stick) only to be applied if other measures fail (ibid.). Therefore, this research focuses on economic and communicative policy instruments, which are also applied in the cases.

Economic instruments

Seduction (the carrot) is an important but often expensive measure (Thomsen and Van der Flier, 2008; Bemelmans-Videc et al., 2003). Examples are subsidies, low-interest loans, fiscal instruments, market-based instruments such as energy performance contracting, typically by an ESCO etc. (Ürge-Vorsatz et al., 2007).

Economic instruments providing incentives for energy efficiency improvements are needed to promote energy efficiency through market-led measures and price signals: subsidies or preferential loans could be combined with EPCs (Klinkenberg and Sunikka, 2006). The improvement by one or two certificate levels could be a prerequisite for a financial incentive (ibid.). To be effective, the municipal government binds obligatory requirements for homeowners to carrots, such as organisational and/or managerial criteria to homeowners' associations (HOAs) etc. (cf. Tambach, 2009).

Subsidies and low-interest loans

Subsidies are applied to trigger investments in private dwelling improvement. In the past years, municipal governments applied subsidies for dwelling improvement, but without a long-term effect on the prolonging of dwellings' life span in terms of maintaining and safeguarding dwellings' quality (cf. Tambach, 2009).

For urban regeneration projects, local authorities can work together with SVn (stichting Stimuleringsfonds Volkshuisvesting Nederlandse Gemeenten), a corporation, functioning as incentive fund for municipalities. As low interest loans are seen as subsidy in Dutch jurisdiction, local authorities have to formulate 'low-interest-loan-regulation'.

Local authorities pay an amount of money in a revolving fund, which is managed by SVn. From this fund, they are able to provide low-interest (also called 'preferential') loans to support homeowners in financing home-improvements. Homeowners can spread repayment costs over a period of around 20 years (loan term) to have a relatively low increase in housing costs.

SVn controls homeowners on their ability to pay the improvements on credit, and advises municipalities upon this matter. In addition, some municipalities actively conduct first checks. By lending money for interest rates, (in average four percentage points) lower than market rates, municipalities lose interest and by issuing loans, they participate as a kind of societal entrepreneur emphatic in risk bearing investments (see also KEI, 2007).

Fiscal incentives

The use of subsidies grew fast in the sixties and seventies of the last century but was cut back in the last decades because of rising costs and political changes (Thomsen and Van der Flier, 2008). Over the last years, fiscal incentives are gaining attention as being less expensive and more effective (ibid.; Sunikka 2006).

The Organisation for Economic Co-Operation and Development (OECD, 2006) concluded that environmental taxes contribute effectively to environmental policy. The CPB Netherlands Bureau for Economic Policy Analysis and Ecofys also concluded that the energy tax contributes effectively to environmental policy, and without these taxes, the energy use would have been twice as large in Europe. The Netherlands is a leading European country with regard to the share of green taxes in the total amount of national tax revenues: revenues from green taxes increased from van € 6 milliard in 1990 to € 20 milliard in 2008, and make up 14% of the total share of the Dutch tax incomes since 1995 (Ter Haar, 2009). Calculations by CE, an independent research and consultancy organization, specialised in the development of innovative solutions to environmental problems, show that tax-increases on petrol, diesel and LPG are effective instruments to lower CO_2-emissies in traffic (ibid.).

Fiscal rewards or tax rebates for energy efficiency investments, combined with fiscal penalties for maintaining unsustainable situations could be an essential instrument to influence dwelling owners. Not only on national scale, but also on local scale as OZB tax relief for homeowners applying energy efficiency measures (Tambach and Meijer, 2009). Municipalities can levy OZB tax from owners and tenants of real estate (but not from tenants that rent a house). The basis for levying is the value in the economic market, which is determined by surveyors on the basis of the 'Wet Waardering Onroerende Zaken' (WOZ) - the 'Immovable Property Tax Act'- and every municipality determines OZB tax heights themselves. The Dutch national government (for the notional rental value for owners-occupiers and the income tax) and the district water boards ('waterschappen') make use of the WOZ value to determine their taxes, too (Koopmans et al., 2005).

Households and other minor consumers, pay much more per ton CO_2 than consumers in any other sector (major consumers make part of the emission-trading-system) (cf. Ter Haar, 2009). In addition, the current OZB-system does not reward owner-occupiers for their investments in energy efficiency measures – on the contrary: the more they invest in such measures, the higher the OZB-tax. This is in conflict with the many local climate policy aims to lower housing costs for citizens by the promotion of energy saving measures. So why not reward owner-occupiers for investments in energy efficiency measures for their homes?

Apart from this, and according to Ariely (2009), the incentive of offering s.th. 'for free' (e.g. a tailored retrofit advice) is a source of emotional and irrational excitement. Starting an action by offering s.th. for free seems to be effective (Clean Energy Group and Smart Power, 2009) and more effective than with a rebate (Boerbooms et al., 2010).

Communicative instruments

Communicative instruments play an important instrument for knowledge transfer by local authorities. For example municipalities need to communicate information on a dwelling's quality well to home-buyers, and communicate economic instruments well to homeowners. Other examples are (environmental) education, support, organization and voluntary action etc. (cf. Ürge-Vorsatz et al., 2007).

Where other policy instruments fail, persuasion - the sermon - (Bemelmans-Videc et al., 2003) can be an indispensible instrument for municipalities to influence civil behaviour, particularly with regard to sustainability. Examples in this sense can be appealing for sense of responsibility and/or self-interest, like owners' responsibility for the environment and climate change and the sustainability of interventions (cf. Thomsen and Van der Flier, 2008).

The EPC does not seem to be of decisive economical value in especially the private housing market yet (Tambach et al., 2010). In this respect, persuasion by the local and/or national government can be supportive in persuading homeowners, –buyers and brokers to understand the value of an EPC - and of energy saving measures that follow from it - for their home, translated most commonly not only in a lower energy bill but also in more comfort.

According to Godin (2002), the old marketing rules such as advertisements don't work so well anymore, because people aren't likely to have easily solved problems, consumers are hard to reach, and satisfied consumers are less likely to tell their friends. In addition, he stresses to differentiate customers, to find the group that's most profitable and the group that's most likely to sneeze, and to ignore the rest.

CASESTUDIES IN THREE MUNICIPALITIES

The Hague: case in Rustenburg-Oostbroek (district)

Policy approach and instruments

Rustenburg-Oostbroek is a district of The Hague with a weak position in the housing market, and dwellings with energy efficiency deficits. With this pilot, the municipality intends to develop a marketing strategy to market energy efficiency measures via a tailored retrofit advice for homeowners. A service organisation, named 'Serviceorganisatie Rustenburg-Oostbroek' supports homeowners with all aspects, entailing dwelling improvement. It developed three instruments in cooperation with the municipality, which are:

- A free tailored retrofit advice and/or extra subsidy upon investment costs, after application of all other available subsidies applied for seven staircase entrance flats, selected out of thirteen due to subsidy limits. EPCs show one E-, 5F- and 3G-labels with an average energy performance, indicated by an Energie-Index (EI) of 2.67 (F-label).
- A free tailored retrofit advice at the moment of designing a roof superstructure was applied for six selected owner-occupiers.
- A free 'Groen-MOP' (long-range maintenance plan including energy-saving measures) for large (and combined) HOAs. The service organisation selected one large HOA, combined by six smaller HOAs for experimenting with a Groen MOP.

A personal approach of and communication with owner-occupiers by the advisor at the moment of conducting a tailored advice at people's home, and of the project leader is applied. The steps, followed to seduce owner-occupiers to finance in and take energy efficiency measures are depicted in Figure 1.

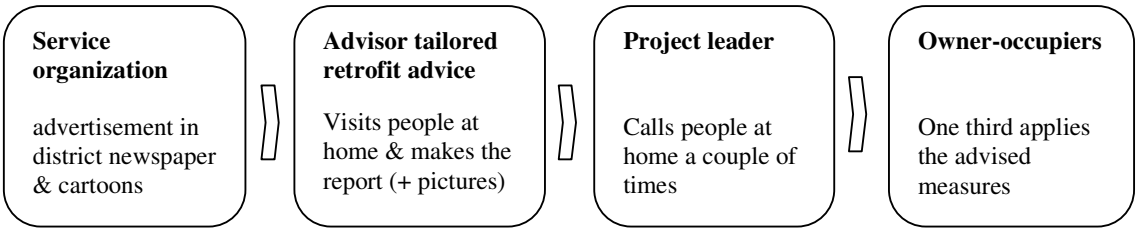


Figure 1: *Marketing strategy followed by the service organisation and the advisor.*

Effectiveness and cost-effectiveness

Thirteen owner-occupiers reacted on the advertisement in the district-newspaper to obtain a free tailored retrofit advice and extra subsidy for energy efficiency investments. Three of in total nine owner-occupiers finally applied the energy efficiency measures, advised by the tailored retrofit report. Half of six selected owner-occupiers, engaged in drawing up a design for a superstructure, integrated double glazing in the tender for the (isolated) superstructure (Serviceorganisatie, 2010).

The service organisation's subsidy did not make part of the tailored reports, the reaction and application time for subsidy was short and taking at least two measures in one time may have been too high a barrier for the owners. The application of renewable energy technologies using solar energy was stimulated neither by the subsidy nor explicitly by the reports: only two of nine reports promoted a solar boiler, respectively solar panels. The municipal government had no costs for both the pilot project and subsidy, granted by the service organisation. The costs of € 47.860 for the pilot project were covered by a national IPSV

('Innovatie Programma Stedelijke Vernieuwing') grant for innovative urban regeneration projects (Municipality of The Hague, 2010). The highest costs consist of personnel, project costs and the organization of the service organisation, followed by direct subsidies: intensive support of homeowners is both labour-intensive and expensive to make subsidy-regulation become successful.

Dordrecht: case in the Dichterskwartier (neighbourhood)

Policy approach and instruments

The Dichterskwartier is a neighbourhood with a weak housing market position, with dwellings suffering from maintenance and foundation backlogs, and energy efficiency deficits. The municipality started with gaining a social basis for neighbourhood regeneration plans by formulating a common approach with the residents. The approach entails three steps (Municipality of Dordrecht, 2010a):

1. Making homeowners aware of their own responsibility for their dwelling's quality,
2. Strengthening their organizational capacity, and
3. Realizing their investment capacity.

To support homeowners with dwelling improvement, the municipality has contracted 'Bouwadviesbureau De Groene Werf (dGW)', which has developed three 'improvement packages' with homeowners, taking a central place in the approach as they are seen as principals by the municipality. The lengthening of the dwelling's lifespan by 25 years by regular maintenance, made part of the municipal contracting criteria. Packages can be combined, but the intention is that the package for improving the energy quality must be combined with the package for working away construction backlogs and for major maintenance (Municipality of Dordrecht, 2010b). In addition a free report on necessary home-maintenance is provided to homeowners, and the municipality will offer a 2% interest loan (height and term package-dependent) (Municipality of Dordrecht, 2011).

Effectiveness and cost-effectiveness

The municipality expects, 75% of 141 property owners will be willing and considered for a subsidy and preferential loan. 40 to 50 homeowners, who are supported by dGW have indicated they are willing to think about dwelling improvement. Owner-occupiers are interested in a free maintenance report, and a few have started to ask for offers of contractors. However, barriers can be found in the time the municipality needs to prepare and decide on a (temporary) subsidy- and preferential-loan-regulation, intended to run till 2015 or till the subsidy ceiling is reached. A bottleneck to the project is the ending of the national subsidy for a tailored retrofit advice, and an uptake of measures on the level of an entire housing complex.

The breakdown of municipal costs for dwelling improvement (€ 2.4 million in total) (Municipality of Dordrecht, 2010a) is as follows:

- Payment SVn for preferential loan 44,6%
- Subsidies for improvement packages 30,6%
- Process costs 21,0%
- Municipal assessment of subsidy and loan requests 3,8%

Municipal costs are covered by € 1,5 million of so-called municipal strategic investments, € 0,9 million by an impulse regulation based upon the 'Besluit Impulsbudget Stedelijke Vernieuwing 2008-2009' (ibid.). But there also seem to be certain riscs, for example a worsening of the foundation condition of the dwellings.

Schiedam: case in the Newtonbuurt (neighbourhood)

Policy approach and instruments

The Newtonbuurt is a neighbourhood with a weak housing market position, with dwellings having mainly maintenance backlogs, energy efficiency deficits and some houses with foundation problems. The policy approach is based on total control of the execution of stimulated improvement measures to work away maintenance backlogs and by oral communication with homeowners. The improvement by taking energy efficiency measures is now explicitly integrated in this approach.

An interview with a civil servant, working on private dwelling improvement, delivered the following municipal approach: First, agreements on execution times with homeowners are written down in notes and letters. Second, owners are controlled by home-visits, oral communication and making new agreements - if necessary. Third, and if the first two steps haven't been effective, owners receive letters, home-visits and oral communication. The fourth step, which needs to be avoided, is enforcement, but also here, oral communication and a personal approach is intensively applied.

Other instruments applied are a free technical report of the dwellings for homeowners, a free tailored retrofit report, and free advice and support by the 'Servicepunt Woningverbetering'. In addition, homeowners can request one preferential loan (with an interest rebate of 5% and a minimum interest rate of 1,5%, but with different loan heights and terms) for financing the working away of maintenance backlogs, to improve the dwelling's foundation and energy efficiency. The municipality cooperates with the national government and with local brokers to finance the free tailored advice.

Effectiveness and cost-effectiveness

The effects if this case cannot be measured yet, but they can be compared to the approach, which will also be followed for the Newtonbuurt: Since the start of the municipal private dwelling improvement project in 2005, 1.400 low-interest loans stemming from a revolving fund have been honoured by the municipality. In 2.800 first-phase-dwellings, maintenance backlogs have been worked away, and one on three to four dwellings have been improved with a low-interest loan, with an average investment of € 17.000.

Despite high municipal investment in preferential loans by 2014 (the end of the dwelling improvement project), municipal costs seem to be limited to the interest lost and management costs for the revolving fund at SVn. The municipality obtained national grants to solve 'bottlenecks' in urban regeneration projects (from the 'Knelpuntenpot ISV'): one grant for excessive foundation problems and another grant for higher-than-normal maintenance backlogs stadsvernieuwing, including costs for supporting homeowners.

DISCUSSION

The level of participation in the subsidy schemes by owner-occupiers, as the case studies demonstrate is low. It requires an intensive communication by service organisations to become successful. This is labour-intensive and costly. A low cost-effectiveness of capital subsidies was also reported by Ürge-Vorsatz et al. (2007) in relation to CO_2 reduction. In comparison to preferential loans stemming from revolving funds, the investment level by owner-occupiers by a subsidy is relatively low.

The case study in The Hague indicates that by applying a personal approach and by oral communication by the advisor, who spent two up to three hours at people's homes (and by the project leader that calls them hereafter) seems more effective than the written communication via the district newspaper, a more distanced and 'cold medium' (McLuhan, 1997). This is illustrated by the thirteen reactions on the newspaper-advertisement, which also show, the old marketing rules don't work so well anymore (cf. Godin, 2002). The case also indicates that applying a personal approach at the moment of designing a roof superstructure seems more effective than at a random moment by advertisement.

However, for financing the stimulation of private dwelling improvement, the municipality is largely dependent on the national government. Offering a 'free' tailored retrofit advice for homeowners was made possible in the cases in The Hague and Schiedam on the basis of the temporary national subsidy regulation, which has now stopped. Municipal subsidy regulations or agreements with brokers, building upon this national subsidy tool, are now in danger to abruptly break down – and with it the local market for energy-saving measures.

In Germany, investors in energy efficient renovations and -measures for owner-occupied or rented housing stock are supported by the 'Energieeffizient Sanieren' incentive programme of the KfW Bankengruppe, a promotional bank under the ownership of the Federal Republic and the 'Länder' (federal estates) by preferential loans and investment subsidies. This and earlier programmes can be seen as successful in terms of CO_2 reduction, job-creation and continuity (cf. Clausnitzer et al., 2010). Whereas such loans could be regarded as a hidden subsidy with a risk for free-riders, in the KfW programme owners and buyers have to prove, subsidies are only spent for the purpose of energy efficient renovation or -measures, and that such renovations, meeting EnEV-standards, are executed by specialists (Tambach et al, 2010).

By an OZB-exemption or WOZ-tax rebate (or tariff differentiation), energy efficiency investments in dwellings could be stimulated (cf. Schillemans and Blom, 2006). The current Municipal Act ('Gemeentewet') neither offers possibilities for municipalities to differentiate OZB tariffs on the basis of a dwelling's energy consumption, nor does it include an OZB tax rebate on the basis of a dwelling's energy performance as lawful exemption (ibid.). It seems that to improve these possibilities, an adjustment of the WOZ Act or Municipal Act would be necessary.

CONCLUSIONS

First results indicate, municipalities are investing in costly support-and-communication-trajectories, in marketing quality improvements and providing financial support to homeowners, but yet it seems without the hoped-for large-scale improvements. Local authorities could act more effectively, if the national (and European) policy framework conditions were set properly (cf. Collier, 1997).

Notwithstanding, organizations that support and communicate with owners may have a positive effect on investment decisions on quality improvements of private homeowners. A personal approach and oral communication seems to come to the benefit of the effectiveness of policy measures like a tailored retrofit report and to urging homeowners to execute improvement measures. As oral and written cultures alternate, we can conclude to be living in a 'new oral culture' (McLuhan, 1997). The case studies indicate, good and clear oral

communication, but also control on the application of improvement measures is a prerequisite to the success of a subsidy or preferential loan regulation.

In conclusion, it seems that marketing strategies and financial support cannot be regarded as a panacea to overcome legislative hiatuses, described in the introduction. Nevertheless, chances for municipal governments to improve the quality assurance of blocks of flats lie for example in the attachment of legally binding quality criteria to division permits for such property into apartment rights, and to the sale of such rights.

More long-term oriented financing instruments are needed to support private dwelling improvement and build up a structural local market for dwelling improvement (cf. Tambach et al., 2010), for example by property (WOZ-) tax rebates. It may also be more effective, if the national government could set up a national revolving fund to support municipalities in providing low-interest loans for home-improvement on a more permanent base, and also to spread risks.

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MODEL OF ECONOMIC JUSTIFICATION OF CONSTRUCTIONS' RENOVATION

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Abstract
In the life cycle of constructions we often cope with the problem if it is economic justificated to renovate certain construction. On the market we meet growing problem of older constructions which are more and more neglected and unkept. This is the consequence of high number of new apartments and other constructions. General crisis has also an influence on negligence and has forced owners of constructions to economize and consequently at negligence of older constructions what brings to diladaptation. This will also happen to new constructions because owners act too less responsible or economic, therefore the reason of diladaptation is the lack of knowledge of owners. They do not know how to take care of constructions and how to maintain them regularly and when to sanitate them. By originating the damages are often connected high cost which means that the issue of preventing diladaptation is important not only from the view of security and aesthetic but also from the view of national economies and sustainable development.

Keywords: Renovation, sanitation of buildings, maintenance of buildings, physical deterioration, functional obsolescence, economic obsolescence.

INTRODUCTION

Around the world the awareness of regular maintaining and renovation objects as the right and only way for preserving the value of buildings has been expanded more and more. However there is still not enough large emphasis at the field of planning basis and modernization of building in accordance with technical development and requirements of modern user, which would ensure not only preservation but also decrease of fixed property's value. Only with maintaining we ensure following exploitational ability of buildings, where we have to execute renovations on the basis of previous assessment of the reason for damage's origin and condition of damaged objects. For each object separately the costs, risks and advantages of renovation or substitutional building have to be deliberated. Built constructions as fixed property represent an important issue of national wealth of society or country. The aim of each country is that fixed properties keep their functional ability as long

as possible, which is possible to achieve only with appropriate relationship to fixed property and good managing with them. We have more and more neglected buildings all around the world which are at the edge of destruction and on the edge of suitability of pillar construction. At that kind of buildings the owners still do not know how to decide right or is it worth to renovate that building or to build the substitutional building. Thus it will be indirectly able for the owners by the help of this model how to decide in this case. The model does not include only economic decision but also includes all the others criteria which influent on this decision. Thus we are developing multicriteria decisive model of economic justification of renovation or substitutional building. By the help of that model it will be possible to decide about economic justification of renovation or substitutional building on the basis of criteria of physical deterioration, functional obsolescence and economic obsolescence and profitability. We consider profitability at buildings of business activities while we do not consider profitability at public buildings, because profitability of that kind of buildings is indirect. Pšunder and Torkar (2006) define mentioned criteria as.

- Physical deterioration: we understand it as reducing of value, caused because of condition deterioration as consequence of use.
- Functional obsolescence: it means reducing of buildings value because of bad construction, structure or materials, which can cause reduced usefulness of fixed property.
- Economic obsolescence is reducing of fixed property's value because of factors which origin from environment. These can e changes in standardization, legislation, infrastructure or environment town plan.

Model does not deal with objects which are written in register of cultural inheritance, which means that certain architectural changes are allowed only on the basis of very well-founded reasons and on the basis of essential studies by which existing possibilities have to be checked. Basic guidance at regular maintaining and investing maintaining work on the building of cultural inheritance is keeping of genuineness – authenticy. Thus we have to renovate that kind of buildings not regarding on costs which origin during renovation.

Thus we will enter mentioned criteria: physical deterioration, functional obsolescence and economic obsolescence and profitability into real problem by the help of methods of multicriteria deciding of economic justification of economic justification or substitutional building. Real examples of saluting with multicriteria deciding have been practically different form case to case, after which the deciding methods have been developed and then launched as methods for individual categorization of deciding problem.

Thus we are developing multicriteria decisive model by which we will be able to estimate economic efficiency of renovation or substitutional building. It is the definition of time term in the buildings' life time until when it is still justificated to renovate or sanitate considering higher profitability or benefit which will be brought by substitutional building with its activity.

THEORETICAL BASIS

Many scientific fields and disciplines like philosophy, psychology, economy, mathematics and even more specified fields as decisive theory and decisive analyze have been occupied with problems of deciding (Bohanec and Rajkovič, 1995). Especially important question is how to help to the one who is taking decision to take qualitative

decision on the easiest and the most systematically organized way. Decisive situations where we estimate variants only by one characteristic are very rare. Usually we take decisions on the basis of different views on variants, and then we speak about multicriteria deciding (Bohanec and Rajkovič, 1988).

Multicriteria deciding is acknowledged and widely used method which supports decisive paradigm and is used on different fields of study (Bell et al, 2003). The origins of multicriteria deciding go back in the middle of the 20. century, when Koomans represented concept of non-dominant vector in 1951 and when Kuhn and Tucker represented optimal conditions for existence of non-dominant solutions (Pomerol and Babrba-Romero, 2000). Decisive moment for development of multicriteria deciding was in 1972 when the first international conference on multicriteria deciding was organized at Columbian university in South Carolina. Multicriteria deciding was there defined as independent scientific field (Pomerol and Babrba-Romero, 2000). Since then many scientific subscriptions have been published.

At multicriteria deciding we cope with more or less difficult decisions of choice among different variants where we are not able to create final decision of choosing the best variant without use of methodological accession.

Requirements at choice of the best product are for example the lowest price, the longest time of use, the strongest materials, the least influence on environment, the easiest use etc. We know out of practice and experiences that we can not fulfill all the requirements because usually these are opposite to each other. It is necessary to make compromise and choose one variant among many of them that suits to requirement or criteria the most. (Omladič, 2002). It is necessary to use methodology which makes possible the interactive optimization on the basis of many criteria.

Methodology of multicriteria deciding is based on the fact that there are many factor which influent on the choice of solutions, for achievement of final aim are not all the same important. Decisive problem is divided on smaller sub-problems on the first level, these can be further divided on even smaller sub-sub-problems-that means sub-problem on the first level and so on until the satisfaction of wideness and deepness of decisive scheme (Bohanec and Zupan, 2004). Thus we get decisive scheme. Wideness and deepness of decisive scheme are dependent of extensiveness and pretentiousness of problem with which we cope.

The essence of the multicriteria deciding method is that we divide the decisive problem on smaller sub-problems and treat them separately (Koprivšek and Oblak, 1997). At that method we divide decisive problem on levels (we make hierarchy) namely that on the highest level is the main aim or decisive problem and under it are criteria or sub-problems which can be set and divided on optional number of levels, hierarchically the lowest are alternative decisions or variants (Zadnik, 2000).

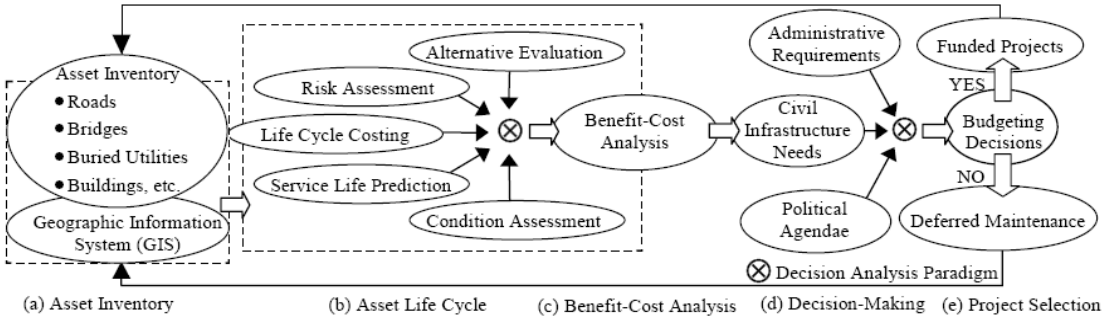
The basic question which appears at multicriteria deciding is how to find the appropriate profitability's function. Neuman (1953) and Chankong and Haimer (1983) cited by Rajkovič and Bohanec (1988) quote that is has to be ensured the existence and monotony of that function in accordance with measure theory. Rajkovič and Bohanec further ascertain that appropriate sentences ensure sufficiency for existence and monotony of profitability function. We call these conditions of sufficiency axioms.

Defining the profitability function by the help of axioms' checking is named axiomatic accession. Rajkovič and Bohanec (1988) quote that most of theorists acknowledge axiomatic access as the only right access at taking decisions. Practical men reproach difficulties to this access at checking of axioms and in certain situation not being practical. Therefore we often meet in praxis the direct access where person taking decision defines the function of profitability by his own judgments on the basis of his experiences and beliefs. It is possible that are direct and axiomatic access combined, which can be seen in practice. Here

we have direct identification of decisive knowledge which can be axiomatic grounded if it is possible (Rajkovič and Bohanec, 1988).

There exist many methods for support of multicriteria deciding. Individual methods are appropriate for simple decisive methods with small number of criteria and alternatives, again other are designed for the most difficult problems.

At developing of multicriteria model we resulted from model which was developed by Vaniers and co-authors (2006), which is decisive model for managing with fond of buildings.



Picture 1: Proposed framework for decision making. (Vanier and Lounis 2006)

It is the framework which was firstly designed for definition of building which needs certain interventions the most. Model is based on the relation of invested sources and profit which is got because of them and what can be defined by the help of analyze of costs and profit. In the complex of that analyze we consider momentary condition of buildings, their remaining life time, complete life costs and all potential risks connected with individual building. We have to analyze all the alternatives or variants which are available.

CONCEPT OF PROBLEM

Value of the building decreases because of deterioration's and obsolescence's kind which were listed above. As a rule first appears physical deterioration, then with time appear also functional and economic obsolescence. Thus we have formulated mathematically the value of building or fixed property after the certain time as (Kovačec, Pšunder, Soršak, 2010):

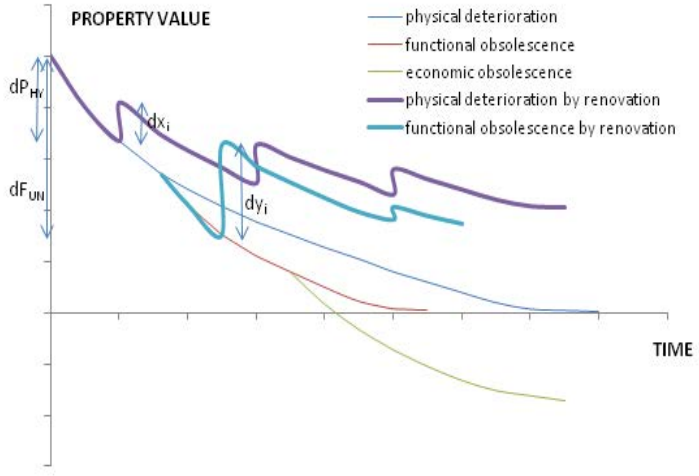
$$V(t) = V_i - dP_{HY} - dF_{UN} - dE \quad (1)$$

Where is:

V(t) – value of fixed property after the certain time;
V_i – initial value of fixed property;
dP_{HY} – extent of physical deterioration for which the value of fixed property is reduced;
dF_{UN} – extent of functional obsolescence for which the value of fixed property is reduced;
dE – extend of economic obsolescence for which the value of fixed property is reduced.

On the Picture 2 it is the chart where is represented that in the cases when we cure physical deterioration or functional obsolescence we can exceed initial value of the building or fixed property by enough high input. Regarding to cost of curing, the economic obsolescence (Pšunder, Torkar, 2007) is incurable. Here is necessary to ask a question how high can be the

inputs at the physical deterioration and functional obsolescence that it is not economic to build the substitutional building. Thus we are looking for time limit in the buildings' life time until it is justificated to renovate or sanitate buildings regarding to higher profitability which will be brought by new building and its activity.



Picture 2: Value of the building at "the recovering" of deterioration and obsolescence.

Thus we have formulated "Eq. (1)" as:

$$V(t) = V_T - \sum_{i=1}^{n}(dP_{HVi} - dx_i) - \sum_{i=1}^{n}(dF_{UNi} - dy_i) \quad (2)$$

Where is:
dxi – extend of inputs in the "recuperation" of physical deterioration;
dyi – extend of inputs in the "recuperation" of functional obsolescence.

On the basis of above equations 1 and 2 we have dervated following equation, which will be the basis for multicriteria decisive model for building's renovation described in the following chapter.

The condition of economic justification of renovation of non-economic buildings, these are public buildings, is formulated as:

$$V(t_{after\ renovation}) \geq V(t_{OS}) + C_{renovation}$$
(3)

Value of building before and after the renovation can be defined with method of comparable sales. Conditions of economic justification of business buildings' renovation, these are buildings which bring benefits, are formulated as:

$$V(t_{after\ renovation}) \geq V(t_{OS}) + C_{renovation} + benefits$$
(4)

MULTICRITERIA DECISIVE MODEL

Suggested multicriteria decisive model is based on represented theoretical points of departures in previous chapters and with combination of individual methods. It involves single criterion techniques, as well as multiple criteria techniques including, weighted mean.

At chosen multicriteria decisive model we treat one building. In the first stage we choose a building and try to study throughout the condition of it as it is represented on the Picture 3. Then we define possibilities of building's renovation in variants. After that we define renovation's costs of individual variants. Then we estimate the value of existing building and profitability of it in case of business building. We also define values of sub-criteria of existing building which are basis for further estimation. We choose the team of professionals and fixed property's estimators from build profession and who estimate and value fixed property after value international standards – MSOV (2007). Estimators and professionals estimate values of fixed property after purchase-value way which is based on the principle of Whitmer (Encyclopedia of Investments, 1990) that deliberate investigator for estimated fixed property is not prepared to pay more than costs of building equal fixed property amount, which has to be considered in our multicriteria decisive model because we are looking for economic justification of renovation or substitutional building. After defining the value of the building we start with multicriteria deciding. Here we use the team of professionals and fixed properties' estimators from construction profession, which estimate criteria represented in able 3 after preference measure scale with interval 0-10. Lower limit suits to expressive bad or undesired value of parameter, the upper one the most ideal and desired. Thus 10 mean ideal, the best, the most desired value, 0 the worst, undesired value. Thus the most important criterion gets weight 10 while are weights of remaining criteria defined relatively in the relation to the most important criteria. When the team of professionals finishes with the estimation with Delphi method we define estimations' unity of different professionals and we use achieved estimations for continuation of deciding.

After definition of estimation we start working on profitability's function. We define it after method of value's defining. The advantage of this method is that it is simple because we need to define only smaller number of preference in general. Thus we take as the example the sub-criteria of remaining life-time, where we make:

Class	To less	little	satisfying	appropriate
Interval of largeness (years)	0-25	25-50	50-75	75-100
profitability	0	0,50	0,75	1,00

Table 1: Defining of profitability

We define profitability also for others sub-criteria on the same way.

After defining the estimation we start with count of profitability which is made after following equation:

$$Profitability = \frac{\text{Estimation}}{\text{Common estimation}}$$

(5)

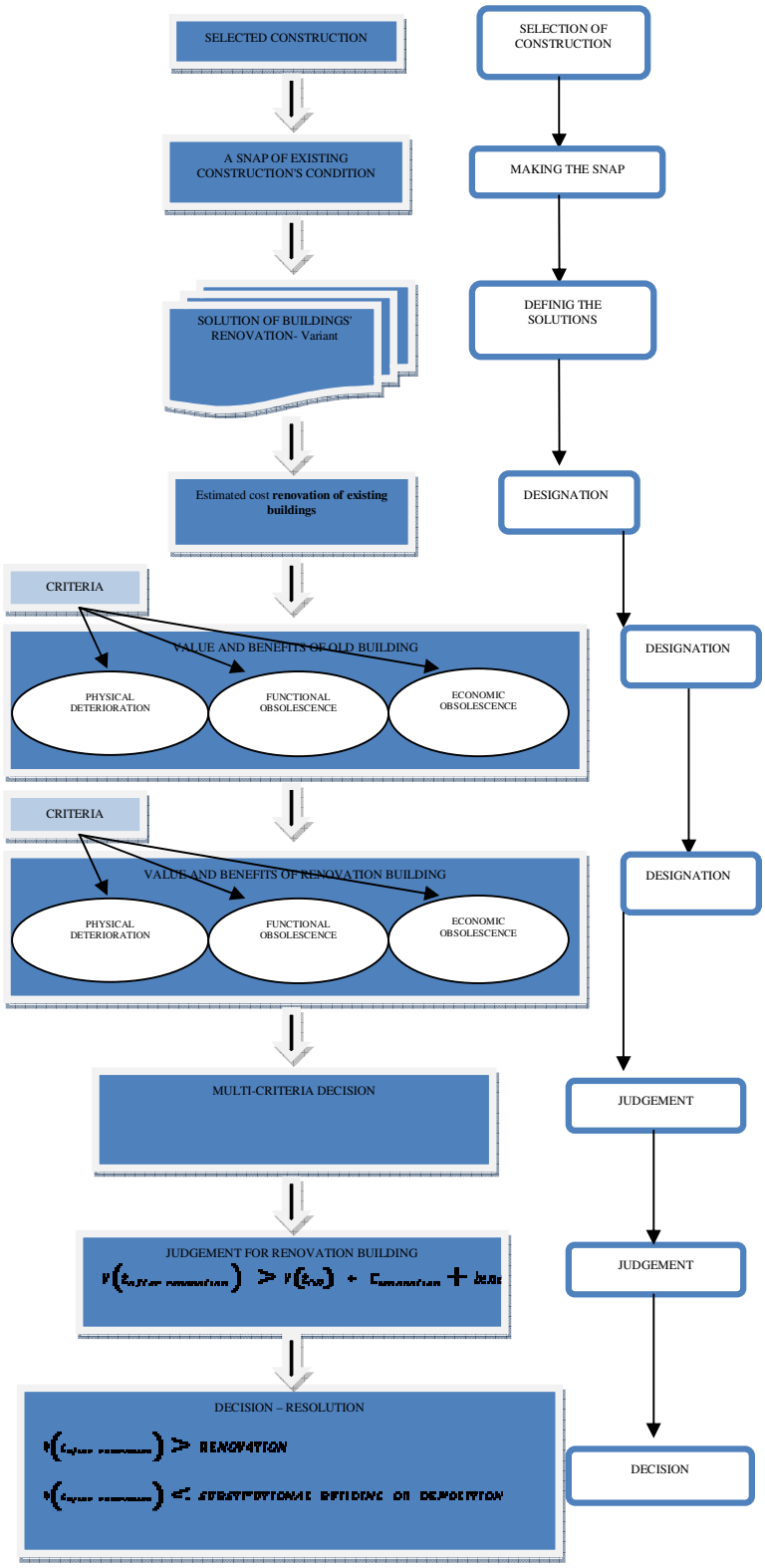
For estimation we take the estimation of individual main criterion (Table1), while we take common estimation of individual main criterion for common estimation. After definition we make scheme of criteria, Picture 4, where we divide main criteria by percentage in the way to add together estimations of sub-criteria and then we multiply this estimation with the sum of all estimations, thus:

$$k = \frac{\sum \text{estimation of sub} - \text{criterion}}{\sum \text{estimation of criteria}} * 100\%$$

(6)

Where is:
k – Main criterion

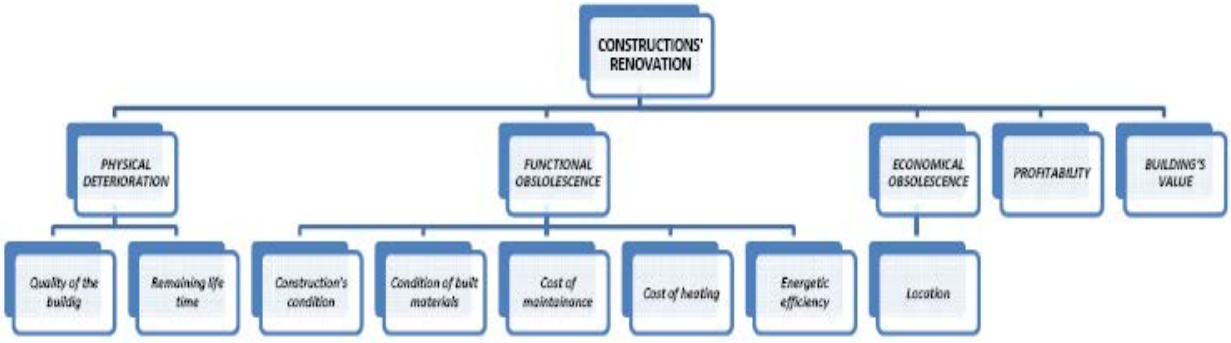
The same division expressed by percentage we make also for sub-criteria.



Picture 3: Multicriteria decisive model of economic justification of the building.

CRITERIA		Renovation of the building Variant 1			...	Renovation of the building Varianta n		
Main criteria (k)	**Sub-criteria (k_p)**	**Estimation (o_{p1})**	**Estimation together**	**Benefit (k_{r1})**		**Estimation (o_{pi})**	**Estimation together**	**Benefit (k_{ri})**
PHYSICAL DETERIORATION (X_1)	*Quality of the buildig (y_1)*							
	Remaining life time (y_2)							
FUNCTIONAL OBSLOLESCENCE (X_2)	*Construction's condition (y_3)*							
	Condition of built materials (y_4)							
	Cost of maintainance (y_5)							
	Energetic efficiency (y_6)							
	Cost of heating (y_7)							
ECONOMICAL OBSOLESCENCE (X_3)	*Location (y_8)*							
PROFITABILITY (X_4)	*Profit (y_9)*							
BUILDING'S VALUE (X_5)	*Value of the buildig after market method (y_{10})*							
VALUE								

Table 2: Multicriteria deciding



Picture 4: Scheme of criteria for evaluation.

After division expressed by percentage we count profitability of main criteria after equation:

$$k_1rX1 = (k_1(p(y1)) * k_1(r1(y1)) + k_1(p(y2)) * k_1(r1(y2)))/100 \quad (7)$$

$$k_1rX2 = (k_1p(y3) * k_1r1(y3) + k_1p(y4) * k_1r1(y4) + k_1p(y5) * k_1r1(y5) + k_1p(y6) * k_1r1(y6) + k_1(p(y7)))/100 \quad (8)$$

$$k_1rX3 = (k_1p(y8) * k_1r1(y8))/100 \quad (9)$$

$$k_1rX4 = (k_1p(y9) * k_1r1(y9))/100 \quad (10)$$

$$k_1rX5 = (k_1p(y10) * k_1r1(y10))/100 \quad (11)$$

After that we count final profitability of variant of building's renovation 1 after equation:

$$k_1r1 = (k_1X1 * k_1rX1 + k_1X2 * k_1rX2 + k_1X3 * k_1rX3 + k_{X4} * k_{rX4} + k_{X5} * k_{rX5})/100 \quad (12)$$

Equation is valid for each variant of building's renovation. After definition of profitability for individual variant we choose variant with higher value of profitability. After that we check chosen variant of building's renovation after equation 3 or 4, it depends if the building is business or non-business. On so far as we get higher value of renovation after equations 3 or 4 then the decision about renovation is right, in case that it is lower then the decision about renovation is not appropriate, however we can decide for substitutional building or demolition and selling the land.

EXAMPLE

Represented model has been tried in company Gradbeno podjetje Ptuj d.o.o. on many cases and we have got successful results and confirmation of use the chosen model. The test of the model will be show on one of the examples.
Quoted equations have been tested on the real building Color Medvode in Slovenia. Building is abandoned factory which was bought by Slovenian company. This company rents this factor which is old and necessary of renovation or substitutional building. Thus the company could enlarge its rental and use of building with renovation. In this way we will make comparison between two variants of renovation of mentioned buildings, which have been prepared by architecture biro.



Picture 4: Factory Color Medvode.

CRITERIA		***Renovation of the building Variant 1***			***Renovation of the building Varianta 2***		
Main criteria (k)	***Sub-criteria (k_p)***	***Estimation (o_{p1})***	***Estimation together***	***Benefit (k_{r1})***	***Estimation (o_{p2})***	***Estimation together***	***Benefit (k_{r2})***
PHYSICAL DETERIORATION (X_1)	*Quality of the buildig (y_1)*	*5*	*11*	*0,50*	*6*	*12*	*0,60*
	Remaining life time (y_2)	*6*		*0,50*	*6*		*0,75*
FUNCTIONAL OBSLOLESCENCE (X_2)	*Construction's condition (y_3)*	*5*	*28*	*0,75*	*5*	*32*	*0,75*
	Condition of built materials (y_4)	*5*		*0,75*	*5*		*0,75*
	Cost of maintainance (y_5)	*5*		*0,50*	*7*		*0,50*
	Energetic efficiency (y_6)	*6*		*0,50*	*7*		*0,75*
	Cost of heating (y_7)	*7*		*0,50*	*8*		*0,50*
ECONOMICAL OBSOLESCENCE (X_3)	*Location (y_8)*	*5*	*5*	*1*	*5*	*5*	*1*
PROFITABILITY (X_4)	*Profit (y_9)*	*9*	*9*	*0,75*	*10*	*10*	*1*
BUILDING'S VALUE (X_5)	*Value of the buildig after market method (y_{10})*	*10*	*10*	*0,90*	*9*	*9*	*0,80*
VALUE		*63*		***0,625***	*68*		***0,641***

Table 3: The example of Color Medvode.

Variant 1:

$k_1rX1 = (45 * 0{,}50 + 55 * 0{,}50)/100 = 0{,}500$

$k_1rX2 = (18 * 0{,}75 + 18 * 0{,}75 - 18 * 0{,}50 + 21 * 0{,}50 + 0{,}25 * 0{,}50)/100 = 0{,}466$

$k_1rX3 = (100 * 1)/100 = 1$
$k_{rX4} = (100 * 0{,}75)/100 = 0{,}75$
$k_{rX4} = (100 * 1)/100 = 0{,}90$

$k_1r1 = (17{,}46 * 0{,}500 + 44{,}44 * 0{,}466 + 7{,}93 * 1 + 14{,}28 * 0{,}75 + 15{,}87 * 0{,}90)/100 = 0{,}623$

Variant 2:
$k_1rX1 = (50 * 0{,}60 + 50 * 0{,}75)/100 = 0{,}675$
$k_1rX2 = (15 * 0{,}75 + 15 * 0{,}75 + 22 * 0{,}50 + 22 * 0{,}75 + 25 * 0{,}50)/100 = 0{,}625$
$k_1rX3 = (100 * 1)/100 = 1$
$k_{rX4} = (100 * 1)/100 = 1$
$k_{rX4} - (100 * 0{,}8)/100 = 0{,}8$

$k_1r1 = (17{,}64 * 0{,}675 + 47{,}05 * 0{,}625 + 7{,}35 * 1 + 14{,}70 * 1 + 13{,}23 * 0{,}8)/100 = 0{,}739$

The results show that variant 2 is better than variant 1. That's why we check variant 2 after equations 3 and 4, so it depends if the building is business or non-business. Because in this case we have business building we check with equation 4, where the building has also fulfilled the condition.

CONCLUDING REMARKS

By help of multi-criteria decisive model it is possible to decide in which time limit of building's lifetime is it reasonable and economic justified to take a decision not to maintain or to improve sanitary conditions, but to demolish and construct new building or substitutional building regarding the criteria, therefore physical deterioration, functional and economic obsolescence in connection with the value of the object and profitability or benefit. Discussed model was tested in company Gradbeno podjetje Ptuj d.o.o. which deals with construction of all kinds of buildings. In the paper are represented only short abstracts of model. We will develop this model in the future that will regard business and non-business buildings in details and at the same time define the possibility of economic judgments of renovation and substitutional construction of buildings.

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STUDY OF THE SUBMITTAL PROCESS USING LEAN PRODUCTION PRINCIPLES

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Abstract
In the Architecture, Construction and Engineering (AEC) industry office activities link the information flows from project teams and the production processes on the field. Despite their importance to the overall project, office activities have been overlooked and several authors point out that they are often mismanaged, lack planning, or are buffered to account for the great amount of variability within processes developed at the office level, eventually resulting on site inefficiencies and cost overruns. This paper presents a study of the submittal process through the use of Lean Thinking. Submittals are documents exchanged between the general contractors, subcontractors, the project architect and its team of designers and consultants. Submittals carry information about products and processes used to deliver a project, and are submitted from the parties constructing the project, or supplying materials to it, to the designers so that the submitted information can be checked for conformance to project specifications. The study shows that for the project investigated the submittal process lacked transparency, had low workflow predictability, and showed low levels of reliability. The study concludes that the submittal process can be streamlined by enhancing communication and information sharing amongst stakeholders, through the understanding of the causes of variation in lead times and the understanding of participants' needs.

Keywords: lean construction, lean office, submittal process

INTRODUCTION

In the United States like in many other countries in the world the construction industry plays an important role in the country's economy. In the United States, in 2009 alone, the Construction Industry contributed with 4.1% of the US Gross Domestic Product (BEA 2010), and accounted for more than 7.3 million of paid employees (US-Census-Bureau 2010). However, the inefficiencies of the construction industry are well known and include: low productivity rates, poor quality of work (Koskela 1996), cost overruns, delays, constant changes, rework and claims (Gould and Joyce 2009).

Project management in construction is largely based on the traditional (conversion) model that considers that "the conversion processes can be divided into subprocesses, which also are conversion processes" (Koskela 1992, p. 12). For example, cost estimates are based on data gathered from previous projects and follow a work breakdown structure (WBS), i.e., a

hierarchical division of work in smaller parts, in which the unit cost of each major process (e.g., structure) is the sum of the cost of each subprocess (e.g., formwork, reinforcing steel, placing concrete). In these estimates, the flow aspects of the process (moving materials, inspections, waiting times) are not explicitly considered and accounted for and only the transformation tasks are tracked. As a consequence the focus of construction project management, based on the traditional model, lays in assuring that each subprocess performs as productively as possible, which does not necessarily translate in the best performance for the entire project. The sum of the local optimums in each subprocess does not equal the optimum of the entire process.

The use of Lean Production concepts, principles, and tools applied to construction production processes (e.g., activities developed on site) has proven to be possible and result in notable improvements in the performance of construction project (e.g., Kemmer et al. 2010; Schramm et al. 2009; Matt 2008; Howell and Ballard 1996). In spite of considerable success of the referenced studies, not much has been done regarding administrative processes of office-related activities in construction (Kemmer et al. 2009), notwithstanding the importance of these processes in any construction project.

Lean Thinking applied to nonproductive processes is termed Lean Office. In the office environment two main types of demand can be defined within an administrative system: value demand and failure demand. Value demand is the demand for the service that the system is set to provide, or in other words, what the client wants. Failure demand is the demand that results from "the failure to do something or to do something right to the client" in the first pass (Seddon 2008, p.32).

Office related activities support the work of construction teams working on site and without office activities production processes cannot occur because people have to be hired, paperwork has to processed, bills have to be paid, and information has to be made available. Besides their importance to support the overall performance of the project, some office related activities are often performed by highly trained and skilled workers, such as Professional Engineers, representing a significant part of the overhead cost of the projects and therefore of the overall cost of each project (Kim and Ballard 2002).

Some of the administrative processes in construction projects are related to the constant exchange of information between the intervening teams in the project (Atkins and Simpson 2008). These teams are responsible for two major processes in construction projects identified by Koskela as the design process and the construction process (Koskela 1992). The purpose of this exchange of information is to first ensure that the designers' intentions and requirements are implemented and second to record decisions of what happens on site in order to allow post-construction investigation (Mays and Novitski 1997).

Amongst the office activities, the submittal process deserves attention as it is one of the processes used to exchange information between the design team and the construction team. The submittals are documents that are prepared by the construction team and contain detailed dimensions, types of materials and equipment, and illustrate application conditions, allowing a determination of how interfaces with other products and systems should be dealt with during the construction phase (Atkins and Simpson 2008).

THE SUBMITTAL PROCESS

During the construction phase, the general contractor (GC) and the subcontractors (Subs) work with suppliers to define and detail the products that will be used to satisfy the specifications set forth by the Architects and Engineers (A/E) of the design team. These documents containing product information (e.g., shop drawings, samples, and product data discussed later in this paper) are then sent to the architect and project consultants for review and approval. Each group of documents related to a specific item of the project (e.g., specifications for the concrete mix, product samples related to the flooring) sent by the GC is called a submittal. The process of preparing, submitting and all the intermediate steps until the approval of the submittal is called the submittal process.

The submittals may include different types of documents such as shop drawings, product data, samples, reports, manuals, and warranties. Even though some of these documents are sent to the design team only to be part of the project's record, the majority of these documents, particularly shop drawings, samples, and product data, need to be approved by the design team before installed or built in the project (Atkins and Simpson 2008; Gould and Joyce 2009). Shop drawings are the working documents, detailed and precise, that represent every component of the project, method of assembly, and materials to be used. Product data presents information about products and may be required either as supplements to shop drawings or to ensure that the products meet the required standards. Product data may include illustrations of the product, brochures, and information about the product's performance. Samples show the characteristics of a specific material and are often required to show colors and finishes (Gould and Joyce 2009; AIA 2007; EJCDC 2007).

RESEARCH METHOD

This paper presents the results of a pilot case study that was part of a broader research project. The research work was carried out in two construction companies, based in San Diego/CA, and identified as Company A and Company B. Both companies independently pointed out to the submittal process when inquired about which process should be investigated as part of a study on office activities.

Case studies were used as a strategy to collect and analyze the empirical data. This research approach, as suggested by Yin (1994), concerns the study of contemporaneous events that cannot be manipulated in their environment.

According to Yin, case studies have the advantage of covering contextual conditions, relying on several types of evidence such as documents, interviews, observation, physical artifacts, and archival records (Yin 1994). The study started with two preliminary studies i.e., pilot case study 1 and pilot case study 2, followed by a case study and consequent conclusions and recommendations. This paper only addresses pilot case study 1 carried out at Company A with a brief cross-case analysis for the findings of both studies, due to space limitations.

Company A aimed at improving and standardizing its submittal processes based on the performance of one of its best teams assigned to a starting construction project. In Company A the submittal process was managed on site by the construction team, and according to a top manager of the company (information obtained during a meeting) the aforementioned team ran the process smoothly without major problems, but lacked a streamlined and standardized

procedure to develop the submittal process. Thus it was the company's goal to understand what was being done by this team, improve what could be improved on a new project, and standardize this process to implement it companywide.

This pilot case study was conducted on a 12-story building (cast in place concrete, post-tensional slabs, and structural steel roof). This 220,000 sq.ft mixed-use project with 136 apartment units, retail spaces and subterranean parking will support the charity work (feeding the hunger, and provinding housing, healthcare, and education to those in need) of a non-profit organization in San Diego, CA. The project had already been delivered to the Owner when the Pilot Case Study started. That said, all the information obtained was related to past events.

A mixed approach (Yin 1994) was used in this research project to simultaneously collect qualitative and quantitative data throughout the research. For the pilot case study cross-sectional quantitative data was provided by the company, which had kept archival records of the submittal process in the form of spreadsheets that were used as a submittal schedule (a.k.a. submittal log). The submittal log contained the record of the process to help manage and control the submittal process. The qualitative data was collected through semi-structured interviews that were performed on a weekly basis with Company A.

Sources of evidence

The data collected was categorized herein as: time data (actual and planned), quality data, nominal data, and procedural data. These categories are defined below. Based on the information provided by the company, Figure 1 was drawn to represent the major milestones of the submittal process from the date the submittal was received to the time it was finally distributed to those doing the field work.

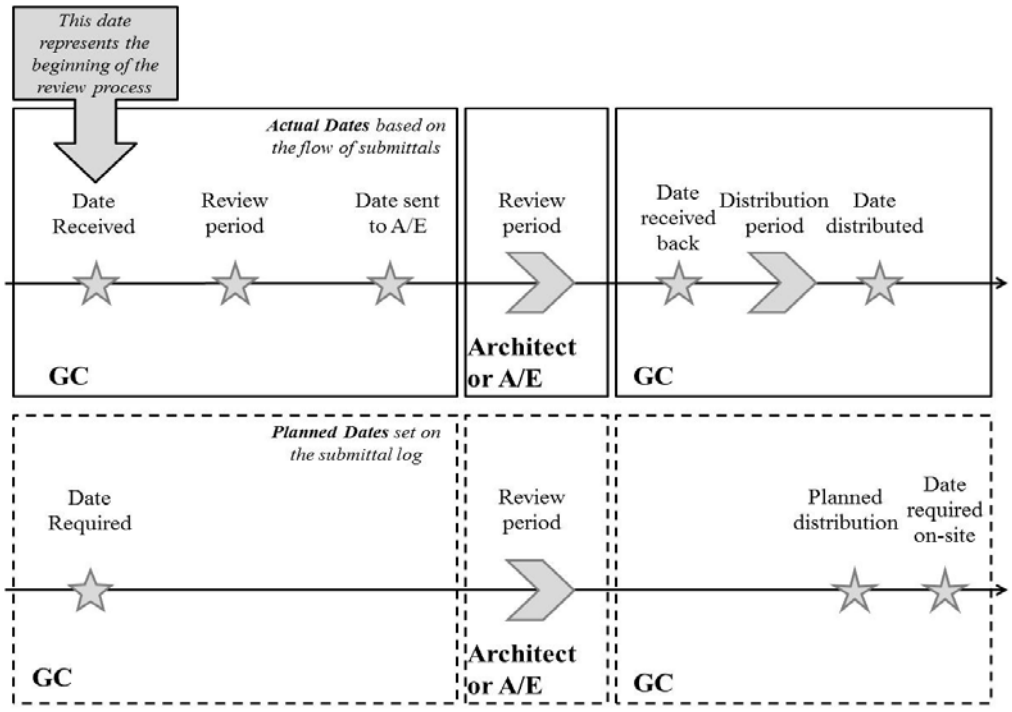


Figure 1: *Data collected.*

Time data
Time data includes actual data and planned data. Actual data reflects when an event actually took place (e.g., when a submittal was delivered by a Sub to the GC; when the GC sends a submittal to the A/E). Planned data are dates that were introduced into the submittal log at the beginning of the project (e.g., when a subcontractor was required to deliver a submittal to the GC; when the submittal was planned to be distributed approved to the subcontractor) which reflect the dates when the event happened, and the planned dates that were set in the log at the beginning of the project.

Quality data
The quality data reflected the approval status, i.e., Approved (A), Approved as Noted (AAN), Revise & Resubmit (RR), Rejected (R), and For Record (FR) that was determined in two different phases of the submittal process:

1) The GC's review period – during this phase a submittal marked as A, AAN or FR had no or minor notes and was released to the Architect for approval. A submittal marked as RR had major problems and could not be sent to the Architect before revised and resubmitted for the GC's review. A submittal marked as R was no longer needed to be submitted. A submittal marked as FR, was sent to the Architect to add to their files.

2) The Architect or the A/E's team review period - during this phase the Architect or the A/E marked "Approved", or AAN, or FR may had minor notes, but was returned to the GC and then to the subcontractor and was good to go. A submittal marked RR had major problems and had to be revised. In these cases the submittal was sent back to the GC and then to the subcontractor to RR, and all review cycle started again until the submittal was "Approved" or AAN. A submittal marked R was no longer needed to be submitted.

Table 1 summarizes the possible status for a submittal and the corresponding meaning for each one.

Table 1: *Status of the submittals*

Status	Meaning
A	The submittal is good to go
AAN	The submittal is approved with minor changes and does not need to go through a new cycle of review
RR	The submittal is not ready to go. It is returned to the party who submitted it for a new cycle of review. Once the party revises the submittal and addresses the comments on the submittal, a new round of review is started again. This loop may continue until all comments are addressed
R	The submittal is no longer required (as a result of a change order, for example)
FR	The submittal does not need approval, but will make part of the construction documents.

Nominal data
The nominal data reflected the type of submittal delivered for approval (e.g., shop drawings, samples, or product data).

Procedural data
The procedural data reflected the party responsible for the approval of the submittal, (e.g., Architect, Structural Engineer).

Data analysis
The data analysis was focused on review cycle times i.e., how often a part or a product actually is completed by a process, as timed by observation (LEI 2008), approval status, and variability within those indicators. In an attempt to identify patterns, and following the indication of the Project Manager (PM) of the construction team assigned to the project, the data was first analyzed for the entire process and then analyzed separately by variables within each category: quality, nominal, and procedural.

The findings of the pilot case study were presented to the GC's construction team who provided some comments which were later addressed in the analysis of the pilot study.

RESULTS

According to the information provided by Company A's informants, the submittal process for this pilot case study started when the GC prepared the submittal schedule (or submittal log), where the specification sections, due dates, and responsible parties were represented. For this project, as in many others where there is no contractual relationship between the subcontractors (and suppliers and fabricators) and the owner, the subcontractors submitted the submittals to the GC for approval. Then, ideally, the GC reviewed each submittal, approved it, and sent it to: a) the Architect who also reviewed it, approved it, and sent it back to the GC; or b) to the A/E, then the architect received the submittal, sent it to the respective consultant for review, the consultant approved it, and sent it back to the Architect, who then reviewed it once again, approved it, and sent it back to the GC. Once the A/E reviews were completed and the submittals approved, the GC would send the submittal back to the respective contractor. Figure 2 illustrates a desirable timeline for the submittal process as described. The shaded stars correspond to the due dates that were set by the PE on the submittal log (SL) at the beginning of the construction phase.

For this case, the SL was built on an excel spreadsheet and contained different types of information. The SL listed all the submittals required that were indicated in the specification book for the project, and key information such as: Architect or A/E allowed review time; the estimated delivery lead time (estimated time to deliver a product or service once the subcontractor received the approved submittal), the due date each submittal was required to be submitted, and the date the submittal was required on site.

The submittal review process would start once a subcontractor sent a submittal to the GC for review. In an interview, the PE stated that during this period (ideally 3 to 5 days) the GC's construction team assigned to the project verified that what was submitted matched the plans and specifications. This verification was done to ensure that no time was wasted by sending an incorrect or incomplete submittal to the Architect.

During the review process, the GC's construction team would define a category for each submittal. The possible categories for this project were: 1) A; 2) AAN; 3) RR; 4) R; and 5) FR (see Table 1).

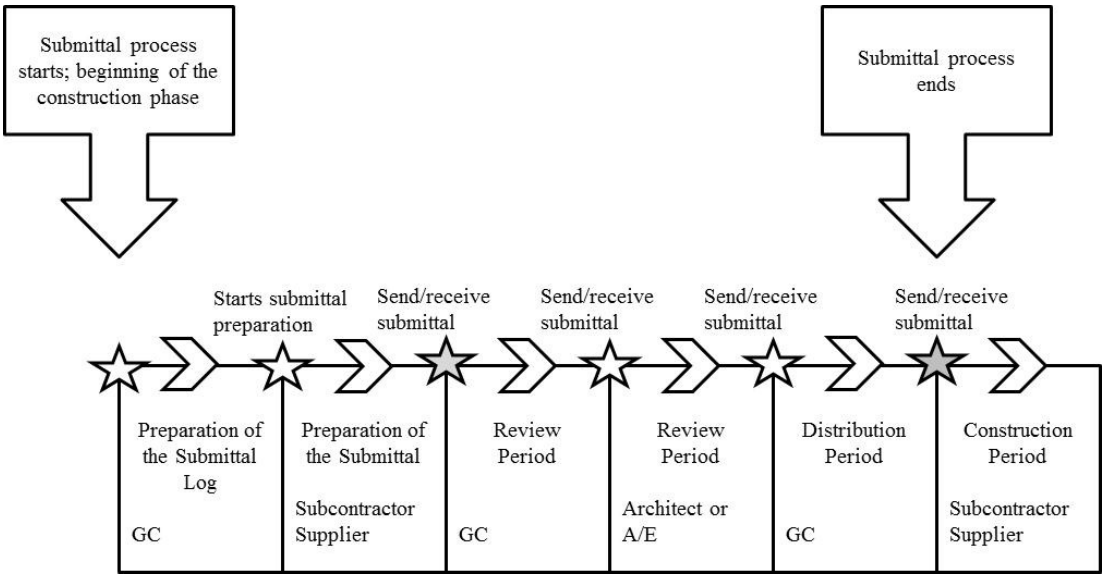


Figure 2: *Desirable Submittal Process Timeline.*

Once the submittal was sent to the Architect, a new review loop started. The review was done either exclusively by the Architect or with the help of consultants. Ideally, the Architect and/or the A/E had 14 days to review the submittal (in some cases depending on its complexity, different times were set for this review). Once the Architect or the A/E review was complete, the submittal was sent back to the GC, who in turn distributed it to the subcontractors. Ideally the GC released the submittal within 3 days.

Provided that the A/E stamped the submittal A or AAN, the subcontractors were not required to resubmit the submittal. In some odd cases even though the submittal was categorized as AAN the submittal had so many notes and corrections that the subcontractor was asked to submit a clean copy FR. In an interview, the PM's team informed the research team that the project for which the data was analyzed pertained to a project that had a smooth submittal process with no major problems. Ultimately, the submittals were delivered on site in a timely fashion, which is what the team considered important.

Data analysis

The indicators for this pilot case study were categorized into two groups: 1) time indicators, which include cycle times, and lead times, i.e., the time it takes one piece to move all the way through a process, from start to finish (LEI 2008); and 2) quality indicators, which include the relative percentage of submittals set as A, AAN, RR, R, and FR. Table 2 lists and defines those indicators.

The analysis of the data presented herein followed the indications of the PM's team. In an interview, the PM informed the research team of the estimated lead times including a breakdown of the estimated lead time (ELT) by participant of the project and estimated cycle time. This information is listed in Table 3. This information includes the cycle times (CT) for the GC and A/E reviews, the GC distribution time during the review process, and lead time (LT) for the submittal process as described by the PM's team. The values listed in Table 3 were obtained solely based on the PM's team expert judgment.

Table 2: *Indicators*

CATEGORY	INDICATOR	MEANING
Time	GC_CT - GC's Review Cycle Time	Represents the average time a submittal spent at the GC for approval
	A/E_CT - A/E's Review Cycle Time	Represents the average time a submittal spent at the A or A/E for approval
	GCD_CT - GC's Distribution Cycle Time	Represents the average time a submittal spent at the GC to be delivered to the subcontractors
	LT - Lead Time	Represents the average time a submittal spent at the GC and at the A/E for approval and delivery (LT= GC's CT + A/E_CT + GC_DT)
	PLT - Planned Lead Time	Represents the planned total time a submittal spent at the GC and at the A/E for approval and delivery (as set at the beginning of the project on the SL)
	ELT - Estimated Lead Time	Represents the estimated time a submittal spent at the GC and at the A/E for approval and delivery (as described by the PM's team)
Quality	Approval Percentage	Represents the percentage of submittals that were A, AAN, RR, R and FR.

Table 3: *PM's expert judgment estimates for the cycle times and lead time of the submittal process*

	GC	**A/E**	**GC**
CT	Review 3 to 5 days	Review 14 days	Distribution 3 days
LT	20 to 22 days		

The PM's team gave the research team access to the actual SL for the pilot case project. Indicators for all submittals were organized by the research team into different types of variables. To begin with, time indicators were analyzed considering the entire project and by each type of variable: quality, nominal, and procedural. After that, the quality indicators (A, AAN and RR) were calculated. Table 4 presents a summary of the results obtained for the time indicators. This analysis was only performed for the variables that were representative of processes that had a PLT of 11 days (93% of the data).

The shaded cells presented in Table 4 are discussed in more detail as they represent data that differs from what was expected by the project team. First of all, the LT (33.1 days) is about 1.5 times higher than the ELT (22 days) and more than three times the PLT (11 days). Next, the submittals spend, on average, more time to be distributed by the GC than to be reviewed by the GC (GCR-CT>GCD-CT). The GC-DT for product data (13.8 days) is about two times the GCT-CT for shop drawings (7.2 days). The submittals AAN took on average six days longer to be returned to the subcontractor than submittals A. Lastly, the LT of submittals sent to the A/E is lower than the LT of submittals sent to the Architect.

Table 4: *Submittal process: actual cycle times and lead times*

SUBMITTALS		GCR-CT (1) (DAYS)	A/ER-CT (2) (DAYS)	GCD-CT (3) (DAYS)	LT (1)+(2)+(3) (DAYS)	PLT (DAYS)	ELT (DAYS)
Project	Average	7.6	14.8	10.7	33.1	11	22
	Median	2	7	6	31	11	--
Quality							
A	Average	4.8	13.6	11.1	29.4	11	--
	Median	0	8	6	25	11	--
AAN	Average	9.5	15.8	10.7	36	11	--
	Median	3	11.5	6	34.5	11	--
Nominal							
Shop Drawing	Average	6.8	15.3	7.2	27.5	11	--
	Median	2	9	6	20	11	--
Product Data	Average	7.6	15.3	13.8	36.7	11	--
	Median	1	13	6	36	11	--
Procedural							
Submitted to the Architect	Average	10.5	14.8	16.9	42.2	11	--
	Median	1	9	8	36	11	--
Submitted to the A/E	Average	6.6	14.9	8.4	29.9	11	--
	Median	2	10	5.5	26	11	--

Figures 3 to 6 present charts with histograms for the LT, GCR-CT, A/ER-CT, and GCD-CT, respectively. On the same charts empirical cumulative distribution lines overlay the histograms on a secondary axis. Note that all submittals shown in Figures 3 to 6 had a PLT of 11 days as defined in the SL, corresponding to 139 observations. From the observation of Figure 3, it is clear that there is a great amount of variability in the actual lead time, and the LT numbers are very different from the PLT or even the ELT. The median value of the observed LTs is 31 days (see Table 4), which is quite different than the ELT of 20 to 22 days and only met on 38% of the cases (see Table 3).

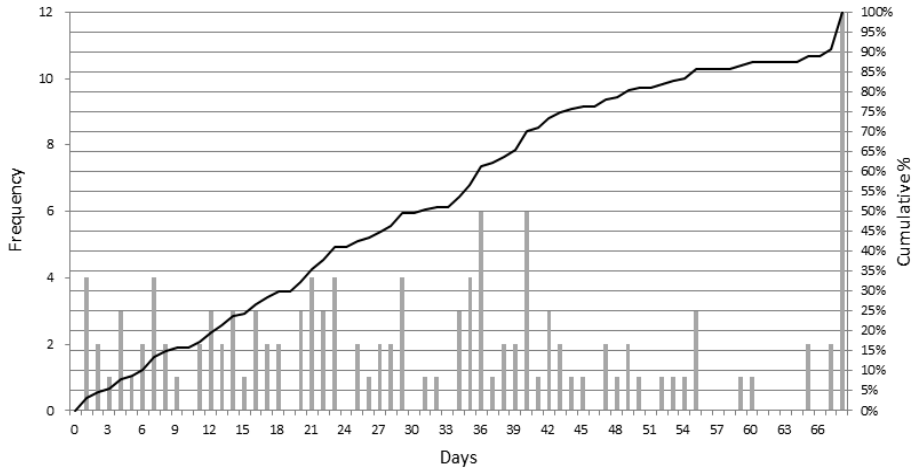


Figure 3: *Submittal process actual lead time.*

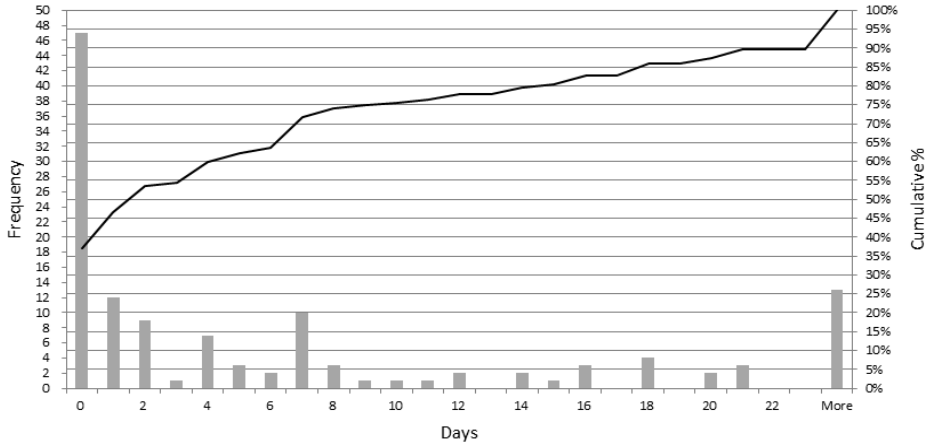


Figure 4: *General Contractor's actual review cycle time.*

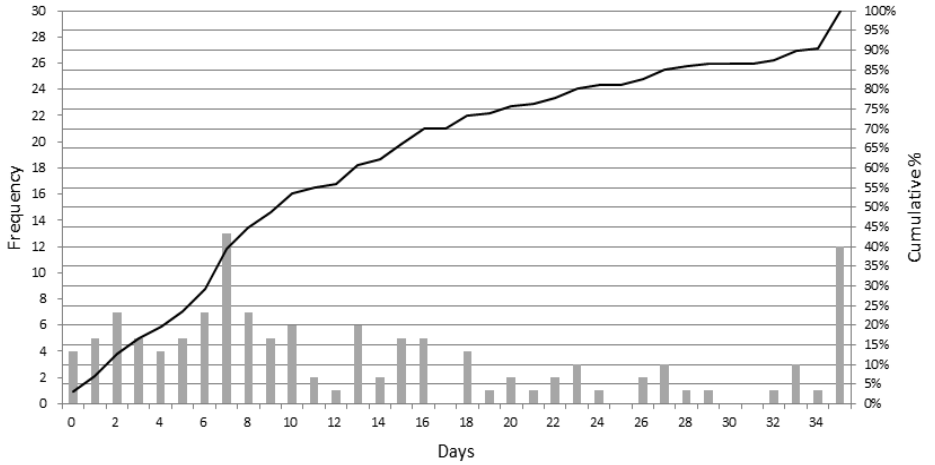


Figure 5: *A/E actual review cycle time.*

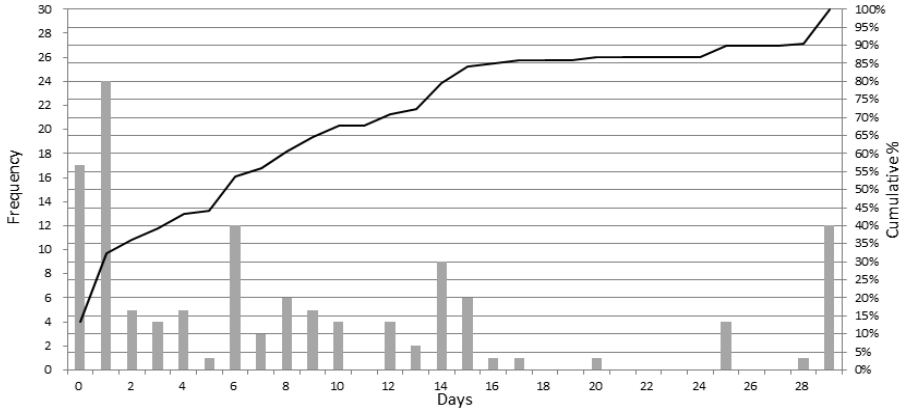


Figure 6: *General Contractor's actual distribution cycle time.*

Figure 4, which reports the GC review time, also shows great variability. However, the median value of about 1.5 days that may be observed from this figure is actually less than the estimated values of the 3 to 5 days reported in Table 4.

Figure 5 shows the A/E review cycle time. From this figure it may be observed that about 62% of the time, the A/E actually meets the estimated deadline of 14 days defined by the PM's team. Naturally, it is worth studying the reasons that lead to having the A/E team exceed the crucial value of 14 days in 38% of the submittals. Figure 6 shows the GC distribution time and it is worth analyzing the facts that lead to 62% of the submittals having a distribution time greater than the estimated distribution time (expected GCD-CT of 3 days).

Figure 7 presents a summary of the previous figures and allows a comparison between: planned cycle times and lead times as defined in the submittal log; estimated cycle and lead times, as described by the PM's team; and the actual average of cycle and lead times that were registered on the submittal log.

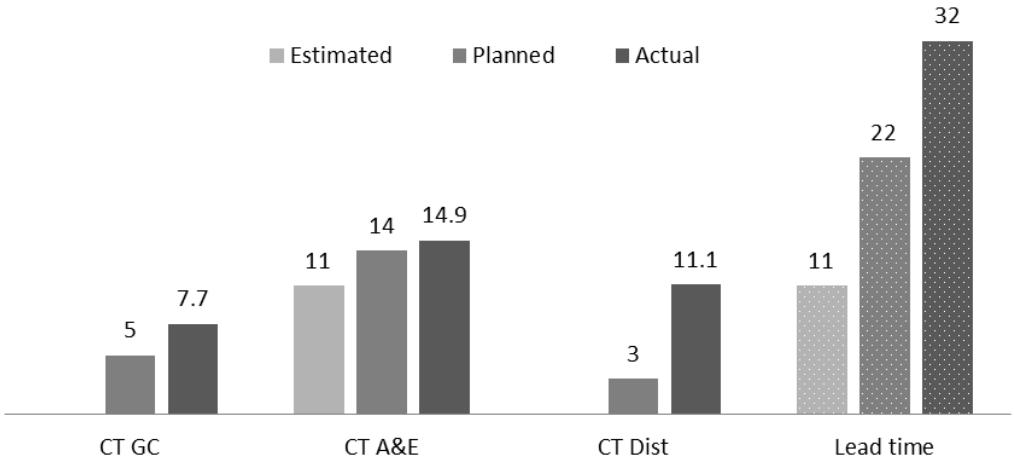


Figure 7: *Estimated, planned, and actual average cycle times and lead times.*

Figure 7 shows that the submittal activities took longer than planned and even longer than estimated. Also it is worth noting that the GC actually took longer to distribute the submittals than to review them. The reasons behind these findings should be analyzed. More importantly, the differences between planned and actual times should be accounted for in the future pre-construction preparation of submittal logs. A possible explanation for the deviations noted are that even though the PM's team acknowledged that they should consider their own review time, as indicated in Table 4, in the SL they did not in fact consider their own review and distribution times in the initial scheduling phase.

Figure 8 presents a chart which shows that in 57% of the time, the subcontractor delivered the submittal earlier than required to the GC, sometimes even much earlier than the due date that was scheduled by the GC. Although this number may not sound alarming, the complement is that 41% of the time the subcontractor delivered the submittals late to the GC as shown in Figure 8.

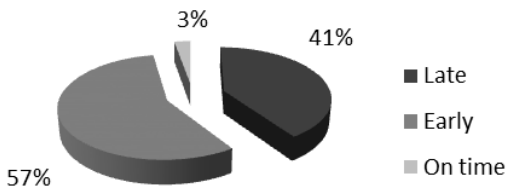


Figure 8: *Relative portion of submittals submitted by the Subcontractors to the General Contractor on time, earlier, and later than planned in the schedule.*

Another important finding was that in 49% of the cases the submittals were distributed late to the subcontractors, as shown in Figure 9.

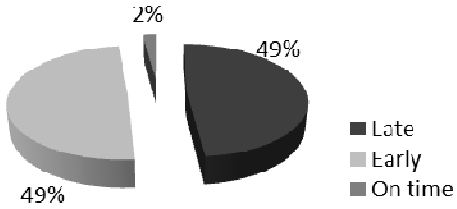


Figure 9: *Relative portion of submittals distributed to the Subcontractors on time, earlier, and later than planned in the schedule.*

Figure 10 presents a summary of the results obtained for the quality indicator. In this case one can see that the vast majority of submittals after the A/E review were AAN (58%) followed by the submittals A (35%) and the submittals RR & R (7%). The data did not have submittals FR.

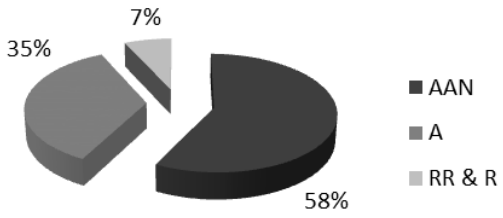


Figure 10: *Relative proportion of submittals status.*

Analysis

In contrast to the PM team's statements that the submittal process was smooth, the results presented in the previous section seem to indicate otherwise. The submittals were often delivered later than required on site and the lead times for the submittal process seem to be almost unpredictable. For 75% of the submittals the lead time for each submittal approval

took any time between 0 to about 45 days (see Figure 3) to be approved by the GC and the A/E.

The planned lead time did not reflect the estimated lead time, or the actual lead time, for that matter. In fact, the planned lead time was about half of the estimated lead time, and a third of the average lead time of the project. Additionally, the subcontractors pushed the submittals for approval regardless of the real needs of the project. This practice is well documented as impeding the flow of work/information and has been identified as a cause for rework and work in progress, a clear indication of wasteful practices.

The submittal process had different CT and LT for different variables within each type of variables studied. For example, submittals AAN took on average 6 more days to be returned to the subcontractors than submittals A. The submittal log did not account for those differences.

Three unexpected results were obtained. First, despite the PM's indication, the lead time for product data was, on average, 7 days longer than the corresponding lead time for shop drawings. The PM's team of the GC in Company A had indicated that shop drawings were expected to have a longer lead time than product data since they are much more complex and may detail dimensions with low tolerances.

Next, the cycle time for the Architect's review was longer than the cycle time for the A/E review, even though the review by both the A/E adds two more handoffs and a new approval loop to the process. According to the GC, when the submittal has to be sent to the consultants the Architect works on it immediately, suggesting that the Architect is more attentive to monitoring the work of the consultants than his own.

Finally, the cycle time for the GC's distribution was higher than the cycle time for the GC's review. According to the GC this should not occur. Nevertheless, the PM considered that it could be related to the fact that in some cases the Architect use submittals as a way to finish the design, leading to submittals where many notes have to be considered, and eventually leading to change orders.

The analysis of the meaning of the status for the submittals allows categorizing the each status in terms value. Only A and FR represent value added as they deliver value to GC and the Architect and ultimately to the Owner. AAN represents contributory activities as by adding notes to the submittal the GC and the A/E enable the submittals to add value to the process. RR, and R represent represents the failure to prepare the submittal right the first time in terms of what the Architect wants and it is waste. Table 5 summarizes the analyses of the submittal process for this pilot case study in terms of demand and value. The data shows that in 58% of the submittals there was value enabling demand and contributory activities, in 7% waste and failure demand were generated due to the need to rework.

Table 5: *Submittal process: actual cycle times and lead times*

STATUS	MEANING	DEMAND	VALUE
A	The submittal is good to go	Value	Value Added
AAN	The submittal is approved with minor changes and does not need to go through a new cycle of review	Value Enabling	Value Added/ Contributory
RR	The submittal is not ready to go. It is returned to the party who submitted it for a new cycle of review. Once the party revises the submittal and addresses the comments on the submittal, a new round of review is started again. This loop may continue until all comments are addressed	Failure	Waste
R	The submittal is no longer required (as a result of a change order, for example)	Failure	Waste
FR	The submittal does not need approval, but will make part of the construction documents.	Value	Value Added

Cross Case Analysis

The two pilot case studies were quite different from each another. The first difference is that Company A's projects are new building construction and building renovations, while Company B's projects are water and waste water infrastructures and treatment facilities. At Company A the submittal process was managed on site by the PM's team assigned to the project. In contrast, Company B managed the submittal process at the main office by an administrative department with different teams assigned to review different Divisions.

Despite the differences in the processes of the two companies, the results were similar: the unpredictability of the cycle time of the Owner introduces great variability to the process, and this variability reduces the reliability of the submittal process. In addition, failure demand is present in both submittal processes and is represented by the high number of submittals that needed to be RR or were R.

CONCLUSIONS

The first conclusion that was drawn from the study is that the submittal log set at the beginning of the construction phase to manage and control the submittal process is in fact a data base used to monitor the performance of the submittal process. This log does not help to manage or plan the process. In fact, because the indicators used to build the log do not reflect the reality, the plan is completely disconnected from what really happens. Additionally, because the log does not allow a visual reading of the real indicators of the process, the submittal log does not help control the submittal process either. The log does not show the flow of information and one cannot manage what is not measured.

In addition, the unpredictability of the cycle times of participants in the process introduce great variability to the process and this variability reduces considerably the reliability of the submittal process.

Finally, through this study, two main types of waste were identified in the submittal process:

- Time waste is reflected as the time spent by the PM's team to set up an inadequate submittal log.

- Rework and failure demand is reflected by the percentage of submittals that were R or RR

As final remarks it is worth noting that:

- The project was delivered via the design-bid-build method
- The project had already been completed when the research team had access to the data
- A limited number of events were observed which do not allow for statistical generalization. Instead, the study can be generalized through the application of a similar research method to similar populations to allow for analytical generalization.

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INTEGRATED HOUSING SUPPLY CHAIN MODEL FOR INNOVATION: NARRATIVE ANALYSIS TOWARDS DEVELOPING PATHWAYS METHODOLOGY

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Abstract
There are significant problems in the supply of housing in Australia yet very little attention has been paid to the housing construction supply chain. To date the housing supply debate has been largely focussed on housing demand, affordability and land supply. It is contended that one of the key causal factors of poor housing supply is the poor coordination between supply chain actors. The development of integrated supply delivery solutions have not been extensively recognised in the Australian residential sector. Ad hoc examples and applications by some major building companies has seen some limited success, however, this has not been diffused throughout the sector with little real impact on overall sector performance and individual company competitiveness. Whole-scale industry improvement requires a concerted effort to undertake a stepwise change. A key to the solution is to investigate successful examples of integrated supply chains which have resulted in productivity and/or innovation performance improvements. The aim of this research is to undertake a case study analysis of successful implementation of delivering an innovation to the Australian housing construction industry which required an integrated construction supply chain model. The paper describes the theoretical background to the study and the preliminary results of the case study.

Keywords: housing, supply chain innovation, case study

INTRODUCTION

The housing sector has always been seen as an important part of the economy and is considered a key indicator of the health of the Australian economy. The construction industry typically represents between 6-12% of the GDP of an economy. In Australia in 2009 the residential sector accounted for approximately $70b and from 2000-2009 the average was 47% of the total spend in the construction industry. With anticipated population growth the significance of housing infrastructure provision is expected to increase in the next two decades. The Australian National Housing Supply Council estimates that around 3.2 million additional dwellings will be required in the next 20 years to accommodate a population growth from 2008 to 2028 (ANHSC, 2010). Moreover, it also forecasts that the current demand-supply gap of 178,400 dwellings will increase to approximately 640,000 by 2028. According to the Australian Bureau of Statistics (ABS, 2010), the country currently needs to be building 17,400 homes every month. Housing supply, however, has oscillated between 10,000 to 16,000 dwellings per month since 1990. Based on th e average number of approvals over the first three months of 2010, the current supply is around 14,500 dwellings per month. The shortfall means we are faced with a crisis in our capacity to plan, design and construct to meet our nations needs unless we act immediately to improve our capacity for a more efficient, effective and innovative supply system. Discussions on land supply, planning and development approval processes have been ongoing discussion in the housing

affordability debate for decades in Australia (Holmes, London and Sheehan, 2008). The land development and housing supply pipeline is an important future challenge for the federal government of Australia and is being spearheaded through the Council's 2010-2011 agenda. It is contended that very little attention has been paid to the housing construction supply chain and that productivity and performance improvement of this sector has a role to play in improvements to the housing supply problem.

The problems of the housing sector have been described as; low profit margins for builders and subcontractors, high risk, fragmented supply, adversarial relationships between firms, wasted resources (time, cost and materials), low innovation, poor communication flows, low productivity and poor project management skills. The industry is highly resistant to change, participants tend to not have a holistic view of the industry and feel powerless to affect change. There are significant large national companies who are the market leaders in the residential sector who have some capacity to affect change, however in reality it is suspected that this group struggles to do so in a whole-scale concerted manner. The underlying structural and behavioural characteristics create an overwhelming inertia that resists change. The next tier of the housing sector, namely the trade subcontractor level is highly competitive and fragmented and typically involves numerous small to medium sized companies who generally operate in an uncoordinated and uncooperative environment. Then the third tier of the chain typically involves the major multinational materials and product suppliers. The industry participants similar to most sectors of the construction industry tend to be focused on short-term survival rather than overall industry improvements for the medium or long term.

The industry structure involves chains of firms that contribute to many different parts of planning, designing and constructing the final housing development. Because the industry is highly fragmented with numerous firms and many steps along the production chain it is assumed that an integration of the supply chains will lead to innovations. It is assumed that whole scale industry improvement requires a concerted effort to undertake a stepwise change towards integrated supply chain solutions to improve coordination and thus reduce cost, time delays and risk. A key to the solution is to investigate successful examples of integrated supply chain case studies which have resulted in productivity and/or innovation performance improvements. This paper seeks to explore performance improvement efficiency through the creation, development and implementation of innovations in the sector by providing a description of the successful implementation of the waffle footing system innovation in Australia by an "innovator group".

The overarching aim of the study is to undertake a case study analysis of successful implementation of delivering an innovation to the housing sector which required an integrated construction supply chain model. The objectives include:

- Identify the barriers and enablers to creation, development, adaptation and implementation of the innovation
- Examine the characteristics of the process of integration of the construction supply chain towards creation, development and implementation of an innovation by an innovator group
- Develop a methodological process pathway for innovation creation and diffusion for an integrated housing construction supply chain

The overall research question which this study seeks to address is, "What is the pathway for identification, creation, development and implementation of innovation within the innovation group?"

THEORETICAL BACKGROUND

There are two underlying premises to this study. First the assumption that an integrated construction supply chain is necessary to achieve significant productivity and innovation performance improvements in the housing sector. Second that there is a structured methodology which can be developed which describes a pathway for supply chain management that will enable diffusion of innovations, either incremental or monumental, product or process that will improve the performance of the industry. The theory that provides the framework for this study is a combination of diffusion theory and construction supply chain theory.

Construction supply chain theory

A central idea of supply chain theory is that holistic supply chain integration relies upon each firm at each tier in the supply chain knowing and aiming for a common objective (London, 2008). The common objective may be an innovation or it simply may be concerned with efficiency and effectiveness across the whole supply chain. One of the most significant problems is that once a supply chain becomes fragmented at each tier in the chain there is an outcome from a firm and that firm passes their product and/or service to the next firm at the next tier in the chain and a silo effect takes place. Each firm has unique objectives and 'pushes' on to the next tier the outcome they assume the next tier can 'bear'. The outcome is generally the most efficient for the firm but may not necessarily completely satisfy the next tier's objectives [i.e. the customer's objectives]. It is almost certain that the firm would not be considering the objective of the whole chain nor any other levels in the chain at all. This is central to the concept of supply chain management where the concept of 'pull' vs. 'push' explores a different way of thinking about holistic supply chain performance outcomes alongside the individual outcomes at each tier. The final 'customer's objectives and desired outcome effectively 'pulls' through the products and/or services provided by each tier in the chain. Although this fundamental principle is a long standing assumption within the supply chain theorists domain it is suspected that it is still one of the most basic problems in relation to developing integrated supply chains and creating holistic performance goals for supply chains.

The case study that is analysed is an example of an innovation or an outcome being established that is outside the normal practice of the supply chain participants and the usual outcome at each tier. This particular case study was a step wise change in the practices related to residential footing system design and construction in the Australian housing sector. There is theory already established in relation to diffusion of innovations and this theory provides a starting point to interpreting and exploring the particular innovation that shall be studied in this project.

Diffusion theory

Rogers' theory of innovation diffusion (1962; 1995; 2003) provides an initial framework through which examination of the diffusion of an innovation through construction supply chains can be examined. Rogers' defines the diffusion of innovations as the process by which knowledge of an innovation is transmitted through communication channels, over time, among the members of a social system. The theory of innovation diffusion has been used in many different sectors including health, information technology and construction. In particular London et al (2007) and Walker et al (2005) explored e-business and information technology adoption in the Australian construction sector using concepts from this theory. The four key elements comprising Rogers' diffusion theory are defined as;

- The innovation: an idea, practice or object that is perceived as new;

- Communication channel: can be mass media and/or interpersonal networks and is the means by which messages about the innovation gets from one individual to another;
- Time: comprising a) the innovation-decision process, b) relative time which an innovation is adopted by an individual or group – an innovation's rate of adoption
- The social system; a set of interrelated units that are engaged in joint problem solving to accomplish a goal.

Rogers (2003) also outlined the innovation process as consisting of a sequence of five stages including:

- Agenda-setting: the initiation stage when a broad organisational problem is identified which generates a need for an innovation. Within this stage there are two key processes; firstly an identification and prioritisation of problems and requirements and secondly a search within the organisation to find innovations to resolve or manage the identified problems. It is in this stage that the initial motivation is created which drives the later stages in the innovation process.
- Matching: the stage where the problem from the organisation's agenda is conceptually matched with the innovation to determine how well they align. The feasibility of the innovation in resolving the organisational problem is also considered at this stage. This stage is critical to determining if a new idea is sustained in an organisation over time as key decisions are made which may lead to the termination of the innovation process even before its implementation. If it is perceived that the organisation's agenda fits with the innovation then the match is planned and designed.
- Redefining/restructuring: the stage when the innovation is adapted based upon the organisation's needs and structure or vice versa. It is anticipated that a degree of change occurs in the innovation and the organisation during this stage. The ease within which organisations experience the innovation process is influenced by the origin of the innovation (ie whether the innovation comes from within or external to the organisation) as well as the degree of change the innovation creates (radical vs incremental).
- Clarifying: the stage where the innovation has been spread more widely in an organisation. A high degree of uncertainty surrounds its members as an innovation is implemented in an organisation. As a result, individuals go about seeking answers to reduce uncertainty at this stage and construct their meaning of the innovation over time. Innovation champions can play a critical role in the innovation process during this clarifying stage.
- Routinizing: the stage when an innovation has become synonymous with the regular activities of an organisation, which completes the innovation process.

The identification of the different stages in the innovation process has been particularly useful for understanding how to effectively introduce new ideas in organisations because through this we are able to gain insights into the main sequence of decisions, activities and events in the innovation process. However, one would anticipate that to develop and diffuse an innovation in a fragmented industry such as the housing sector would require a collaborative effort between firms along supply chains. It would also require a champion or group of champions who have enough resources and 'pull' to enable the development of the innovation. Beyond these propositions we do not know any more detail of the characteristics of the innovation process or methodology which would integrate the supply chain and achieve innovation diffusion.

Within this framework diffusion is largely measured through the degree of adoption within a system. Adopters are categorised by Rogers' as innovators, early adopters, early majority or laggards. London et al (2007) eventually challenged this simplistic binary approach to categorisation. However, according to this categorisation London et al (2007) explored late adopters and laggards of technology to develop an e-business technology adoption profile of the majority of the industry players, whilst Walker et al (2005) explored early adopters of technology. The work by London et al (2007) on e-business innovation diffusion in the construction industry was unique in that this piece of work identified pathways of adoption by the later majority adopters and laggards. That study challenged the basic premise to Rogers' work in that adoption was considered as a binary proposition, ie to adopt or not to adopt. This conceptualisation was tested. There were different rates of adoption and these were related to the way in which the players involved underwent transformations in their perceptions about the particular innovations. These patterns can be seen in three identifiable pathways which were termed: Perceptions Pathway, Compatibility Pathway and Communication Pathway.

The present research is more particularly focussed on the creation phase, ie the innovators and towards the development of a pathways conceptualisation and methodology for the innovator group. Therefore it would be worthwhile to explore the relevance of the five stages of the innovation process for describing and explaining the successful implementation of an innovation in the housing construction innovation in Australia by an "innovator group" and after that preliminary analysis to then further examine any unique characteristics in relation to pathways for innovation creation, development and implementation. The participants in the "innovator group" include those players who were actively engaged with the identification, creation, development and implementation of the waffle footing system innovation process. The innovator group is differentiated from the other adopter groups in that participants are actively engaged in the creation and development of the innovation and they are not simply adopting something which has already been designed, tested, evaluated and implemented. Manley and McFallan (2006; 2008) also conducted research on innovators in the construction industry and their particular contribution was an identification of the business strategies used by innovators for effective implementation. In particular through a survey with over 3000 key Australian construction firms Manley and McFallan (2008) identified the relative importance of five key types of business strategies was examined relating to employees, marketing, technology, knowledge and relationships. The strategies which had the greatest impact included investment in research and development, participating in partnering and alliances on projects, ensuring transferral of project learning into business processes, monitoring of international best practice and recruitment of new graduates. This piece of work however did not explicitly map the process pathway for innovation creation, development and adaptation by an innovator group.

METHODOLOGY

The study involves an in depth analysis of the creation and diffusion of an innovation in the housing construction industry in Australia. The innovation case study is the creation, design, development and implementation of the waffle pod footing system. The empirical study is organized in three phases:

- Phase 1 exploratory description of case study: description of the chronological history of the creation and development of the innovation including key players, events, drivers and decisions. This will also map the development and then the transition into more widespread diffusion.

- Phase 2 critique of process: detailed critique of the process including the factors affecting creation, development and implementation. It will involve the identification of the barriers and enablers for development and implementation of the innovation.
- Phase 3: development of integrated supply chain innovation methodology: description of the actual process and then the critique of barriers and enablers will allow the development of a structured methodology of 'best practice' for innovations requiring an integrated supply chain approach. However it is noted that this is only one exemplary case study and so as an exemplary case study it is significant in its own right but further studies would be required for improved validity and reliability for broader generalisation.

The study focuses on the organizational, communication, economic contextual factors as they relate to the technological innovation rather than the technical factors of the innovation. It is apparent that the technical innovation has been reasonably well documented already. The project is ongoing and we are now midway through Phase 1. This paper reports the preliminary results of Phase 1. The study is limited by the reporting of only one example of an innovation.

Phase 1

The first phase involves the conduct of detailed semi-structured face-to-face interviews with key players of the "innovator group" associated with the waffle footing innovation. This data collection and analysis will be supplemented with a document analysis on the documents that have been published or developed during the time of innovation development and initial diffusion. Six interviews with seven participants from five organisations have been conducted to date. It is anticipated that in total there will be eight interviews with ten participants from seven organisations which will be analysed for this study. Table 1 presents details relating to the interview participants. The duration of the interviews is between 60-120 minutes.

The interview participants were asked questions relating to four key areas:

- their role in their organisation at the time and their specific role in relation to the waffle pod footing innovation
- key events or milestones/critical moments in the innovation process
- barriers and enablers which hindered/drove the innovation
- key players in the innovation process

The narrative inquiry approach is employed to uncover stories which highlight the organisational, communication and economic factors impacting on the creation, development and adaptation of the innovation. The key actions and events which influenced decisions made are systematically studied to connect and see the consequences of those events over time mapped against the creation, development and adaptation of the innovation (Riessman, 1993). The specific technique of story analysis is used for data analysis as it offers a way of connecting different stories to understand the phenomenon and in particular changes that take place over time (Bell, 1993). The unit of analysis is the participant and these are now considered as unique cases. There are two key parts to the analysis which are within-case and cross-case analysis. The interviews are recorded, transcribed and subjected to two stages of analysis.

The first part of analysis involves a within-case analysis of the case studies to identify links between stories particular to each case. Stories are identified and coded into the five stages of the innovation process. The following steps are undertaken in this stage of analysis:

- Entire interviews are transcribed into "rough drafts" to develop narrative segments.
- The narrative segments are interpreted to identify the meaning of each individual story. In each story a particular feature is identified to demonstrate a certain element of a particular stage of the innovation process. Based on the participant's decisions, activities or events described within the stories, each story is then classified into categories according to the primary characteristics of the five stages of the innovation process.
- The next stage involves linking the different stories into chronological order. The stories coded into the five stages of the innovation process are then "pasted together" to form a "metastory" to demonstrate the participant's experiences related to the waffle pod footing innovation.

The second part of analysis involves a comparison across cases to identify common themes and irregularities.

Table 1: Interview participants

Case study	**Organisation type**	**Position in organisation**	**Role in relation to waffle footing innovation**	**Location**
C1	Large housing developer, CO1	State Manager (retired)	Supply of experimental/prototype sites Organisation of supply chain to create and implement system	Australia-wide
C2	Footing contractor, CO2	Managing director	Construction of footing system for experimental/prototype sites	South Australia
C3	Building materials supplier, CO3	Sales representative (retired)	Promotion, distribution and selling of the system nationally	Australia-wide
C4	Plastic spacer manufacturer, CO4	Managing director	Manufacturing of key component of system, ie plastic spacer	South Australia
C5	Engineering consultant firm, CO5	Managing director	Engineering design of the system Monitoring and testing of experimental/prototype sites Obtained approval/ accreditation for system	South Australia, Victoria
C6	Engineering consultant firm, CO5	Managing director (retired)	Engineering design of the system Monitoring and testing of experimental/prototype sites Obtained approval/ accreditation for system	South Australia, Victoria
C7	Polystyrene supplier, CO6	Sales representative	Distribution of the system in Victoria	Victoria
C8	Industry association, CO7	State Manager (retired)	Promotion of the system in Queensland	Queensland

RESULTS

Each participant was analysed as an independent unit and subjected to the two stages of analysis as outlined previously. Barriers and enablers to the creation, development and adaptation of the waffle footing system innovation were identified and a summary of this is provided in Table 3 (refer to appendix). It is not the intention of this paper to discuss this part of the results, however, the table summary serves to indicate the various key themes identified in relation to the barriers and enablers which participants in the innovator group experienced. Many of the barriers and enablers are consistent with those identified in the literature, however, there are a number of these which are particularly unique to the innovator group (bolded text). For example, one of the key issues discussed by the participants involved complications associated with protection and formalisation of intellectual property. This is perhaps something that is unique to the experiences of the innovator group since other adopter groups would not have issues concerning protection of intellectual property.

A number of similarities between the participants experiences related to the creation and development of the waffle footing system innovation were identified and the five stages of the innovation process can be mapped reasonably well as a result of the interview data analysis. The first stage of the analysis involved categorising the participants' stories into the five stages of the innovation process; namely, agenda-setting, matching, redefining, clarifying and routinising. The findings reported in this paper are a result of the second stage of analysis, which involved a comparison across six cases. Analysis of cases C7 and C8 is ongoing. Specifically, the manner in which participants within the innovator group each experienced the five stages of the innovation process will be discussed with key themes identified across the six cases. Table 2 provides a summary of the key themes arising from the cross-coding of the participants' stories into the five stages of the innovation process. A detailed discussion of the key themes identified within each stage is provided in this section. Before this, a brief summary of the waffle pod footing story is described to provide context for the discussion which follows.

Table 2. Cross-case comparison of key themes arising from the participants' stories coded into the five stages of the innovation process

Stages	C1	C2	C3	C4	C5	C6
Agenda setting	Opportunistic surveillance		Opportunistic surveillance		Opportunistic surveillance	
	Performance gap				Performance gap	Performance gap
Matching	Establish fit between problem and innovation	Establish fit between problem and innovation	Establish fit between problem and innovation	Establish fit between problem and innovation		
Redefining/ restructuring	Changes to organisation/ innovation	Changes to organisation/ innovation	Changes to organisation/ innovation	Changes to organisation/ innovation	Changes to organisation/ innovation	Changes to organisation/ innovation
		Collaborative efforts between participants	Collaborative efforts between participants	Collaborative efforts between participants	Collaborative efforts between participants	Collaborative efforts between participants

Clarifying	Role of champions	Role of champions	Role of champions		Role of champions	
	Reducing uncertainty	Reducing uncertainty	Reducing uncertainty		Reducing uncertainty	
Routinizing	Widespread diffusion	Widespread diffusion			Widespread diffusion	Widespread diffusion
		Reinventions	Reinventions	Reinventions	Reinventions	Reinventions

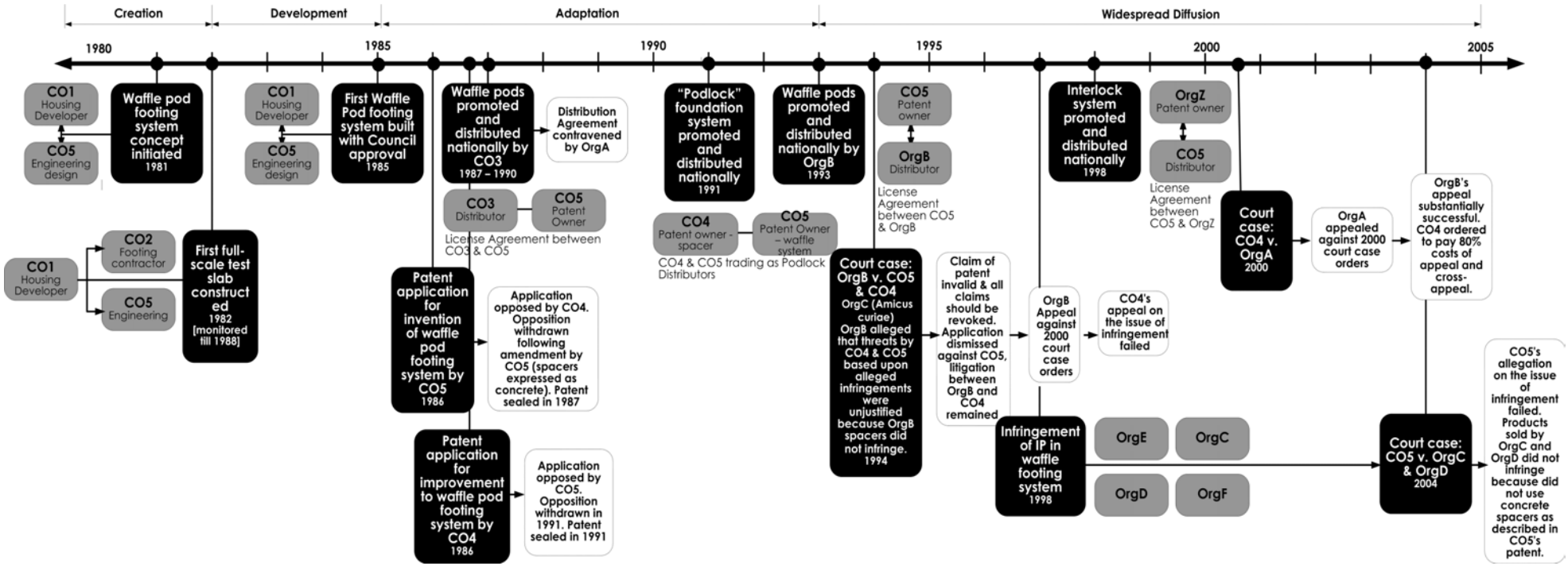


Figure 1. Summary of the chronology of events surrounding the waffle footing system innovation 1980-2005

A summary of the chronology of some of the key events and developments surrounding the waffle footing system is presented in Figure 1. The waffle pod footing system story begins in the early 1980s in Adelaide, South Australia. The state management of a large national housing developer (CO1) was looking for more efficient ways to increase revenues and the waffle footing system was seen as a strategy which offered an opportunity to achieve this. The initiative to create, develop and implement the waffle footing system innovation was championed by C1, who was the state manager of CO1 at the time. During that time, CO1 was trading with an engineering consulting firm, CO5, which had just embarked on a program of research and development in the footings area. The late 1970s and early 1980s saw major developments in Australian building codes in terms of how footings were specified and the waffle footing system was a part of the different streams of research CO5 were engaged with during that time, which was championed by C5. A number of other key players contributed to the creation, development and implementation of the waffle footing system (refer to Table 1).

The footing system although originated in South Australia some 18 months after the first installation had spread to the other states of Queensland, New South Wales and Victoria. There were interesting developments from 1986 onwards when CO5 sought protection to own the exclusive right to commercially exploit the waffle footing system by applying for a patent in 1986. The patent was entitled "Building Foundation Form Work Arrangement" which involved "levelling the ground on which the foundation is to be located, positioning a plurality of box-like hollow members in rows on the levelled ground, separating the hollow members by spacers, positioning lower reinforcing rods on the spacers and between the hollow members, positioning a reinforcing mesh over the hollow members and pouring concrete into channels between the hollow members and over the hollow members so as to envelope said reinforcing rods, mesh and hollow members and thereby form the foundation with a plurality of intersecting reinforced beams and an overlaying reinforced floor slab" (APO Patent Application 198667009, 2011). Not long after in 1987, CO4, sought to apply for a patent entitled "Improvements relating to building foundation form work". The invention CO4 was seeking to protect involved an improvement on the use of concrete blocks, which was proposed by CO5 as spacers. CO4's spacer is "in essence, a framework which holds in place pairs of vertical plates set at right angles to each other." (FCA-FCD, 2011). The plate fits over the corners of the hollow boxes and holds them in place relative to each other.

Both CO4 and CO5 opposed each other's patent applications. CO4's opposition to CO5's application was withdrawn following an application for amendment was made by CO5. The amendment involved specifying the specific use of spacers made out of concrete, which was different from CO4's plastic spacers. CO5's opposition to CO4's patent application was then withdrawn and both patents proceeded to sealing. Over the following years, the waffle footing system gained increasing popularity and there were various business ventures with alliances developed as 'spin offs' from the business in Adelaide. From the mid-1990s onwards CO4 and CO5 experienced a number of infringements on their patents which eventuated in a series of litigations and court cases (refer to Figure 1).

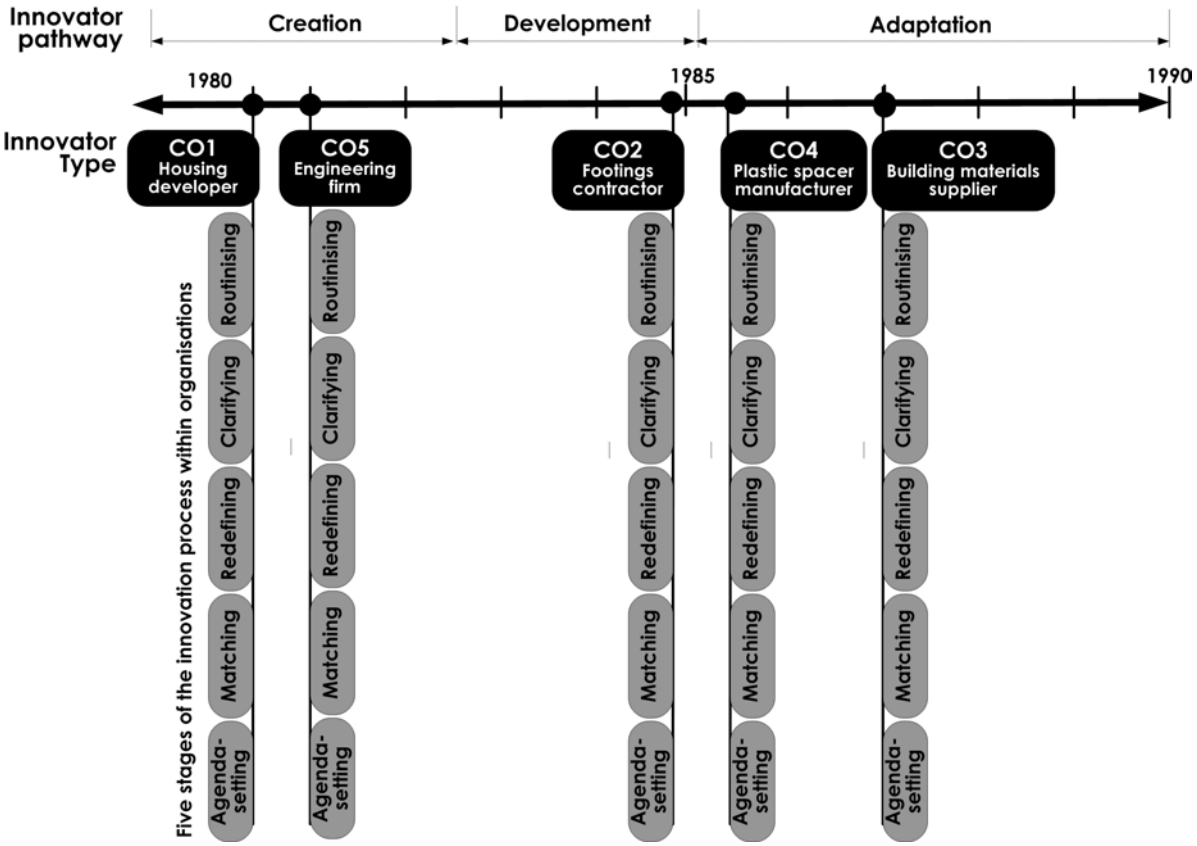


Figure 2. Innovator types and Pathway towards creation, development, adaptation and implementation of innovation

One of the key findings of this research to date is a more complex categorisation of participants within the innovator group. Whilst past research examined the innovation process within organisations (Rogers, 2003), this research explores the innovation process across organisations, ie, within an "innovator group" comprising a number of organisations located at different tiers of the supply chain. Given that the innovator group is made up of various organisations there was more than one clear "cycle" of the innovation process occurring whereby there were individual cycles within each organisation taking place concurrently alongside the overall innovator group pathway. The previously accepted broad classification of "innovators" does not capture the specific characteristics of those case study organisations observed in this research. The preliminary findings demonstrate that participants within the innovator had various roles to play at different stages of the innovation process in the successful implementation of the waffle footing system. Furthermore the analysis highlighted that there are different types of innovators which are:

- Innovator-creator: those who are responsible for initiating and creating the innovation
- Innovator-developer: those who contribute towards the design, planning and development of the innovation
- Innovator-adapter: those who enter at latter phases and contribute to the innovation by modifying/adapting the innovation

Agenda-setting

In diffusion theory (Rogers, 2003) the agenda-setting stage initiates the innovation process and is where an organisational problem is identified thus generating the need for an innovation. Analysis of the interviews with key players (C1, C5, C6) involved with the waffle

footing system innovation revealed that the agenda-setting stage was significant in that for many of the organisations it was during this stage that the initial motivation to resolve an identified problem was created which helped to drive the later stages of innovation. A total of eleven stories identified from the interviews were coded into the agenda-setting stage. Two main themes were identified as part of this stage including; performance gap and opportunistic surveillance.

The first theme of performance gap is about inconsistencies between how individuals within an organisation perceived its performance and how they expected to perform. C1, C5 and C6 indicated that a perceived performance gap was a trigger to search for an innovation.

> *"the traditional was a brick build-up…and what that meant was you had unknown rock excavation on the strip footings…when you hit rock, you called the customers up and said you're going to have to pay us some more money so straight away you're off-side… So my drivers were…so that we could actually fix the customer's price and charge no extras for them… I wanted to be able to control the actual costs… the other thing that hit me was in multi-storey car parks I'd seen where these waffle pods had been used…I just said, cant we do that same stuff here?" (C1)*

> *"the idea was to get a footing system that was as near as possible to a factory-produced…and above-ground…cause once you start digging you lose control of what you're building, you get over runs, your trenches collapse" (C5)*

> *"because we were involved with footing designs and having problems with movement. As a structural engineer I had designed waffle slabs for first floors…So I figured we got nowhere for support in soils or footings in soil and maybe a waffle will be a good concept"(C6)*

For these participants the need for an innovation was borne out of the inefficient manner in which traditional in-ground strip footing systems performed which involved excavated trenches with foundation walls built up to the required floor level from the footing. This method was considered labour intensive and not particularly cost-efficient. The problem also with the traditional footing system was unknown required footing depths due to differentials and variability in in-ground movement and consequently the difficulty of trying to accurately control the amount of concrete used. Both C1 and C5 highlighted the key disadvantage of the traditional system as its inability to control quantities and costs. The desire to develop an above the ground footing system which was *"as near as possible to a factory-produced product"* was thus seen as a way to achieve fixed or accurate cost predictions. The experiential problem solving method was employed in the creation of the innovation whereby the innovator-creators drew upon prior experiences in the attempt to create a more efficient product. For C6, the idea of the waffle footing innovation came from his earlier experiences of having designed waffle slabs for first floors as an engineer whereas C1 relied upon broader experiences gained from working overseas:

> *"…the margins in housing are quite low, they're terrible because of the inefficient way we did things but it reminded me of the landscapes around Durban where I'd been working over there. So in one of my thinking modes … I thought why cant we cut and fill and slab as we did over there. So I started exploring that"*

The second theme revolved around the participants being engaged in opportunistic surveillance (Rogers, 2003) by continuously being on the look out for new ideas which might be beneficial to the organisation. Past work into the innovation process has highlighted that organisations are often driven more by solutions as compared to problems (March, 1981). Given the high number of problems typically faced by organisations, the chances of identifying an appropriate innovation to deal with a specific problem is relatively low. The

possibility of matching an innovation to a problem faced by an organisation can, however, be higher if organisations begin with a wanted solution or innovation. As a result a large number of organisations tend to be involved in opportunistic surveillance to identify promising innovations which may be relevant for dealing with existing problems in the organisation. Indeed this was the case for three of the participants interviewed who each indicated that they were actively scanning the environment for new ideas and "thinking about things":

> *"So what we did was set up some internal R&D projects…so we had different streams to what we were doing" (C5)*

> *"had a break when I realised one day sitting in the office…I'm paid to think about things" (C1)*

> *"James Hardie is basically a building materials supplier…they were actually looking to diversify and try something else and have another product that they could promote Australia-wide" (C3)*

In the case of C4 in particular, knowledge of an innovation launched the innovation process in the organisation. The organisation took on an opportunistic approach whereby knowledge of the waffle footing system created a need for the innovation process. Prior to the organisation discovering the product there was no specific plans for its use except that the organisation was looking to diversify its product-line. Therefore even though the innovation process is often initiated by a perceived need to address a particular problem it can also be triggered by knowledge of an innovation, as in the case of this innovator-adapter (C03).

Matching

A total of thirteen stories were coded into the matching stage. A common theme that the participants experienced during the matching stage related to establishing the fit between problem and innovation. At this stage, participants determined how well the innovation aligned with the identified organisational problem:

> *"so in discussion with my marketing people that time, I said, "What do you really want, like if you could really put the price on the market fixed, no extras would that be a value proposition?" They went "oh boy, would that be!" They said, "go for it!"" (C1)*

> *"the first one I actually witnessed…it was an eye opener for me... Straight away I went into gear and said right, this is the easiest way to do it…if you dig a foundation right in the ground you really cant form it up…that'll cost money and time whereas just the simple process, form up the perimeter of your house foundation…lay some pods in there" (C2)*

> *"So we used to supply and fix. So he started the ball rolling on that and I would never have worked any other way because that's the way I liked to work so I was a good candidate" (C2)*

> *"cos basically everybody no matter what industry you're in especially in the building industry you're forever looking to save costs wherever you can. And this was a cost saving exercise" (C3)*

> *"I was a foundation contractor and when I heard about it I didn't like the way it was put together … and because I knew about patents … So I just wanted to improve it by making a better spacer to hold it together. So I came out with this" (C4)*

As highlighted by these quotes the matching stage was a particularly critical stage in the innovation process for these participants as it marked the decision to proceed with the design, development or implementation of the waffle footing system innovation within their

organisations. The specific benefits of the waffle footing system were anticipated in the form of fixed pricing (C1), ease of construction (C2), appropriate work method of supply-and-fix (C2) and cost savings (C3) and matched against organisational needs. The waffle footing innovation "found a home" in the respective organisations due to the high degree of fit between the innovation and organisational needs or problems. The matching stage can also be influenced by organisational capacity or specific expertise/experiences related to the innovation process as demonstrated by C4. For C4 the decision to adapt the waffle footing system innovation was largely a result of having prior understanding of dealing with an innovation in a different industry and in particular with patents. The waffle footing system innovation was established as one which fit with the organisation's specific expertise and capacity and thus a decision was made to be involved with the adaptation of the innovation.

Redefining/restructuring

Nine stories were coded into the stage of redefining/restructuring. The first theme of the redefining stage involves changes which occurred to the organisations or innovation during the redefining stage.

> *"We invested in a couple of staple guns and stapled them together. So it was so simple…and I self taught myself" (C2)*

> *"The only thing that I did was waffle pods…I was employed to drive that…They had people that were already promoting CO3 products and this was an add on for them to promote…And that's the other thing its changing the whole spectrum …they could then turn around and use it as an advertising thing and say CO3 can build a house for you" (C3)*

As highlighted above, the innovation process resulted in a degree of change for the participants in terms of work practices and organisational structure. For C2, the waffle footing system can be classified as an incremental innovation as it did not require a high degree of technical expertise to implement and therefore was implemented relatively easily as C2 indicated, "it was so simple…I self taught myself". For CO3 however, the innovation was a little more radical. Not only did the innovation lead to the creation of C3's role, which was specifically to promote the waffle footing system, it also affected the "whole spectrum" of the organisation's marketable products in that the organisation was then able to expand its market share by the ability to supply products for the construction of an entire house. According to Rogers (2003) the redefining/restructuring stage is when the innovation imported from outside an organisation loses its foreign character, that is, the innovation is adapted to suit the organisation's needs or structure and vice versa. Even though the innovation process did result in changes, there was a slight difference in the way the redefining stage was experienced by the innovator group analysed on this project in that given they were largely the ones creating and developing the innovation, they were provided the opportunity to shape the innovation to suit their organisational needs, rather than change the innovation to suit the organisation at a later stage, as highlighted by C1:

> *"I can remember…trying to find plastic tubs or bails or hay or something – but it didn't matter what we stuck in there and I was cost controlling" (C1)*

For C1, a primary objective of their organisation centred on an ability to control costs and therefore during this stage was found to be developing the waffle footing system to achieve that. Being involved at the start of the innovation process as an innovator-creator, the organisation was able to create the an innovation which was particularly aligned to the objectives of the organisation.

The second theme was the collaborative efforts between participants in the innovator group in the implementation of the waffle footing system innovation whereby various forms of agreements or arrangements were developed in order to successfully achieve diffusion of the innovation.

> *"I remember when we did the test slabs…I got all the materials and things from suppliers…I was communicating with our direct suppliers and I said you're going to be a part of this" (C1)*

> *""it was all up and down and I wasn't really enthused by them…So I suggested that we form it up with higher formwork. So out came my formwork cos I was a concretor over in Lincoln and I also had a concrete pump so I suggested we pump it in…to work in with the waffle system I think CO5 thought of it, CO1 took it, I produced it and it was just a happy meeting and we were all happy to work with each other. And CO1 always paid me on time so no major dramas" (C2)*

> *"CO1 gave us this block of land and that footings was built for free. All the suppliers and contractors contributed to it so people were happy to put in as an industry but to give us access to that block of land for that period of time was just something that they did. So there was quite a bit of visionary in doing that. A long commitment type of thing…we did that work very thoroughly very diligently and that provided base information that I think nobody had ever had to give credibility to the design methods we were using" (C5)*

> *"We did spend quite a bit of time so we did some researching…So once we got all that testing stuff we were doing engineering stuff for CO1 and they were quite keen to see the outcome of this because they could save money…. So they supported…they gave us a piece of land" (C6)*

> *"So CO3 were keen to be behind us and have the rights and we had some sort of a contract with them" (C6)*

Even after the decision was made to create the innovation, a considerable amount of time was spent in the design and development of the waffle footing system. This was particularly important because not only were the participants simply importing an innovation to be implemented within their organisations, they were also implementing an innovation in which required designing and planning. This is an added layer of complexity which the innovator group has to undergo, which many organisations adopting prior developed innovations do not have to encounter. Therefore the participants were committing themselves to a high degree of uncertainty in the decision to create, develop and/or adapt the innovation and as raised by C3, perhaps a "highly revolutionary" move. The quotes above clearly demonstrate the different roles each participant within the innovator group played in the successful implementation of the waffle footing system.

Clarifying

The clarifying stage occurs when an innovation has been implemented in a more widespread manner in an organisation (Rogers, 2003). Within the context of the waffle footing system innovation the clarifying stage involved the innovator group spreading and promoting the innovation to different tiers of players in the construction supply chain. Twenty-four stories were coded into the clarifying stage. Two key themes were identified in this clarifying stage of the innovation process including reducing uncertainty and the role of champions.

Given the newness of the waffle footing system, its implementation was surrounded by a high degree of uncertainty. The first theme revolved around the participants undertaking various activities and strategies aimed at reducing uncertainty of different players in the supply chain.

C5 highlighted a number of strategies which were used to diffuse the waffle footing system and reduce uncertainty amongst potential adopters including publishing and presenting at conferences to develop credibility and provide confidence to those who are considering adopting the innovation.

> *"I presented at a 1987 MBA conference in Queensland and out of that came a whole string of contacts. Then I presented…at a local government conference in Perth and out of that building surveyors who check and approve building applications all came to learn about it… The key thing was doing it at different levels" (C5)*

Despite this, the analysis is consistent with past work into the innovation process which has highlighted that the management of the clarifying stage is often challenging and complex because misunderstandings and side-effects may occur. Within the context of the waffle footing system innovation, professional jealousy and overcoming mindsets and perceptions were highlighted by participants as key problems in the promotion of the innovation.

> *"so the civil engineer wanted a raft footing system. So I said that's ridiculous why not we turn around and use a waffle pod system? The engineer wouldn't have it" (C2)*

> *"So it was professional jealousy … they [engineers] wouldn't use it for a long time" (C3)*

> *"The product might be terrific but sometimes it's very, very hard to change mindsets no matter what industry, no matter what you're doing. Because people are so used to their own practices, systems and whatever and it works" (C3)*

C3 in particular explained that he experienced a high degree of resistance and "head banging" in his efforts to promote the waffle footing system to engineers and footings/foundation contractors. According to him the resistance to adopt the waffle footing system was not related to technical issues but rather to do with "human nature". For the engineers, adopting the waffle footing system was seen to be something that would benefit another engineering company whom they were in competition with and therefore these engineers saw nothing to be gained out of being in favour of the innovation. On the other hand, the foundation contractors perceived that the newness of the waffle footing innovation would equate to a degree of difficulty in having to change their existing practices and systems. For these contractors, the waffle footing system was out of their comfort zone and seen as simply "too hard" adopt.

The second theme is about the role of champions in the innovation process during the clarifying stage. An innovation champion may be viewed as "a charismatic individual who throws his or her weight behind an innovation, thus overcoming indifference or resistance that the new idea may provoke an organisation" (Rogers, 2003, p. 414). The management of the clarifying stage during the innovation stage was characterised by a high level of uncertainty. C1 took on a central role in explaining to those players meant to construct the waffle footing system to reduce uncertainty by running seminars and providing demonstrations:

> *"I took the concrete gangs to CO5's offices … and ran seminars on how to put a box together…cos I was determined and you have to champion that so you've got to just push that through like most things in innovation" (C1)*

In the case of the waffle footing system innovation, uncertainty existed not only in the minds of those outside the innovator group but also within the innovator group. As highlighted previously, the collaborative efforts between participants in the innovator group was key to the successful implementation of the waffle footing innovation. This collaboration, however,

was enabled through the efforts of C1, who played a central role in "negotiating my [his] supply chain":

> *"Well I was negotiating my supply chain to move from timber decks on bearers to concrete which means that they were getting 13 metres of concrete of job ….So wouldn't you make sure that you looked after us... And they did believe in this as well…because I think we had a good… ethical trading. We always try to fulfil our part to pay you on time... I mean you've got to look after these people" (C1)*

As indicated, there seemed to be mutual understanding and respect between players in the innovator group in the effort to implement the waffle footing system. The champion in this case, C1, ensured that the anticipated benefits for the group were clearly spelt out so that they would be more willing and committed to participate and contribute to the creation and implementation of the innovation. The credibility and "ethical trading" practice of the organisation was also seen to help in creating a degree of assurance in the group within an uncertain environment. Furthermore, C1 took great care in "looking after" the players in the group by paying appropriately, which C2 indicated was seen as particularly important for his organisation.

Routinising

Twenty-six stories were identified from the interviews which were coded into the routinising stage. Two key themes were identified in this stage including drivers to widespread diffusion and re-inventions.

A number of key drivers led to the widespread adoption of the waffle footing system innovation. One of the primary drivers which C1 described as a "breakthrough" was approval gained from the relevant authority which deemed the waffle footing system as one which complied with the required codes and guidelines related to footing systems in Australia.

> *"So that was the actual first system built… so the significance of it was that it was approved by the authority that had to approve footing systems and it was a breakthrough…So from that point it became accepted and we were pricing our land and house packages with it or when people came to us we could definitely give a fixed price… and then it started to be picked up by other builders" (C1)*

Obtaining approval was significant in that it demonstrated to the industry and more importantly it provided the assurance for others to be confident in their use of the waffle footing system. Following this, it was the adoption by a group of early adopters consisting large builders which drove the innovation and "went like wild fire".

> *"…all the competitors were using it. They saw CO1 were doing it, got the ball rolling and they thought why not. I think it took a few years [for that wave to happen] before they were gutsy enough to come into it" (C2)*

> *"a couple of major builders thought it was a good idea and once they got on board it just went like wild fire" (C5)*

Sustainability is another concept closely related to routinising which has received considerable attention in recent years. It is defined as the degree to which the innovation continues to be used after initial adoption has occurred (Rogers, 2003). A number of factors have led to the sustainability of the waffle footing system innovation. C5 explained that specific events or characteristics of the industry at different times have helped to ensure the sustainability of the innovation. One example he provided is the ability of the polystyrene

component of the waffle footing system contribute towards achieving the current requirements for house energy ratings by the Building Code of Australia whereby:

> *"waffle pod footing system, because of polystyrene in it, it's worth 1-star out of six extra…So that at the moment is another thing that's pushing the system" (C5)*

The second theme is concerned with re-inventions which were done on the waffle footing system. Consistent with the literature related to the innovation process which indicates that innovations tend to undergo adaptations and are continuously re-invented to suit changing organisational and environmental needs, the waffle footing system experienced a number of iterations. Of significance was the introduction of polystyrene boxes for a component of the waffle footing system to replace an earlier cardboard box. As with many developments, the use of polystyrene was seen as beneficial in a number of instances when compared to the cardboard boxes however was also disadvantaged due to its bulky nature and the difficulties associated with transporting the product.

A key issue which was raised by all participants in relation to re-inventions concerned the protection of intellectual property. As the system begin to gain acceptance, the engineering firm, CO5, which developed the idea of the waffle footing system sought to protect their intellectual property by developing a patent on the system. The process which they eventually experienced was one fraught with difficulty and "a major stuff up" which was characterised by litigations and court cases. As C3 explained, a key player within the innovator group, CO4, which initially patented a plastic spacer which was a central component of the waffle footing system later attempted to patent the "improved waffle footing system" and claimed it as his own.

> *"And once the system started to move then all this other junk started to develop…the people that had the spacers were saying that the royalties should come to them from the waffle pods. And the people who had to waffle pods were saying that the royalties should come to them…it was a major stuff up" (C3)*

At the same time, as the waffle footing system was gaining increased widespread uptake in the industry, more and more companies started to re-invent the innovation to market as their own product. C4 and C5 explained how these companies were infringing on their patents which led to a series of litigations and court cases between various parties:

> *"well in Australia you can't defend a patent…without being very rich because you've got to be able to go through with the legal stuff to defend it against the people who're breaching it in small ways or even large ways" (C5)*

> *"we were having court cases and this is people infringing on our patent…everybody tried to get around our spacer" (C4)*

While the court cases and litigations did not hinder the successful implementation of the waffle footing system innovation it does raise another important issue in relation to the protection of intellectual property for those who were central to its creation as highlighted by C6:

> *"If anything Australia needs to do is change the system of patents because its not fair to someone like me who's started off something that's so popular that gets nothing out of it because of some crook" (C6)*

The lack of protection of intellectual property offered by the existing system of patents in Australia does not appear to be a conducive environment for innovative behaviour. There does not seem to be any incentive which rewards innovative behaviour. This is perhaps quite

a significant issue which needs to be considered particularly in an industry where the pace of innovation is low.

CONCLUDING REMARKS AND FURTHER RESEARCH

This paper presented the preliminary findings of a case study of successful implementation of delivering an innovation to the Australian housing construction industry. It specifically explored the relevance of Rogers' five stages of the innovation process for describing and explaining the successful implementation of an innovation in the housing construction innovation in Australia by an "innovator group". Analysis revealed that the experiences of each participant within the innovator group resembled the conditions of the five stages of the innovation process, namely; agenda-setting, matching, redefining, clarifying and routinising. However the findings also demonstrated that the previously accepted broad classification of "innovators" does not capture the specific characteristics of those case study participants in the innovator group observed in this research. Furthermore not only was the success of the implementation of the waffle footing system reliant upon one champion from one organisation, it was also driven by the collaborative efforts of various participants or champions from a number of organisations within the innovator group, each contributing at different stages of the creation, development and adaptation of the innovation. One of the most significant findings of this research has been an identification of different types of innovators which include; innovator-creator, innovator-developer and innovator-adapter. The next stage of the analysis will involve a detailed identification of the unique characteristics of the pathways for the innovator group for innovation creation, development and implementation.

APPENDIX

Table 3: Barriers and enablers to creation, development and adaptation of the waffle footing system innovation

	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Barriers	Lack of organisation support					
		Professional jealousy	**Professional jealousy**			
		Mindsets/ perceptions	Mindsets/ perceptions			
			Litigations	**Infringements & difficulties in protection of intellectual property**	**Infringements & difficulties in protection of intellectual property**	**Infringements & difficulties in protection of intellectual property**
		Misuse of system doesn't result in benefits	Misuse of system doesn't result in benefits			
					Absence of specific supply chain player: manufacturer	

Enablers	Role of champions	Role of champions			Role of champions	Role of champions
	Firm organisational culture & support for innovation				Firm organisational culture & support for innovation	Firm organisational culture & support for innovation
	Supply chain integration	**Supply chain integration**	**Supply chain integration**		**Supply chain integration**	**Supply chain integration**
		Clear demonstration of benefits associated with system			Clear demonstration of benefits associated with system	
					Suitability of innovation to specific conditions of the industry	

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INCLUSIVE BUILT FACILITIES: A CASE STUDY OF A HIGHER EDUCATION INSTITUTION

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Abstract
Building an inclusive society has been a goal with universal appeal. In respect of sustainable design and construction, due consideration in disability inclusion is necessary for it has social, economic, legal and environmental implications. It is not a new subject; however, there is still a long way for our built environment to be inclusive. In this paper, a practicable means to appraise the inclusiveness of built facilities quantitatively, the Building Inclusiveness Assessment Score (BIAS), is proposed. Literature, guides and standards of barrier-free access and universal design are reviewed so as to construct a hierarchy of relevant inclusion attributes. A multiple-criteria analysis technique, the Non-structural Fuzzy Decision Support System (NSFDSS), is then applied to analyse the weightings of attributes. On-site assessments are undertaken to collect data for grading individual inclusion attributes. The inclusiveness of built facilities in the University of Hong Kong is studied.

In BIAS, a hierarchy of inclusion attributes is appraised. The outcomes are integrated in form of a score. Notwithstanding the research project is still ongoing, preliminary findings from on-site assessments are presented. A novel insight is provided to sustainable design and construction which should not only regard environmental and economic sustainability but also social sustainability. Compare with earlier attempts to quantify the accessibility of buildings, BIAS further reduced the subjective elements. The framework of BIAS can also be modified to assess built facilities of other uses.

Keywords: Barrier-Free Access, Disability Inclusion, Non-structural Fuzzy Decision Support System, Performance Measurement, Universal Design

INTRODUCTION

Building a society for all has been a goal with universal appeal. A society as such is known as an inclusive society that rises above differences of race, gender, class, generation and geography to ensure equality of opportunity regardless of origin, and one that subordinates military and economic power to civil authority (Atkinson, 2010). In architecture, the persuasion of Richard Rogers, the architect of the world renowned Centre Pompidou in Paris, France, probably depicted the ideal of inclusion in broad sense (Cole and Rogers, 1985; pp11):

"It is my belief that exciting things happen when a variety of overlapping activities designed for all people – the old and the young, the blue and white collar, the local inhabitant and the visitor, different activities for different occasions – meet in a flexible environment, opening up the possibility of interaction outside the confines of institutional limits. When this takes place, deprived areas welcome dynamic places for those who live, work and visit; places where all can participate, rather than less or more beautiful ghettos."

Inclusion in architecture is, however, often synonymous to disability inclusion. Disability nowadays is considered as a social rather than a medical issue (Goldsmith, 1997; Holmes-Siedle, 1996), for it is seen as the outcome of interaction between persons with impairments and a non-inclusive society (United Nations, 2006). Under the United Nations Convention on the Rights of Persons with Disability, obstacles and barriers to accessibility in buildings and other physical environment shall be identified and eliminated. 147 countries and regions have already signed this convention since 2007. In the meantime, access for persons with disability to buildings has increasingly become a right under laws (e.g. the Americans with Disabilities Act in the US and the Disability Discrimination Act in the UK). Failure to observe these laws may result in legal proceedings. Universal design is a means to make inclusion in built facilities possible. It is the design of products, environments, programmes and services to be usable by all people to the greatest extent possible, without the need for adaption or specialised design, and it shall not exclude assistive devices for particular groups of persons with disabilities where this is need (Mace, Hardie and Plaice, 1991; United Nations, 2006). This idea is more specifically exemplified by 7 underlying principles (Table 1).

Though there has been gradual progress to promote disability inclusion in buildings, the subject is not free from challenges. A particular challenge is the assessment of accessibility for built facilities. This is done through access audit which is user oriented and access appraisal which is desktop survey dominated (Sawyer and Bright, 2004). The shortcomings of access audit and access appraisal are later highlighted in Wu, Lee, Tah and Aouad (2007). It is thought that the assessment processes are quire complex that involve a lengthy checklist. Meanwhile, they heavily depend on the experience of the assessor for a large number of subjective judgements are included.

The main purpose of this research is to review design guidelines and manuals for disability inclusion in built facilities, to develop a quantitative assessment scheme to appraise the inclusiveness of built facilities and to investigate the inclusiveness of built facilities of a higher education institution, the Hong Kong University. By conducting on-site assessments, both inclusive features and problems leading to exclusion are identified. The sample consists

of 28 buildings which are built between the 1910s and the 2000s. Since this research is still ongoing, only preliminary findings are reported at this stage.

The 7 Principles of Universal Design
Principle 1 Equitable Design The design is useful and marketable to people with diverse abilities
Principle 2 Flexibility in Use The design accommodates a wide range of individual preferences and abilities
Principle 3 Simple and Intuitive Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level
Principle 4 Perceptible Information The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
Principle 5 Tolerance for Error The design minimises hazards and the adverse consequences of accidental or unintended actions
Principle 6 Low Physical Effort The design can be used efficiently and comfortably and with a minimum of fatigue
Principle 7 Size and Space for Approach and Use Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility

Table 1: *The 7 principles of universal design (source: The Center for Universal Design, 2006)*

INCLUSION AND SUSTAINABLE DESIGN AND CONSTRUCTION

Very often sustainable design and construction is solely regarded as design and construction that is eco-friendly. Sustainability is, however, much more than merely environmental protection. It includes not only environmental sustainability but also social and economic sustainability. Social sustainability is seen as "the ability to maintain desired social values, traditions, institutions, cultures or other social characteristics" (Barbier, 1987), whilst the central idea of economic sustainability is "maintenance of capital or keeping capital intact" that follows Hick's well-known definition of income – "the amount one can consume during a period and still be as well off the end of the period" (Goodland, 2002). Sustainability in short centres on the maintenance of capital in environmental, social and economic aspects, and of course, the environmental facet is of particular concern. Further to the three aspects of sustainability, two paradigms of sustainability are developed. While capitals are assumed to be substitutable in weak sustainability, natural capitals are assumed to be non-substitutable to

other forms of capital in strong sustainability (Neumayer, 2010). To qualify as sustainable design and construction, social sustainability which is manifested in equity and accessibility should be represented, for everyone should have equal rights and freedoms. Whereas for economic sustainability, non-inclusion ends in loss of an enormous opportunity given the estimated rate of disability is 10-12% worldwide (The World Bank, 2009).

THE CASE OF THE HONG KONG UNIVERSITY

As the oldest tertiary institution in Hong Kong, the coming year marks the centenary of the University of Hong Kong (HKU) which was established in 1912. With 22,139 students and 6,010 academic staffs in 2009/2010, HKU comprises ten faculties which are mainly located in the Main Campus. The exceptionally hilly terrain of the Main Campus has been a great challenge to fostering disability inclusion despite the Universities' initiative to promote equal opportunities. The Universities' Equal Opportunity Committee (EOC) and then the Disability Action Sub-committee were set up to oversee and expedite disability inclusion affairs. The units are very dedicated in promoting equal opportunities for all and to make HKU a truly accessible campus is on the agenda (The University of Hong Kong, 2011; pp10). Upgrading of buildings to introduce more lifts and wheelchair ramps to ensure wheelchair access has been undergoing bit by bit and tactile guide paths are provided. Other than the endeavours to ameliorate the inclusiveness of built facilities, the Centre of Development and Resources for Students (CEDARS) offers supportive services to students with disability. They include assistance related to basic necessities, commuting and study, and coordination of buddies and volunteers to help the students (ibid; pp11). All in all, inclusion is seen as important cornerstone of a good employer and a good university in HKU: "…the socially inclusive environment, and the respect for individuals that we are promoting, are values that are of utmost importance in the holistic education of the University." (ibid; pp10)

RESEARCH METHODOLOGY

As the main purpose of this research is to develop a quantitative assessment scheme to appraise the inclusiveness of built facilities in higher education institutions, literature, guides and standards in connection with disability inclusion in built facilities are reviewed in the first instance. It plays a crucial role in the subsequent development of the assessment framework which is one of the cruxes in this research. Another crux is to determine the weighting of attributes towards disability inclusion in built facilities. In the following, the assessment framework, the weighting methods and data collection will be discussed separately.

THE ASSESSMENT FRAMEWORK

Designing for persons with disabilities is a movement emerged after the World War II, with the issue of American Standard A117.1 American Standard Specifications for Making Buildings and Facilities Accessible to, and Usable by, the Handicapped by Tim Nugent that earmarks such a move. This standard was later set as the model for corresponding code of practice in the British Standard issued in 1967 and subsequent legislations against exclusion of persons with disabilities in buildings (Goldsmith, 1997). Apart from guides and standards, there have been interests to evaluate whether a built facility is inclusive or not. It can be done qualitatively by access audit or access appraisal. Access audit was used to study the access provisions in public housing estates in Hong Kong in Chan, Lee and Chan (2009), however, it

involves a great deal of subjective judgments and the overall level of inclusiveness cannot be determined. On the contrary, rating scales for individual accessibility criteria are not explained in Wu et al. (2007) who seek to develop a quantitative building accessibility model using the Analytical Hierarchy Process (AHP) to prioritise the underlying accessibility criteria.

For the purpose of filling the research gap, a quantitative assessment scheme which is workable and practical is needed. In the course of developing the assessment framework, reference has been made to Design Manual: Barrier Free Access 2008 in Hong Kong and BS8300: Design of Buildings and Their Approaches to Meet the Needs of Disabled People to determine attributes or factors that contribute to the inclusiveness of built facilities (Buildings Department, 2008; British Standard Institute, 2009). Other guides and standards in Canada, Singapore, the US and the UK are also considered (BCA, 2007a; 2007b; International Code Council, 2009; NRC-IRC, 2010; Peloquin, 1994; Sawyer and Bright, 2007). As the problem is disability inclusion in built facilities in higher education institutions, it is decomposed into elements of different levels from the general to the more specific at the lower levels (Tam, Tong, Chiu and Fung, 2002). The decision hierarchy is then formed when the attributes have been grouped under corresponding criteria. The hierarchy developed for the time being is shown in Figure 1. During the making of this hierarchy a dilemma is posed. On the one hand, it has been underlined in literature that many criteria at multiple levels will make subsequent pair-wise comparison difficult (Tam and Tummala, 2001). On the other hand, items on the checklist should be assorted and incorporated into the hierarchy for pair-wise comparison accordingly. In such a case, the assessment scheme developed will be more objective and it fills the research gap in Wu et al. (2007). On account of disability inclusion which is concerned with physical, visual and speech disabilities, and hearing impairments, the current hierarchy may be amended by further decomposing into separate hierarchies. Example of an improved hierarchy is shown in Figure 2.

There are four levels in the decision hierarchy developed for the time being. Similar to Wu et al. (2007), the top level is the objective which is to provide an index of inclusiveness of built facilities in higher education institutions. The succeeding level is divided into design and management that represent the hardware and the software in disability inclusion respectively. The idea of design here is actually similar to the physical features demarcated in Sawyer and Bright (2007; pp68), while management refers to the acts taken to build and maintain an inclusive environment. Under design attributes are structured under individual areas and facilities. The items in level II to level IV under design are tabulated in Table 2.

Next is the computation of rating for quantitative attributes in the assessment scheme. Individual attributes are rated using a continuous scale from 0 (for exclusive practice, i.e. the worst practice in disability inclusion to 2 (for the best practice in disability inclusion). Contrary to earlier studies which set the starting point for benchmarking the worst practice to the standards prescribed by laws or codes (Ho et al., 2004; Then, 1996), the rating for meeting legal minimum requirements here is 1. Whether an attribute is qualified as the best practice or not is referred to relevant guides and standards. As the actual condition often lies between complete exclusion and the best practice, linear interpolation is used to calculate the rating. If attributes are qualitative in nature, either dichotomous or multinomial classification is adopted to assign a rating (Ho, 2000).

THE BUILDING INCLUSIVENESS ASSESSMENT SCORE (BIAS)

For simplicity's sake, it would be more convenient to present the overall inclusiveness in form of a score or an index. It is called the Building Inclusiveness Assessment Score, or BIAS in short, which is essentially an aggregated figure of the ratings (F) and weightings (w) of all attributes that affect the inclusiveness of built facilities in higher education facilities (Ho et al., 2004):

$$\text{BIAS} = g(w_1, w_2, \dots, w_n; F_1, F_2, \dots, F_n) \quad (1)$$

where BIAS is the Building Inclusiveness Assessment Score;
w_1 (i = 1, 2, … , n) denotes the non-negative weighting of the *i*th inclusive attribute and all w_i's sum to unity;
F_i denotes the (standardised) rating of the *i*th inclusion attribute;
n is the total number of inclusion attributes; and
$g(.)$ is a continuous or discrete function that combines all w_i's and F_i's through the weighted arithmetic mean:

$$\text{BIAS} = \sum_{i=1}^{n} w_i F_i \quad (2)$$

As can be seen in equation (2), it implies a positive relationship between the BIAS and each F_i, given the weightings are positive. In other words, the higher the F_i, ceteris paribus, the higher the score is achieved in the BIAS. Because the computation of rating for quantitative attributes, F_i, has been explained in the last section, the approach to ascertain the weighting of the inclusion attributes, w_i, will be discussed.

THE WEIGHTING METHOD

Irrespective of the approach used to ascertain the weighting of the inclusion attributes, w_i, the outcome should reflect the relative importance of an attribute towards disability inclusion objectively. Owing to the large number of attributes involved, Multiple-Criteria Decision Analysis (MCDA) technique is applied to provide consistent and least biased solution. Among MCDA techniques, the Non-structural Fuzzy Decision Support System (NSFDSS), rather than the commonly used Analytical Hierarchy Process (AHP), is chosen to prioritise the inclusion attributes. Compare with other MCDA techniques, AHP is simple to operate and it enables pair-wise comparison between factors (Ho et al., 2004). When the hierarchy of criteria has been constructed, pair-wise comparison is undertaken and then the consistency level and relative weighting of each criterion are computed (Wu et al., 2007; see Saaty, 1980 for AHP and Chen, 1998 for NSFDSS; also see Ho et al., 2004; pp66 who have explained the procedures of the AHP workshop). An alternative to AHP is NSFDSS which is indeed very similar to AHP. In principle, both AHP and NSFDSS involve three steps namely decomposition, comparative judgement and synthesis of priorities (Tam et al., 2002). NSFDSS is, however, superior to AHP for a simplified scale of importance is used in NSFDSS that enables automatic consistency correction. Besides, NSFDSS can assign more precise priority to the decision criteria for the number of semantic operators used in NSFDSS to measure difference in the magnitude of the first ordered decision and others is greater than that used in AHP (Tam, Tong and Chiu, 2006; Yau and Chan, 2008). It is apparent that

NSFDSS is more desirable and therefore it is chosen to analyse the weightings of inclusion attributes. It is expected that the result of NSFDSS can be delivered by mid July.

DATA COLLECTION

This section describes data collection for assessing the inclusiveness of built facilities in the Main Campus of HKU using BIAS. As one of the purposes of this research sets out to investigate the inclusiveness of built facilities there, on-site assessments of 28 buildings are conducted. The assessments are split into two stages that look into common areas and particular facilities in buildings respectively. At all events they are conducted by at least two assessors who are required to follow the assessment procedures. With intent to minimise the subjective elements, BIAS is created in a way such that the assessors need not to be experienced or professional in the subject. What they need is to be briefed and trained before they conduct actual assessment on-site. Numerical data or yes/no items are the principal data to be solicited, and pictures are taken as record for future reference. In this regard, simple equipment including measuring tape, metal ruler, spring scale and digital camera will be sufficient for the purpose of assessment. The first stage of assessment has been finished in March 2011 and the second stage will begin by May 2011. Preliminary findings from the first stage of assessment will be discussed next.

PRELIMINARY FINDINGS

With regard to the buildings surveyed they are of diverse design and built form. Through the use of BIAS suggested above, their inclusiveness is appraised. Because this research is still ongoing, preliminary findings for the first stage of assessment (i.e. which is confined to the common areas) are presented below.

Lift is not available in a multi-storey building. It means that this building is exclusive to persons with physical or ambulant disabilities. Similar exclusion is caused by the presence of a step(s) in front of entrances that are not bevelled.

Tactile guide path is provided along external access route; however, it is seldom connected to lift zones. Besides, the tactile guide path is usually chopped when it overlaps with channel covers and gratings. In many staircases, tactile warning strips are not provided at landings.

In respect of ease of navigation, room numbers are assigned in an inconsistent manner. Though the layout of buildings is relatively simple, navigation is made difficult as different methods are used to number rooms of the same building.

Handrails fixed at height other than the recommended range are not uncommon (i.e. between 850mm and 950mm). On handrails Braille and tactile information and horizontal extension (of not less than 300mm) at each end are sometimes missing. In some short stairs, handrails are not installed.

Indication and notification for lifts is beyond sufficient. Very often there is no audible signal to indicate arrival of lift, its direction of travel and closing of the doors. Moreover, some lifts do not have visual indication to show acknowledgement message in case of emergency.

Wheelchair users may find it difficult to move out of lift cars for interiors finishes at appropriate height is non-reflective.

No provision of accessible toilet in some buildings is noticed. Where accessible toilets are provided, some of them are cramped with space insufficient for manoeuvring, whilst some are not provided with emergency call bell and alarm.

Accessible car parking spaces are often provided, nonetheless, requirements in dimensions and marking are not often met. Usually the accessible car parking spaces are narrower and the markings are smaller than required.

CONCLUSION

The argument that disability inclusion is an issue in sustainable design and construction is not false as increasingly more built facilities are obliged to be inclusive under law. In existing buildings, for example, alteration may become necessary. In this regard, disability inclusion is concerned with environmental and economic sustainability rather than merely a social issue. Among accessibility assessment methods that are currently available, they largely rely on assessors' subjectively judgements and are principally qualitative in nature. There have been attempts to improve the process by developing a quantitative assessment model, however, still considerable amount of subjective elements are present in the model. BIAS proposed here prevails for the inclusion criteria of individual areas and facilities are introduced into the hierarchy and subsequently weighted. It gives not only an inclusiveness score but also unearths the perceived weightings of the inclusion criteria. As can be seen in guides and standards, barrier-free design requirements in Hong Kong are relatively less strict. The Multiple-Criteria Decision Analysis technique to be used to analyse the priority of the inclusion attributes was discussed. NSFDSS rather than AHP is chosen for it is less time-consuming and yields more precise result.

The inclusiveness of built facilities in the Main Campus of the University of Hong Kong has been studied. As point out in the preliminary findings there are rooms to make the built facilities more inclusive. More imminent issues are to provide lifts and accessible toilets with emergency call bell and alarm. Other minor improvements such as provision of tactile warning strips at landings and Braille and tactile information on handrails are recommended. Last but not least, the philosophy of disability inclusion in built facilities should be building for all rather than persons with disabilities only. Contrary to that misbelief is inclusion in built facilities benefits everyone. It should be promoted in all societies no matter they are young or aged – a young society also calls for inclusion as parents with infants inside pushchairs want barrier-free passages.

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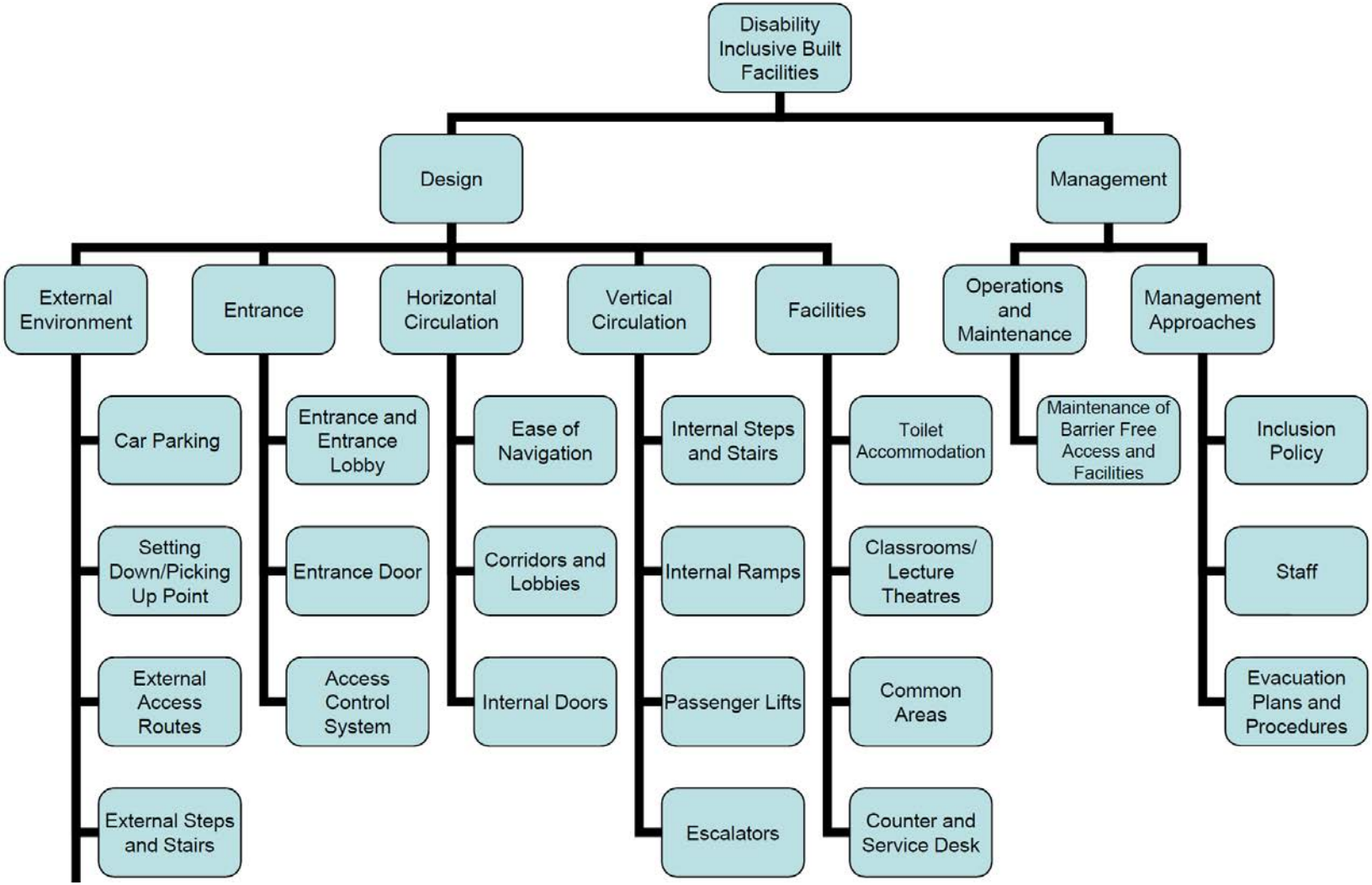


Figure 1: *Hierarchy of attributes that affect the inclusiveness of built facilities in higher education institutions*

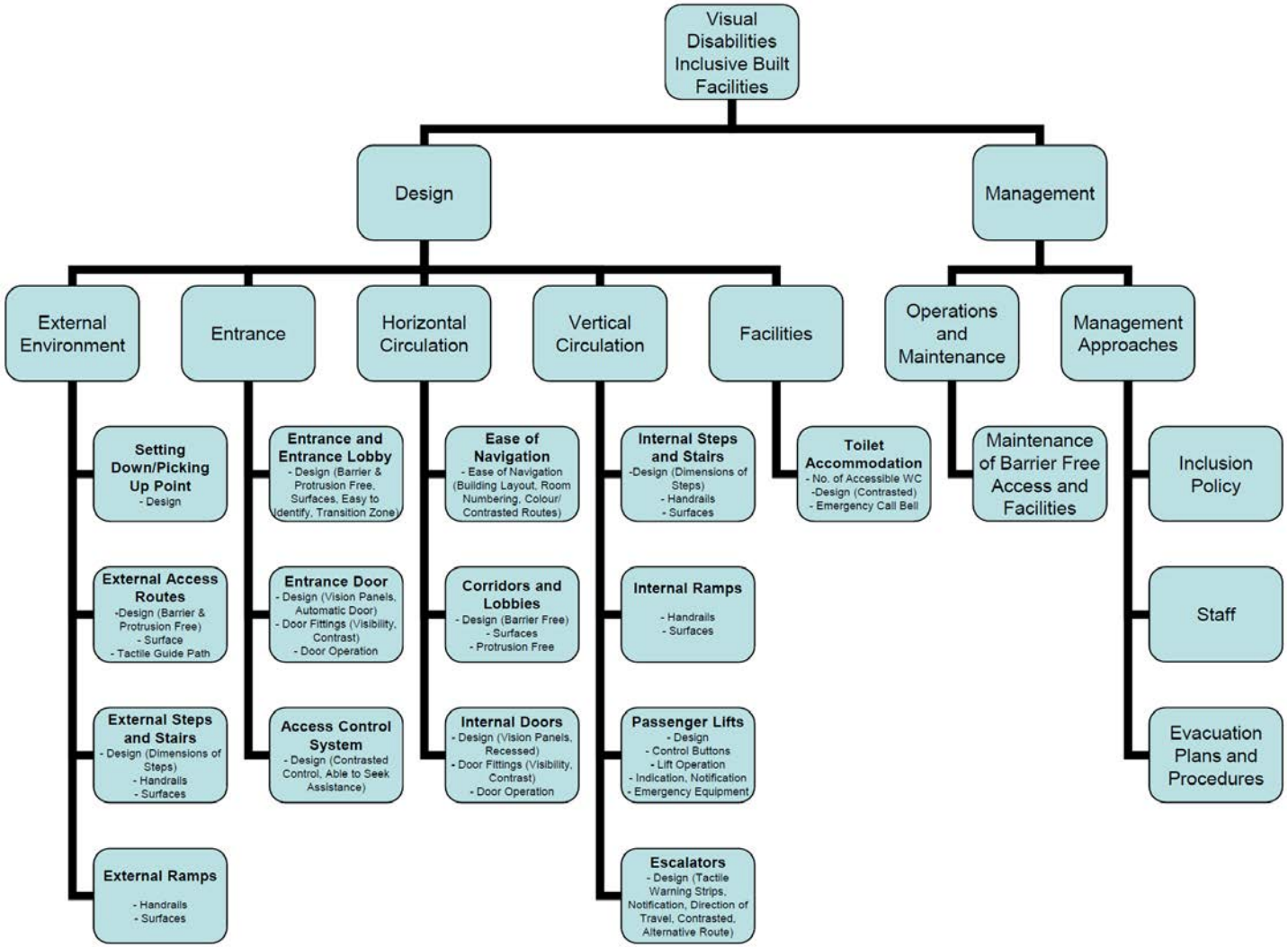


Figure 2: *Improved hierarchy of attributes that affect the inclusiveness of persons with visual disabilities in higher education built facilities*

Level II	Level III	Level IV
External Environment	Car Parking	• No. of Accessible Parking Space • Design of Accessible Parking Space
	Setting Down/ Picking Up Point	• Design of Setting Down/ Picking Up Point
	External Access Routes	• Design of External Access Routes • Surface of External Access Routes • Provision of Tactile Guide Path
	External Steps and Stairs	• Design of External Steps and Stairs • Handrails of External Steps and Stairs • Surfaces of External Steps and Stairs
	External Ramps	• Design of External Ramps • Handrails of External Ramps • Surfaces of External Ramps
Entrance	Entrance and Entrance Lobby	• Design of Entrance and Entrance Lobby
	Entrance Door	• Design of Entrance Door • Door Fittings • Door Operations
	Access Control System	• Design of Access Control System
Horizontal Circulation	Ease of Navigation	• Ease of Navigation
	Corridors and Lobbies	• Design of Corridors and Lobbies • Surfaces of Corridors and Lobbies • Protrusion Hazard
	Internal Doors	• Design of Internal Doors • Door Fittings • Door Operations
Vertical Circulation	Internal Steps and Stairs	• Design of Internal Steps and Stairs • Handrails of Internal Steps and Stairs • Surfaces of Internal Steps and Stairs
	Internal Ramps	• Design of Internal Ramps • Handrails of Internal Ramps • Surfaces of Internal Ramps
	Passenger Lifts	• No. of Accessible Passenger

		Lifts • Design of Passenger Lifts • Control Buttons of Passenger Lifts • Lift Operation • Indications and Notifications • Emergency Equipment
	Escalators	• Design of Escalators
Facilities	Toilet Accommodation	• No. of Accessible WC Cubicles/Accessible Unisex Toilet • Design of Accessible WC Cubicles/Accessible Unisex Toilet • Emergency Call Bell in Accessible WC Cubicles/Accessible Unisex Toilet
	Classrooms/ Lecture Theatres	• Design of Classrooms/ Lecture Theatres • Building Services and Relevant Facilities • Assistive Technology
	(Student) Common Areas	• Design of Common Areas and Fittings • Building Services
	Counter and Service Desk	• Design of Counter and Service Desk
N.B. 1. Design in general is concerned with dimensions and layout of individual areas and facilities. 2. Surfaces are referred to the firmness, the slip resistance, the pattern and the luminous contrast of finishes. Provision of tactile warning strips is also under surfaces. 3. Handrails have to meet requirements in dimensions and shape, fixing position and luminous contrast. It is also necessary to provide Braille and tactile information on handrails. 4. Door: door design is about the dimensions of doors; door fittings are about the furnishings or fixtures on door leaves; door operation is about the opening and the closing of doors.		

Table 2: *Level II to Level IV attributes under Design in the decision hierarchy*

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IMPLEMENTATION OF INNOVATION: THE INERTIA OF IMPLEMENTING THE OPEN BUILDING CONCEPT IN PRACTICE

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Abstract

The Open Building concept has been developed half a century ago. Despite the relative potential advantages to society, this concept of Open Building has not been widely implemented in the construction industry. Consequently, it did not lead to a general new approach of designing structures. Why does the construction industry use the Open building concept so rarely among their projects? Using in-depth semi-structured interviews with the 'founding fathers' of Open Building in combination with literature, the inertia which obstructs the implementation of Open building in the construction industry are identified. The study shows that inertia on adopting the principles of Open Building are primarily related to the type of collaboration between firms on construction projects. Only few impediments are of technical nature.

Keywords: Innovation in Construction, Open Building, Implementation of Innovation, Inertia

Introduction

In order to answer the housing problem after turbulent periods in the 20th century, mass production of dwellings offers accommodation to many citizens [Habraken, 1999]. Furthermore, mass production has long been recognized as an effective means of reducing a product's unit cost. The organizational structure and work processes in most construction firms have their roots in these mass production principles [Halman et al, 2008]. However, static mass housing is not capable to adapt easily to changing customer demands, to accommodate more than one program of functions over time. Static building structures causes an increasingly inefficient utilized building stock [Habraken, 1999; Kendall and Teicher, 2000; Thillard, 2004].

To overcome the identified problems with static building structures, the Dutch architect John Habraken proposed the open building system in 1961. In this system, the 'base-building' and its interior are separated, the so-called 'support/infill' approach. Open Building has been of interest for many scholars and has been adopted in the last few decades in countries like Japan, UK and USA. In general, the design customization options include interior and exterior design components, as well as the spatial arrangements that determine the total area of a home [Hofman, 2010].

In the past fifty years many pilot projects have been applied successfully at a small scale. However, it remains a challenge to achieve them at a broad scale. In this paper we will explore for possible reasons why the concept of Open Building has not been widely adopted in the building industry. To this end we first interviewed the founding fathers of Open Building and asked them to reflect upon the development of the concept and the resistance in the building industry to adopt the design principles of this concept. This reflection helped us to identify some important inertia. Based on the insights from the adoption theory of innovation we searched for possible solutions to overcome these inertia. These will be discussed in the discussion section of this paper.
The rest of this paper is structured as follows; in the next section the research method that has been used is presented. The section is followed by a section in which the theory of Open Building is discussed and a section in which the results of the interviews are presented. In the last part of the paper the results of the interviews and limitations and implication for further research are discussed.

Research method

The goal of this study is to identify the inertia on Open Building. To better understand the implications of this specific context a literature study was conducted on Open Building. First, the work of Habraken, the founding father of Open Building, was studied. Secondly more work was studied of the scientific working group 'Open Building Implementation' of the International Council for Research and Innovation in Building and Construction (CIB) and the journal 'Open House International'. Also the work of other scholars in this field in the Netherlands were studied by making use of backward and forward reviewing on the key words 'industrialization', 'flexibility' and 'sustainability' [Webster and Watson, 2002; Short, 2009; Cropanzano, 2010].
From literature was derived that the potential respondents in the Netherlands were (and some still are) associated to Eindhoven University of Technology and Delft University of Technology. With respect to many others who made contributions to Open Building, the following five early promoters of Open Building were interviewed in the autumn 2010: John Habraken, Age van Randen, Ype Cuperus, Jos Lichtenberg and Jouke Post.

Data collected by in-depth interviews were used to explain and explore the inertia of implementation of Open Building in practice. Analysis of the interview data increased the understanding of factors that impede Open Building and what compensation mechanisms are available to mitigate these impediments. The interviews took between one and three hours and with permission the interviews were taped and transcribed within 24-hours after the interview.
Each interview began with explaining the research goal and the role of the researcher. Each respondent was asked to answer a set of structured, open ended questions. These questions where supplemented with questions that came up during the interview.
The interview data were analyzed as follows. First the recurring words and important issues and stories where highlighted in the interview transcripts. These words and issues where clustered for each transcript and the clusters where compared across transcripts. Finally the clusters where labeled.

Literature

The basics of Open Building
The founding father of Open Building is the Dutch architect John Habraken. Already in 1961 he published his book '*De dragers en de mensen*' (Supports: an alternative to mass housing). In his book Habraken argued that mass housing disrupts the age-old 'natural relation' between human being and their built environment. He stated that people will lose interest in things which could not be influenced by them as with mass housing. Furthermore dwellings cannot be understood as products or manufactured objects. Thus, dwelling is a fundamentally human process. Therefore, residents needed to be able to make autonomous decisions on their own behalf concerning their dwelling. Concluding, dwellings provided by units of housing accordingly to mass-housing are inconsistent with the human process [Habraken, 1999].
According to Habraken, Open Building implies a strategy consisting of twofold complementary perspectives. First there is the social perspective that seeks to respond to user's preferences by offering flexibility needed for adaptation of individual units over time. Second there is the technical perspective which seeks ways of building where sub-systems can be installed or changed or removed with a minimum of interface problems [Habraken, 2003]. Furthermore, Open Building comprises the following ideas:

- "There are distinct levels of intervention in the built environment;
- Users (inhabitants) may make design decisions as well as professionals;
- Designing is a process with multiple participants, including different kinds of professionals;
- The interface between technical systems allows the replacement of one system with another performing the same function;
- The built environment is in constant transformation and change must be recognized and understood;
- The built environment is the product of an ongoing, never ending design process, in which environment transforms part by part" [Habraken, 1999].

Habraken distinct basically three levels of decision making: the tissue level (urban planning), the support level (architecture of the base building) and the infill level (design of the interior). Based on Habrakens' 'theory of levels' several other scholars defined more layers based on the differences between the technical and functional life cycle of building systems [Brand, 1995; Duffy, 1998]. However, the theory of levels by Brand and Duffy are based on subdivisions of Habrakens' support and infill level:

- Support level. The base building or the support of a building is the permanent construction with a life span up to 200 years. The support provides service space for

occupancy, the infill. The type, number and size of the individual infill units are primarily not determined by the support, compared with more traditional buildings. Part of the support are all the elements belonging to the public routing (stairs and elevators, corridors and galleries, et cetera) and common used utilities (like foyers, community rooms, et cetera).

The support itself could contain several lots. The lots within the support structure must be connected separately to the services which could be found in the public space of the structure. Based on the thoughts of Habraken, the support should accommodate the infill in an adaptable way. This means that the support determines the capacity of change, based on diverse and changing demands, of the infill leaving the support unaffected. [Habraken, 1999; Kendall and Teicher, 2000]

- Infill level. The infill system consists of many systems and subsystems which could be subdivided in many elements and components. In contradiction to more traditional construction projects the elements are not brought to the site to be processed by its own subcontractor in the building based on the site conditions. The infill is a far more integrated set of products which are basically custom prefabricated off-side for an infill unit. Therefore the infill must be installed as a whole. The infill system constructs a unit (dwelling, office space, et cetera) within the support structure [Habraken, 1999; Kendall and Teicher, 2000].

The main goal of Open Building is to achieve independency between building parts, so buildings can be created that are able to adapt to new user requirements. Despite this clear vision, applying the Open Building principles in practice is challenging. The application of Open Building is still prominent in the Netherlands but also the United States and Japan are known for their efforts.

Research findings

Early promoters of Open Building in The Netherlands, John Habraken, Age van Randen, Ype Cuperus, Jos Lichtenberg and Jouke Post, were asked to describe on their past experience the impeding and stimulating factors towards Open Building as well as the opportunities and threats of further development.

Inertia on Open Building
According to Habraken, the conventional way of designing dwellings can best be characterized as a continued process of "re-inventing the wheel", which hampers Open Building (OB). Van Randen mentioned the uniqueness and one-off characteristics of projects; thinking something new for every project.
Moreover, the traditional project organization itself is the most important impediment of Open building. Lichtenberg explains that innovations, especially Open Building Systems, are implemented in the market through projects. Typically the market consists of projects through which OB must be communicated with the market. Habraken, Van Randen and Lichtenberg mentioned that during the process many firms and actors are involved based on a fragmented and scattered division of roles, responsibilities and decision-making. All the actors need to be convinced of OB and OB innovations before it will be adopted and implemented in the project. And also Post experiences the building process of OB projects as difficult, due to the many layers in the process through which OB must be communicated.
According to Lichtenberg, firms feel very uncomfortable to change towards OB (relationships) because they are programmed for a specific task. When firms are confronted with other tasks, they consider those tasks as risky because they are not adjusted to these new tasks.
Besides the riskiness of financial loss, Habraken and Cuperus mentioned that construction firms are reluctant to relinquish former attainments. For example, architects have to design structures with predetermined Open Building Systems and contractors only erect the support system (and thus not the infill) based on different decision-making levels.
Thus as Lichtenberg generalizes, in construction, a project-based industry, there is a long organizational chain between the innovator and the beneficiary, which impedes diffusion. The challenging task of the innovator consists of convincing all the stakeholders of the advantages of Open Building (or any other innovation).

Habraken explains that conventional projects rely on floor plans. Firms, like financiers, contractors, engineers and architects base their work on floor plans. The involvement of many actors complicates the composition of the floor plan and the complexity increases when the end-users will be involved accordingly to OB. With limited influence of end-users there arises a mismatch between the floor plan and end-users demands. Therefore the 'system' should be reshaped around end-users as suggested by OB.
However, why should construction firms change the system, to which they are used to, when they still make money with conventional floor plan? In addition, Post observed that OB projects, where buildings are assembled in an intelligent user-friendly way, are not of interest of the industry as long as construction firms earn money with conventional projects. Also Lichtenberg came to this conclusion. The willingness of organizations to accept Open Building depends on organizations' attitude towards change. As Lichtenberg mentioned; 'to innovate, organizations need to accept something new, but above all give way old routines'.
Furthermore Post remarked that OB only could be successful when supply and demand are complementary to each other. However, without a client demand about flexibility, the construction industry will not likely invest in the development of interdependent interfaces.

Market demand concerning flexibility failed to occur because adaptability of building structures is esteemed by the market as a hidden quality. Moreover, accordance Habraken organizations need to adapt their collaboration on projects in accordance with the developed system; otherwise the building system has no market potential (because it could not be a competitive alternative). Furthermore, when organizations adapt to the system it will stimulate new developments.

Van Randen mentioned legislation as an impediment of Open Building. However, Habraken en Post both mentioned legislation as an incentive of Open Building. From the interviews with the founding fathers it is concluded that some types of prescriptive based legislation could be inertia on OB like the municipal zoning pan, while some types of performance based legislation could be incentives towards OB.

Other inertia on OB mentioned by the early promoters are:

- The small percentage of total investment in Research and Development;
- Dwelling have a high intensity of installation per square meter and this complicates the development of Open Building in house-building;
- The (inter)dependencies of components hampers the implementation of OB in practice. The interfaces between prefabricated parts are not well developed accordance Van Randen. In addition, Lichtenberg mentioned that interfaces between components within systems require (de)mountability to be flexible or adaptable. However, interfaces are complex due to the many actors involved to realize a particular interface.

Opportunities for Open Building

Habraken claims that the discrepancy of customization between cars, clothing, et cetera versus dwellings will result in a breakthrough of OB. However, programs like IFD-building could not be seen as an initiative which stimulates a breakthrough. Furthermore, these initiatives must be seen as a search for a possible directive of development.

The balance between price and quality was mentioned by the founding fathers as an incentive to OB. Habraken explains that the harmonization between the functional lice-cycle and the technical life-cycle (up to 200 years), means the optimal use of capital. This prevents unnecessary demolishing of building components which could last for many years. In contrast, Post suggests constructing buildings for a limited period of time (20 years), because for short periods reasonable estimations could be made of user demands. After 20 years user demands change dramatically and therefore small changes are not sufficient to meet these demands. Constructing for a period of 200 years is very expensive and the estimation of how the building will be used in this period are hard to make.

Labor could be another incentive accordance Lichtenberg and Post. Lichtenberg explains that increasing labor costs on the construction site stimulates industrialization. In addition, Post remarks that higher quality demands and the ambition to realize buildings in a shorter period of time stimulates industrializations and thus could stimulate dry (de)mountable interfaces. Thus, changing labor circumstances could offer new opportunities to OB. This is clearly described by Van Randen; the objective to create as few as possible (inter)dependencies between systems, so that short-term systems could be replaced without any alterations to the long-term systems. Therefore consciousness is required about the need to consider future use of building structures during the design stage, this life-cycle approach stimulates flexibility accordance Post.

Compensating mechanism

First, Habraken suggests formalizing an infill industry (contracts, norms, recognition, et cetera). Secondly, Habraken proposes single point responsibility, or more specific; make firms responsible for the process, logistics and organization of OB projects. Habraken referred to Sekisui, Japan, as an example of a successful innovative open building system for the home-building industry. The concept is based on a stale framework to which standard components from the market are added to construct a fully customized dwelling. The organizational set up is based on a single point responsibility for a more efficient construction process and to simplify the project organization, especially for the customer.

Also in the Netherlands there are initiatives to simplify the project organization and lower the number of contact points in the construction process. Lichtenberg referred to an initiative called Industrial Building 2015 (IB2015), which aims for an Open Systems Building approach with a central role for the industry. The program focuses at five main principles: 1) decoupling of building components, 2) conceptual solutions, 3) industrial connections (interfaces), 4) Building Information Modeling (BIM) and 5) full-service. The current discussion involves the division of roles; who should coordinate and/or fulfill the pioneering role.

Accordance to Habraken and Post, legislation could be an important incentive to OB when designed properly. The Japanese long-term-housing act, an example to which Habraken referred, stimulates sustainable innovation, the act balances between prescriptive and performance based legislation. The end-user could achieve a considerable fiscal advantage when a constructed building as a whole lasts for 200 years. This stimulates market demand for sustainable buildings which subsequently results in pressure on the construction industry to develop sustainable buildings.

Both Van Randen and Lichtenberg explained that the complexity of interfaces results from the many involved actors which affect the interface design. Van Randen suggests an interface specialist; however another actor in an already fragmented industry could result in a diminished coherence within the interface. Lichtenberg defined an interface as a set of design rules, the virtual interface. However, the interface could also be a physical connection. Anyway, it is the task of actors to agree upon design rules and when there is no agreement among actors an adaptor or intermediary-interface could be a solution.

Market demand could also be an important compensating mechanism to overcome inertia on OB accordance to Lichtenberg and Post. Post claims that no OB developments in the industry will take place when there is no clear client demand. Profit oriented construction firms could be stimulated in developing OB solution by holding out the prospect of future sales or projects, accordance Lichtenberg.

Table 1: Inertia on Open Building

	Respondents				
	John Habraken	**Age van Randen**	**Ype Cuperus**	**Jos Lichtenberg**	**Jouke Post**
Impediments	-It is re-inventing the wheel for every project, a characterization of project-based production that impedes the development of Open Building. -Dwellings has a high intensity of installation per square meter this complicates the development of Open Building in house-building. Construction firms still try to optimize conventional construction methods and believe that Open Building is too complex; the introduction of Open Building means restructuring the division of roles and responsibilities around projects. -The conventional construction process relies on floor plans; financiers, contractors, engineers, architects base their work on floor plans. The involvement of many actors complicates the composition of the floor plan and the complexity increases when the end-users will be involved. Therefore the system should reshape the way towards client involvement. However, why should construction firms change the system, to which they are used to, when they still make money with conventional building? -Construction firms fear the unknown and the risk of losing revenues. -Construction firms are reluctant to relinquish former attainments.	-Construction projects are characterized by improvisation; thinking of something new for every project. -Legislation hampers the development of Open Building. -The complexity of working together with many actors restrains Open Building. -The (inter)dependencies of components hampers the implementation of Open Building in practice. The interfaces between prefabricated parts are not well developed.	-Modular Coordination (MC) (design rules for size and place to formalize Open Building in design) has never been implemented, because: (1) the opposition of architects based on the argument that MC restricts freedom of design, (2) MC focused on industrialization which in that days was open to negative publicity, (3) some firms could apply the design rules with only small adaptations while other had to change / invest heavily, (4) some firms tend to lose the competition because products of competitors where easier applicable, and (5) the design rules where too complex.	-During the building process many firms are involved. The construction process is programmed around fragmented disciplines. Due to this fragmentation alternative organization forms are hard to achieve. - All construction firms involved in a project must be convinced of OB. - Interfaces between components within systems require (de)mountability to be adaptable. However, interfaces are complex due to the many actors involved to realize a particular interface. -Firms are programmed to perform a specific task. When firms are confronted with other tasks, firms consider these tasks as risky. - The innovation inertia: OB is accepting something new, but above all overcoming old routines. - Only a very small part of total investments in construction is spend on research and development. - There are no organizations in the industry with enough importance (like Apple, Toyota) that could, top-down, stimulates OB. There are many small to medium-sized enterprises (SME) which have to collaborate in OB projects (and thus stimulating OB bottom-up).	-The building process of Open Building projects goes very slowly with many difficulties, due to the many layers in the process through which Open Building must be communicated. -Open Building could only by successful when supply and demand are complementary to each other. Therefore it is necessary that construction firms change the way they operate in projects towards Open Building. -The market describes flexibility as a hidden quality; only few demands flexibility in projects. Therefore, legislation could formalize flexibility with respect to sustainability. - Open Building projects, where buildings are assembled in a intelligent and user-friendly way, are not of interest of the industry as long as construction firms earn money with conventional projects.

Table 2: Opportunities for Open Building

	Respondents				
	John Habraken	**Age van Randen**	**Ype Cuperus**	**Jos Lichtenberg**	**Jouke Post**
Opportunities	-The discrepancy between customized options for cars, clothing and suchlike, and the few customized options for dwellings stimulates a breakthrough of Open Building. -Programs like Industrial, Flexible and Demountable (IFD) building could not be seen as body of thoughts which stimulates a breakthrough. However, these programs could be seen as a search for a possible directive of development. -The harmonization between the functional life-cycle and the technical life-cycle (up to 200 years) means the optimal use of capital. This prevents unnecessary demolishing of building components which could last for many years.	-The objective is to create as few as possible dependencies between systems, so that short-term systems could be replaced without any alterations to the long-term system.		-Increasing labor costs on the construction site stimulates industrialization.	-Consciously about the need to consider future use of building structures during the design stage stimulates flexibility (life-cycle approach). -Higher quality demands and ambition to realize buildings in a shorter period of time stimulates industrialization in construction, and thus could stimulate dry (de)mountable interfaces. -Buildings should be constructed for a limited period of time (20 years), because for short periods reasonable estimations could be made of user demands. After 20 years user demands changed dramatically and therefore small changes are not sufficient to meet these demands. Constructing for a period of 200 years is very expensive and the estimation of how the building will be used in this period are hard to make.

Table 3: Compensating mechanisms inertia on Open Building

	Respondents				
	John Habraken	**Age van Randen**	**Ype Cuperus**	**Jos Lichtenberg**	**Jouke Post**
Compensating mechanisms	-Formalization (collaborations, contracts, norms, recognition et cetera) of an infill industry. -Balance between price and quality. -Introduction of 'single point responsibility' like Sekisui (Japan) and Tokoman (Finland). Firms are responsible for the process and they arrange the logistics and organization. -Legislation and governmental policy could stimulates OB: the Japanese long-term housing act, which requires building structures to last 200 years, in combination with fiscal benefits stimulates market demand.	-The many involved actors influence the interface design. An interface specialist could be the solution; however a new role is created in an already fragmented industry. As a result the coherence diminishes.		-The complexity of interface results from the many involved actors. An interface could be a design rule; the virtual interface. The interface could also be a physical connection. It is primarily the task of actors to agree upon design rules. Without this agreement, an adapter or intermediary-interface could be a solution. -The innovation program 'Industrial Building 2015' (IB2015) tries to diminish the number of firms to maximum 4-6 main firms. This is a bottom-up approach of projects towards a more efficient and convenient construction process. -The market consists of a certain collection of projects. And for every project many firms need to be convinced of Open Building. Therefore, a certain sale of Open Building projects, introduced by clients, stimulates Open Building.	

Discussion

Open Building, despite its 50th birthday, is still not applied at a broad scale. However, today there are new opportunities for Open Building. First of all, consumers are more demanding than ever. They want to have a say in the design of their future house and have clear demands about what it is they want. Second, sustainability has become much more important, which in the philosophy of Open Building is a key role. Third, the building process nowadays is expensive due to an increased number of parties involved in the process, resulting in communication problems and higher failure costs that are for the expense of the customer and are calculated in and higher price of the building. Therefore, nowadays more importance is given to the extension of the lifecycle of buildings to be able to spread out the costs over a longer period of time. Fourth, there is an ongoing development of increased willingness of companies to cooperate and develop products and systems together, in which Open Platforms plays an important role.
Conventional buildings are developed in a form of closed (static) systems, due to the fixed integration of technical systems into functional building systems. Due to this high level of functional and material integration, it is usually impossible to remove components in order to replace or exchange them. This is the reason why closed building systems are not suitable for easy transformation and cannot adapt to changes in user requirements. Therefore, to achieve adaptability of buildings, an open system is needed. The main difference between a closed and an open system is the separation and decoupling of sub-assemblies that have different functional and life cycle expectancies [Durmisevic, 2006]. To achieve this, a carefully designed systematization of building components into independent subsystems in a hierarchical order is needed. For such systematization, the design of common interfaces that allow independency between components is required. If this can be achieved, a building can consist of different modules that can be independently upgraded, reconfigured, replaced or added. The different modules together can then form a category of components that can be assembled with standardized interfaces. Open Systems Building (OSB) is a framework to achieve this and can be seen as a realization of Open Building.

According to Gann and Salter, construction should be viewed as a process rather than an industry: ‘it includes designing, maintaining and adapting the built environment, involving many organizations from a range of industrial sectors, temporarily working together on project-specific task’ [Gann and Salter, 2000]. Reasoning for this definition could be the following characteristics of construction: ‘the physical substance of a house is a pile of materials assembled from widely scattered sources. They undergo different kinds and degrees of processing in large numbers of places, require many types of handling over periods that vary greatly in length, and use the services of a multitude of people organized into many different sorts of business entity’[Cox and Goodman, 1956]. Gann and Salter’s definition is emphasized by Habraken’s distinction between support and infill. Besides a physically separation of building systems also a distinction between decision-making units and responsibilities, this clear the way, as Habraken puts it, for a support and infill industry.

Construction projects are a gathering of complex product systems, characterized by (1) many interconnected and customized elements organized in a hierarchical way, (2) nonlinear and continuously emerging properties where small changes to one element of the system can lead to large changes elsewhere in the system and (3) a high degree of user involvement in the innovation process [Winch, 1998]. Dubois and Gadde divided complexity in construction in two main categories [Dubois and Gadde, 2002]. The first category encompasses the uncertainty in the undertaking of individual activities which has four causes, (1) management

is unfamiliar with local resources and the local environment, (2) lack of complete specification for the activities at the construction site, (3) lack of uniformity of materials, work, and teams with regard to place and time (every project is unique), and (4) unpredictability of the environment. As a result, centralized decision-making is difficult to apply and this leads to decentralization of authority. The second category is associated with three factors of operational interdependence in construction [Gidado, 1996], (1) the number of technologies and the interdependence among them, (2) the rigidity of sequence between the various main operations, and (3) the overlap of stages or elements of construction. Furthermore, complex product systems need to be adjusted at the construction site, because of (1) the lack of complete specification, (2) lack of uniformity and (3) an unpredictable environment [Dubois and Gadde, 2002]. This supports the research findings of the interview with the founding fathers of Open Building. It describes in general the inertia on Open Building mentioned by Van Randen, Lichtenberg and Post.

Project-based firms in the construction process are focused on individual projects. The realization of projects is based on combining technical expertise from other organizations [Gann and Salter, 2000; Dubois and Gadde, 2002]. Furthermore, the role of an individual firm is very different among projects; because the division of labor among the actors varies greatly form project to project [Dubois and Gadde, 2000]. As mentioned by Habraken and found by Gann and Salter [Gann and Salter, 2000] it is re-inventing the wheel that characterize project-based production. Gann and Salter found that there are limited links across business units and individual projects. Therefore, the rate of organizational learning of Open Building projects is very low.

According to Gann and Salter firms need to integrate the experiences of projects into their continuous business processes in order to ensure the coherence of the organization, especially according to Open Building projects.

Furthermore, adoption decisions by firms concerning Open Building have to be implemented in projects. As mentioned, projects are collaborative engagements with other firms and as a result Open Building has to be negotiated within the project coalition. A firms' ability to do this, the role of the champion, will be strongly influenced by its role in the coalition [Winch, 1998]. This was also literal mentioned by Lichtenberg.

Open Building needs a champion [Schilling, 2000; Rogers, 2003]. According to Rogers, a champion is 'a charismatic individual who throws his or her weight behind an innovation, thus overcoming indifference or resistance that the new idea may provoke in an organization' [Rogers, 2003]. In construction, the champion can come from every part of the industry. Pries and Janszen and Lichtenberg found that champions typically come from component suppliers [Pries and Janszen, 1995; Lichtenberg, 2002]. This was also suggested by Lichtenberg and Post.

A compensating mechanism for the inertia on Open Building could be *the broker* [Winch, 1998; Rogers, 2004; Winch and Courtney, 2007]. According to Winch and Courtney, a broker is a distinctive type of actor in networks or actor that links other actors in the network [Winch and Courtney, 2007]. However, who should take the broker-role regarding Open Building? As mentioned by the founding fathers as well as several scholars [Dubois and Gadde, 2002; Hofman, 2010] construction firms should look for ways to reconfigure their short-term vision based organizations and project coalitions to long-term setup to encounter the challenges of future construction.

Traditionally, the principal architect or engineer and the principal contractor act as systems integrators, a broker-role between clients, regulators, professional institutions, trade contractors (specialized suppliers), specialized consultants and components suppliers [Winch,

1998; Miller et al., 1995]. The latter three could act as Open Building champions as mentioned before. Typically, construction has two separate system integrators, due to the distinction between the design stage and the construction stage. Therefore, the role is shared by the architect/engineer and contractor. As a result the systems integrator role is less effective. In addition, architects displays competence in regulatory frameworks and clients requirements, but are not equipped to integrate all technical systems into a building. Also the contractor's integration capabilities are typically restricted to the managerial rather than technical level [Winch, 1998]. Thus, the Open Building systems integrator has three functions (1) the skills to integrate interdependent components into a coherent whole, (2) detailed knowledge of client requirements, and (3) knowledge of the rules and regulations governing the industry [Miller, et al.; 1995]. Therefore, and as found in the research date, it is questionable or the architect and/or contractor should fulfill the broker role. However, Nam and Tatum demonstrated that the role of the architect and contractor is decisive in the success of Open Building. The systems integrator, although still questionable or this not could be a specialized supplier for example, must be convinced of the merits otherwise implementation will be slow [Nam and Tatum, 1997].
Winch and Courtney suggests that independent and objective organizations should take the liaison role between firms that are otherwise not connected. They could add value to the development of Open Building by validating new ideas, act as auditor. They could also act as an intermediary between supply and demand site by shaping the definitions of research problems and shaping the practice of implementation. However, almost every discipline is separately represented by a professional body. This weakens their ability to act as a broker of Open Building as they typically threaten the interest of only a particularly set of actors [Winch, 1998]. Thus, until know the Open Building broker did not come forward yet.

Rogers' defined five perceived attributes of innovations, (1) relative advantage perceived by individuals, (2) compatibility with the values and norms of a social system, (3) complexity, (4) trialability, and (5) observability or the visibility of the results of an innovation [Rogers, 2003]. To be adopted Open Building needs a relative advantage regarding conventional building as mentioned by the respondents and several scholars. For example, it solves technical difficulties or meet social requirements better than traditional solutions [Ling et al., 2007; Hartman et al., 2006; Hartmann et al., 2008]. Firms who make efforts to implement Open Building should stress the problem-solving rather than the performance-improvement aspects of Open Building [Ling et al. 2007]. Most importantly, clients' sponsorship is essential for the successful implementation of Open Building [Nam and Tatum, 1997]. In general, without an adequate incentive structure than it is unlikely that Open Building take place. In the case of Open Building Systems it is necessary to develop a long-term gain sharing approach. This means a shift form competitive tendering toward partnering. It is assumed that competitive tendering explains the use of standardized building parts used in conventional buildings.
Therefore, competitive tendering hampers customized solutions [Winch, 1998; Dubois and Gadde, 2002]. However, despite the opportunities for high-involvement relationships, taking the step to strategic partnerships would require modification of some of the basic construction norms, like the current focus on the efficiency of individual projects and competitive tendering [Dubois and Gadde, 2000; Gadde and Dubois, 2010]. Thus, as several scholars indicated project organizations are loosely coupled [Brusoni et al., 2001; Dubois and Gadde, 2002; Hofman, 2010]. In contrary with loose coupling, the development of Open Building requires tight organizational coupling [Brusoni et al., 2001; Hofman, 2010].
The founding fathers believed that legislation could stimulate Open Building. Like the Japanese long-term-housing act, so called performance standards, maybe be an appropriate

form for encouraging systemic technological change. Performance standards specifies minimum building requirements, however they does not prescribe the means or components [Gann et al., 1998].
In addition, compared to manufacturing firms of other industries, traditional construction firms are less open to the external environment, they are less market oriented. The nature of the market strongly influences the potential of Open Building; local markets can often mean undemanding customers. Furthermore, firms do not need to change to Open Building to remain successful or viable at all as long as they meet local needs, responding to regulation and adopt new technologies form their suppliers and customers [Reichstein et al, 2005].

Limitations and implications for further research

Only few interviews (5) were conducted in one country (the Netherlands). No interviews were conducted among scholars and practitioners who are making contributions to Open Building today. Perhaps it is more important to speak with (professional) clients, especially housing corporation, who rejects and/or rejected Open Building in the past. Therefore, a broad survey among stakeholders could gain more complete insight into the inertia on Open Building and its possible compensating mechanisms.
Although the limited interview data was verified in literature, there is no guarantee that the data is complete and unbiased. There is also no insight in the interrelation between impeding factors as well as compensating mechanism. The innovation behavior of construction firms have been subject of several scholars. Only few scholars paid attention to the adoption and implementation of Open Building, where Open Building Systems are hold as systemic innovations. A review of literature around 'innovation behavior of construction firms' and 'adoption and implementation of systemic innovation in construction' could provide more insight in the state of the art concerning the implementation of Open Building Systems and other innovations in practice. Furthermore, only few contributions have been made to formulate 'design rules' for Open Building Systems and its adoption and implementation process and in addition applying and testing those design rules.

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TOWARDS AGILE PROJECTMANAGEMENT AND SOCIAL INNOVATION IN THE CONSTRUCTION INDUSTRY

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Abstract

Is project management developing towards a more human- or culture-oriented discipline? Two recent studies of the Dutch construction industry dealt with this issue, and the results of these studies have led to the conclusion that project management has developed in the opposite direction over the past few years, towards a 'harder', more instrumental approach with an increasing degree of specialisation. This approach works well with relatively simple and repetitive construction assignments, but project managers have noticed that their environment is rapidly increasing in complexity, and that this development limits their effectiveness. Some of these issues include the project's immediate surroundings (for projects in the city centre), legislation, regulations, procedures, the number of parties involved and judicial matters.

The highly instrumental management style described above is not entirely suitable for these increasingly complex construction projects. We have observed that these new construction assignments require new management paradigms, but that the existing paradigms are tenacious in their hold on managers' thinking. The dominant form of management today is still technical, Taylorian and instrumental, and the dominant management culture is still task- and results-oriented.

And yet there are some new developments in the field; lean or agile project management is clearly gaining momentum (or so the trade journals would have it seem). Within this 'movement', the human aspect takes precedence over the structure. The average project manager may be satisfied with his competencies in general, but he gives himself a low score on the 'human' or 'social' side of project management. That is also the facet he would most like to improve about himself; especially with regard to skills such as negotiation, conflict management and leadership.

There is a general trend towards social skills and away from purely technical expertise. This implies that project managers do not necessarily have to be engineers. The project manager of the future will definitely have to have people skills, but according to the project managers themselves, they still have a long way to go.

Keywords: Social innovation, agile project management, lean manufacturing, project management competencies, project management careers, paradigm shift

INTRODUCTION: STRUCTURAL LIMITS?

The quest for success!

The 'holy grail' for much of the research on project management is the search for success factors. What determines the success or failure of a project? An American study by Sloan, based on hundreds of case studies (not limited to the construction industry), shows that 70 to 90% of all projects are considered failures. Some reasons for this include: schedules based on political factors instead of hard facts, lack of support from the project sponsor, stakeholders and senior managers who circumvent formal decision-making processes, risks that are downplayed or ignored and team members who do not show up, do not keep to schedules or are insufficiently competent.

Another study asked project managers about failure factors (Arras People 2010). The results of this study supported the conclusions above and added others: scope creep (the project changes and the scope shifts in a different direction), incomplete requirements and poorly formulated or managed expectations. Similar studies have been conducted in the Prince2 environment (for example: Onna 2007) and PMI (2009). These studies also listed issues such as: confusion as to the client's role, lack of a proper project plan, vague definition of the expected result (both as to what it will be as well as what it should not be), overly optimistic schedules and lack of consideration for delays and changing requirements and principles during the project.

Remarkably, many of the failure factors fall in the category 'structure' or 'instrumental' (control is more important than involvement, a great deal of confidence in procedures and checklists, making plans and then rigidly executing them). The answer to failure can be found in the project management methods used, as they all resemble one another. The two most common in the Netherlands are:

- Prince2 (Projects IN Controlled Environment by the Office of Government Commerce)
- PMBOK (the PMI's Project Management Body Of Knowledge (2009))

Problem statements and objectives

This study deals primarily with the 'hard' side of project management; *"if your only tool is a hammer, all your problems look like nails"* (Maslov, 2011). Project managers usually approach problems by applying more structure to the project. This is only to be expected in a sector dominated by engineers: 95% of the managers in the construction industry have a technical background (Pries, 2005). However, it remains to be seen whether the use of even more structure and instruments is effective. Where one project suffers under the burden of too much structure when creative interaction is needed, another project may benefit from a rigid structure. Van Aken (1996) notes that in general:

- Use of instruments has a negative correlation with success;
- Working style correlates strongly with success;
- Few instruments are necessary to achieve success with goal-oriented work processes;
- In many projects, too much structure stands in the way of success.

This paper was drafted with the above discussion in mind. In it, we will discuss questions such as:

- Is project management a discipline that is primarily characterised by a hard, instrumental approach?
- Are there indications that project management is developing towards a more human- or culture-oriented approach?

This study is based on literature research and presents the following two studies;

- The first study (Pries, 2009) describes, examines and when possible quantifies various aspects of culture in the Dutch construction chain. This study is based on literature on the subject, an Internet survey of 241 individuals in the construction industry and 14 interviews.
- The second study (Everts, 2008) analyses the existing and desired competencies among project managers. The conclusions of this study are based on an Internet survey of 150 project managers and six interviews.

DEVELOPMENT TOWARDS AGILE PROJECT MANAGEMENT?

From 'instrumental-Taylorian' towards 'agile' project management

Projectmanagement and organizational management are sometimes seen as the same fields of expertise, but studies show a clear difference between needed competences (Turner, Muller & Dulewicz, 2008). It has been argued that project management is going through the same learning cycle as management all be it with a time lag (Krahn, 2005). Even though both organizational management and project management now claim that they can be 'agile', this paper focuses purely on the latter. Meredith (2006) notes that traditional, hierarchical management is increasingly being replaced by 'consensual management'. One could see this as a form of 'social innovation', in that it deals with the emancipation of workers at all levels. Without treading into the sensitive area of definitions, we can describe this as an increased involvement of employees and clients in formulating policy and of the organisation in implementing that policy.

The world of project management also pays increasing attention to the human side of management (Pries, 2011). In the literature on project management, the concept of 'agile' management is clearly very popular. This agile management approach is especially popular in the field of ICT project management, but we have not yet observed it in the Dutch construction industry.

Agile originated in the world of ICT and software development. It displays many of the characteristics of 'lean thinking'. "Lean Software Development; an agile toolkit (Poppendieck, 2003)" is an example of the concept that originated in Japanese Lean Manufacturing. The Manifesto of the Agile Alliance (http:/www.agilealliance.org/) states: *"We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value: individuals and interactions over processes and tools; working software over comprehensive documentation; customer collaboration over contract negotiation; responding to change over following a plan. That is, while there is value in the items on the right, we value the items on the left more".*

Agile stands for individual interaction rather than procedures and tools; results above paper predictability and reacting to change instead of rigidly following the original plan. In this sense, agile seems to better suit the current zeitgeist than traditional project management due to the dramatic increase in environmental turbulence and complexity in the construction industry (Pries, 2011). In a simple, stable world, traditional project management would suit

just fine; plans are drawn up based on relatively predictable variables and the manager can simply follow the plan. However, in a complex and rapidly changing world, this method is no longer sufficient. Manoeuvrability and flexibility are vital, as managers must be able to adapt to inevitable changes. There is no room for bureaucratic organisations and rigid procedures. Aspects that do fit into this paradigm include (Pitagorski, 2008):

- Self-managing or self-organising teams
- Plenty of interaction with the client, "even when there isn't a problem to be solved!" (Blais).
- Balance between 'top-down' and 'bottom-up'
- Motivated individuals; according to the Agile Alliance: "Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done". But Pitagorsky does raise some doubts about this method. It is useless to ignore the fact that there is a great deal of variation in the competencies of different individuals. Blind confidence is counter-productive; some kind of balance must be found.
- A leader should become more of a coach and facilitator, clearing obstacles from the team's path.

INTERLUDE: A CONTROVERSY BETWEEN AGILE AND TRADITIONAL PROJECT MANAGEMENT?

The academic literature on the subject suggests that there is a conflict between the two approaches to management, but in practice the difference is more subtle. As Pitagorsky (2008) explains: *"The challenge is to stay lean and agile and to satisfy the control needs (…) by blending the wisdom of the traditional and Agile PM approaches. The right blend of formality and flexibility is essential for ongoing success"*. The difference may seem black-and-white in theory, but in reality there are several shades of grey. This is an opinion that the authors find easy to live with. The challenge is to select the right project management model for each specific project. When the project is absolutely unique and displays a high level of complexity with many parties and interests involved (and therefore many potential conflicts), then the manager should not implement a hierarchical and bureaucratic project management model. However, if the accent lies more on implementing a relatively simple plan that enjoys broad consensus among all parties, then such a plan would be ideal. Of course, every project progresses through different phases. The earliest phases of the project demands a more agile approach (exploratory, conceptual, value-adding, interaction), while the later phases will often require a more traditional approach to project management (managing, technology, focus on costs).

Is structure unnecessary then?

We often hear people in the construction field saying 'that culture nonsense' may all be well and good, but that there are still too many fundamental mistakes being made. Contracts and procedures are drawn up wrong and technical design mistakes frustrate the builders. There is of course truth in all of this. Managing the structure is vital in a technical world. Structural thinking is far from nonsense; attention to the structure is absolutely necessary. However, it is much easier to work within a structure if attention is also paid to the culture of cooperation. After all, a person with two legs doesn't hop around on one all his life. It is in this field of culture, or the 'human side' of project management that we are falling behind, and it is on this point that we must innovate as a sector (Pries, 2009). We must invest more in the cultural dimension.

INTERLUDE: THOUGHTS ON ORGANISATION AND COMPLEXITY

How fragmentation has become our worst enemy!
Building used to be much easier in the Netherlands. There was a client, an architect and a contractor. The architect was the boss and the contractor had all-round craftsmen in service. High-quality buildings were assembled by high-quality labour using low-quality materials. After World War II, the focus was on quantity production. These uniform construction tasks offered plenty of opportunities for series production. At that time, especially in the 1960s in the Netherlands, our sector went through large-scale innovations (Pries, 2005; Doree, 2005). Large-scale use of concrete, large elements, modular high-rise buildings; all were phenomenal innovations. Those were also the days of the time-and-motion study. Using a stopwatch, managers could measure productivity and construction increasingly became a science.
The number of specialists also began to increase. The leading role once played by the architect has exploded into 10 specialised consultants, and the average building site now has 30 to 40 subcontractors getting in each other's way.

What about the theory?
This development corresponds with what we find in the literature on the subject. When we examine operations research (as in Daft, 2006; Pries,2009; SBR, 2005; SBR, 2007), then we see a relationship between the serial nature of the production (or its complexity) and the size of the series. Small, difficult series result in piecework, while large, simple assignments are ideal for series production or even mass production (although this does not apply to the construction industry). Piecework requires high-quality labour and craftsmanship, little specialisation, few formal procedures and decentralised decision-making, a well-trained craftsman is only hampered by procedures and checklists.

The times have truly changed!
In today's Dutch construction industry, we are still confronted with the assumption that we can continue with series production. We are faced with countless sub-contractors, a large number of specialists at the construction site (each chosen by lowest bid), coordination problems, but also a fundamentally changed building assignment. Just five years ago, 70% of all homes were built on the edges of the city, where it was relatively easy to build. But today 70% of our assignments are in the complex existing built environment (Pries, 2010). This existing environment comes with its own residents, interest groups and logistical challenges. On top of that, 50 cents of each Euro spent on construction goes to renovation, management and maintenance, and those types of production are much less predictable than new construction. There are no projects involving thousands of homes any more, today's homes must all be unique and consumer-oriented. Moreover, we are faced with any number of sustainability regulations that will fundamentally change our building process. All together, these changes present us with all of the ingredients for chaos. We are faced with a difficult, small-scale assignment that we still want to approach with a simple, large-scale solution.

CULTURE WORKS!

Introduction

We have noticed that people in the construction industry find the culture of cooperation extremely interesting, and they suspect that it may be very important, but that they lack the knowledge and skills necessary in order to implement it (Pries, 2009). We have therefore defined, studied and when possible quantified the various aspects of culture in the building chain.

The importance of culture

Much has changed in the construction sector in recent years. The complexity of the rules and interests pertaining to building projects is here to stay; construction will never go back to the simplicity of yesteryear and we will have to get used to the fact. The natural reaction of the construction industry has been to adopt more bureaucracy and systems like ISO 9001, VCA and a focus on documenting every exception. Our real challenge is to learn how to work together better, but that is not an automatic process (Pries, 2008).

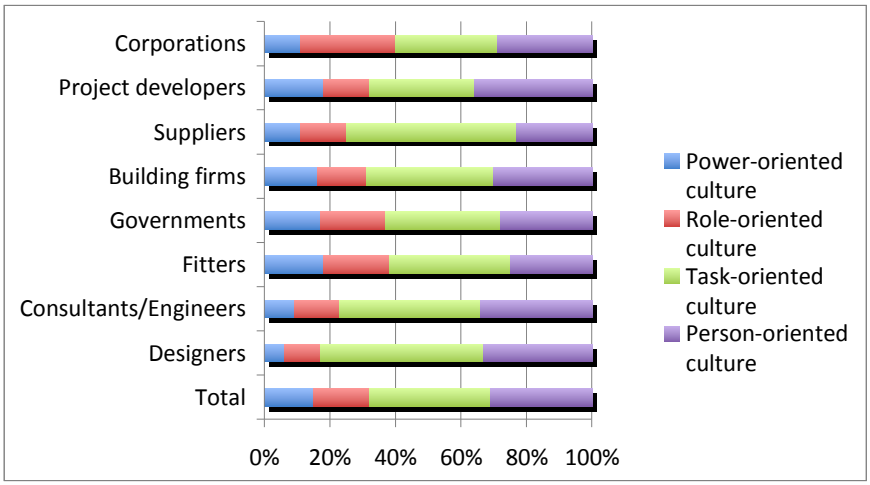
- Cooperation between people with different organisational cultures is by no means a matter of course;
- People often lack any conception of 'other' cultures, and this impedes understanding. Note that this brings an extra problem in the field of project management, because some terms may even have different meanings: goal/result, project charter/project plan/plan of attack, etc. This definitely does not help us understand one another;
- There is often a lack of tolerance for other cultures;
- Dominant parties expect other parties to adapt to their culture;
- The consequences of these issues may include: mistrust, tension and conflict.

Results of the study: task-oriented culture dominates

In a power-oriented culture (Harrison, 1972), people want to make quick decisions. In a role-oriented culture, people want to make careful decisions. In a task-oriented culture, the higher goal is the priority and in a person-oriented culture, the person's own goal is the priority. The task-oriented culture dominates the building chain (37%), but other cultures exist as well. Cooperation among the parties should produce few problems, as they generally share the dominant culture. And yet we observe that the minor differences can lead to misunderstandings in practice;

- Project developers, consultants and designers are more likely to have a person-oriented culture;
- Suppliers, designers, consultants and builders are more likely to have a task-oriented culture;
- Corporations, fitters and governments are more likely to have a role-oriented culture.

Distribution of organisation culture types in the building chain



The good news is that the differences are relatively minor. With just a little effort, we should be able to understand the other parties.

Cooperation in the construction industry graded C-

Symbols, heroes and rituals are expressions of a particular culture (Hofstede, 1993). These aspects do not determine the culture and can change relatively easily. This study provides an overview of these cultural expressions by the various parties. The construction industry is generally an informal sector. People in the industry generally address one another by their first names. Informal meetings are relatively common in the industry. With the exception of project developers, few people wear suits.

Values are the core of any culture. The construction industry is an ambitious sector; almost 90% of the respondents state that they consider ambition to be healthy. Other results of the study are often entirely predictable:

- Meetings often last too long;
- We communicate a great deal via E-mail and not enough face-to-face;
- Internal political hassles are common;
- Managers are promoted from within the sector itself;
- The result is not the only thing that matters (with the exception of project developers (75%), suppliers (58%) and fitters (57%));
- We do not always understand other parties in the building chain. We give ourselves a satisfactory score, but designers and the government are known for understanding other parties poorly. ***We understand one another to a certain extent, but we do not fully understand one another's working methods;***
- ***We feel that we understand other parties better than they understand us.***

THE ENGINEER AS A TYPICAL PROJECT MANAGER?

Introduction: the engineer as a typical project manager?

In the previous section, we saw that construction management is dominated by a technical, Taylorian and especially instrumental approach. The culture is primarily results- and numbers-oriented and cooperation is hindered by exaggerated misconceptions of one another. The industry is beginning to realise this fact (Pries, 2009), and people are recognising that the old way of working is no longer sufficient; we are becoming aware of our limitations.

If this is true, then it should also reflect in the opinions of the project managers themselves. Do our project managers consider themselves well-equipped for their job? Using a survey of 130 project managers, we worked to find the answers to these questions. This was an emphatically introspective study of the self-image of a representative group of project managers, clients, builders and consultants.
In the following section we will argue that project managers will have to adapt to agile project management as the focus shifts from technical knowledge to culture and social skills. As stated before, agile can be applied to organizational management as well, but in this paper only agile project management is discussed.

From technical competencies to social competencies?
Competencies consist of characteristics, knowledge and skills (van Doorn, 2008). Characteristics are not easy for people to acquire or discard; either you have it or you don't. Remarkably, this category gets the highest score. Apparently, project management is not something that anyone can learn (see table below for details).

Project managers consider themselves able to deal with stress, honest, technically proficient (83% of the respondents has a technical background) and persistent. The average project manager is satisfied with his competencies; none of the competencies were rated unsatisfactory. Especially older project managers indicate that they have little that they still wish to improve about themselves.

Results for competencies (purple: characteristic. green: skill. blue: knowledge).

Which competencies do you consider important? Scale:		**Grade average project manager: Scale:**		**Which competencies would you like to improve? Scale:**	
Proactive	4.7	Deal with stress	7.5	Negotiating	3.4
Decisive	4.5	Honest	7.4	Managing conflicts	3.3
Communicative	4.4	Persistent	7.4	Risk management	3.3
Able to listen	4.4	Decisive	7.2	Inspiring	3.1
Honest	4.4	Intelligent	7.1	Leader	3.0
Team builder	4.3	Essentials of working in	6.9	Managing contracts	3.0
Persistent	4.3	Technical expertise	6.9	Managing surroundings	3.0
Essentials of working in projects	4.2	Proactive	6.8	Team builder	2.9
Leader	4.2	Disciplined	6.8	Communicative	2.8
Risk Management	4.2	Leader	6.7	Information & communication	2.8
Time management / Planning	4.2	Time management / Planning	6.7	Pro active	2.7
Deal with stress	4.2	Negotiation	6.7	Cost-benefit awareness	2.7
Information & Communication	4.2	Communicative	6.6	Disciplined	2.6
Inspiring	4.1	Cost-benefit awareness	6.6	Time management / Planning	2.6
Cost-benefit awareness	4.1	Contents plan of approach	6.6	Regulations & permits	2.6
Empathic	4.1	Inspecting	6.6	Able to listen	2.6
Conflict management	4.0	Procedures within your firm	6.6	Decisive	2.5
Organisation	4.0	Meeting	6.5	Organisation	2.5
Management surroundings	4.0	Team builder	6.4	Quality management & control	2.5

Negotiation	3.9	Organisation	6.4	Contents plan of approach	2.4
Intelligent	3.9	Information & communication	6.3	Inspecting	2.4
Managing contracts	3.8	Reporting	6.3	Empathic	2.4
Disciplined	3.8	Empathic	6.2	Able to deal with stress	2.3
Contents plan of approach	3.7	Managing contracts	6.2	Essentials of working in projects	2.3
Quality management and control	3.6	Managing conflicts	6.2	Meeting	2.3
Reporting	3.5	Inspiring	6.1	Reporting	2.3
Meeting	3.5	Managing conflicts	6.1	Persistent	2.1
Inspecting	3.4	Managing surroundings	6.0	Intelligent	2.1
Regulations and permits	3.3	Regulations and permits	6.0	Technical expertise	2.1
Procedures within your firm	3.3	Able to listen	5.9	Procedures within your firm	2.1
Technical expertise	3.1	Risk management	5.9	Honest	1.6

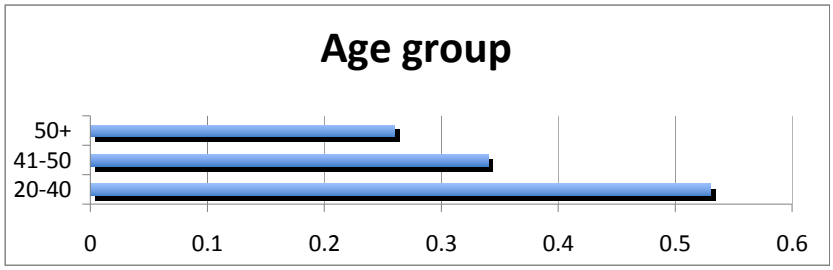
Social competencies: the male engineer as typical project manager?

Project managers give themselves a low grade for 'ability to listen', conflict resolution, empathy and ability to inspire. They also consider themselves poor team builders and mediocre leaders. This ‘human‘ or ‘social' side of project management is also the side that they would most like to improve about themselves, especially with regard to skills such as negotiation, conflict management and leadership. Older project managers in particular place more value on a proper technical background, and men consider it more important than women.

Which developments do project managers observe in the sector?
Project managers see that their environment is rapidly becoming more complex and that this development impedes their performance. Some of these issues include the project's immediate surroundings (for projects in the city centre), legislation, regulations, procedures, the number of parties involved and especially judicial matters.
More than 60% of the respondents have practical experience with an integrated contract, and almost 40% have experience with an even more intense form of cooperation. According to this study, older managers are more likely to implement innovative types of contracts than younger managers. This may seem logical, but younger managers generally consider themselves to have better social skills than older managers, and it is that competency that is vital for construction organisational models that require cooperation.

What differences in vision exist among the various project managers?
Do male project managers give different answers than female managers, and are there differences between younger and older project managers? Remarkably, there is a significant degree of consensus among the different project managers. Only a few points showed any significant differences. These will be dealt with per category below.

Young-Old (experienced-inexperienced)
Young managers prefer the human side of project management. They value communication more highly and think that good people and teams contribute the most to successful projects. They also prefer working for public organisations. As the graph below shows (1=100%), more than half of all young project managers work for public organisations, while only around 25% of the older managers work in public organisations.



Do women have better social skills?
Here we observed a number of remarkable differences. For example, men would like to improve their environmental management skills and their discipline, while women would like to be able to deal with stress and improve their leadership skills. The results indicate that women place a higher importance on, and give themselves higher scores for, 'social' competencies. They also indicate that their social competencies help them realise successful projects. However, when asked what they would like to improve, they state that they would like to improve their more technical competencies. Men answered this question in the exact opposite.

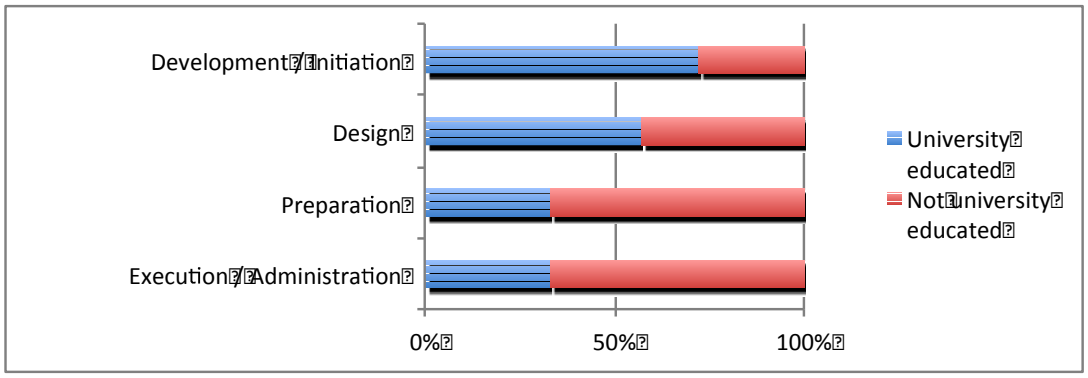
Women are more likely to work for clients; in fact, there was not a single woman in this study who worked for a contractor. The study also indicated that there were more female respondents in the younger categories. This may indicate that the percentage of female project managers in the construction industry is increasing, but it may also indicate that the more experienced women are leaving the industry. The women working as project managers today state that they are planning on remaining employed in the construction industry.

Clients vs. contractors.
Contractors are more likely to value expert knowledge and time management more highly than communication. Project managers working for clients give themselves a higher grade for managing their surroundings and communication. Contractors also think that ICT solutions will become more important to the construction industry in the future. As a result of the increase in innovative contract types, we might expect contractors to become increasingly interested in the competencies related to the design phase and cooperation. Some examples of these competencies include: interest in the end user, negotiation, communication and listening ability. However, the results point to the contrary.

Differences between the building process phases?
Project managers in the preparation phase place less emphasis on pro-activity and more on risk management. They also give themselves higher scores for managing their surroundings, organisation and quality control.

The question as to which factors contributed most to success did not produce significant differences; a remarkable unanimity of opinions across the board. The only extraordinary result was that project managers place a higher value on detailed procedures during the execution phase. In general, the managers do not differ significantly in their thoughts on project management competencies in the different phases of the project. Whether they work in the development or in the execution, they all had similar ideas of the function of project management. This may be one of the reasons why so many of the respondents can work in several phases of the project, or even all of the phases, at the same time. When we differentiate between the level of education in the different phases, it is clear that university-

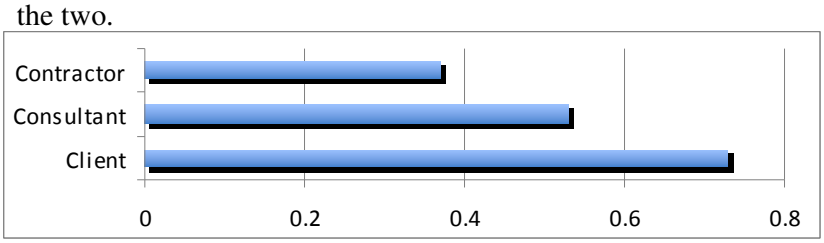
educated managers are more common at the start of the realisation process, while those educated at universities of applied sciences are more common at the end.



From the comparison between the project phases and the different age categories, we noticed the remarkable difference that older managers (50+) make up only a small percentage in the early phases, while the age differences are less pronounced in the preparation and execution phases. This corresponds to the results in that we have shown that older project managers place a higher value on technical expertise and less on the social skills required in the earlier phases.

How do project managers develop their competencies?
A number of questions in this study dealt with how the project managers developed their competencies. The section below will deal briefly with the results of these questions.

- Only 34% of the respondents works for an organisation that spends more than one day per month on personnel development. It would be interesting to compare these data with data from other sectors, such as the service sector. Only 18% of the respondents have a mentor.
- Project managers throughout the construction industry state that practical experience is by far the most important factor in their personal development. Remarkably, training courses receive higher scores than their own academic education.
- More than 30% of the project managers expect to move up to general management within their own organisations. Aside from the question of whether this is a realistic goal, we can ask ourselves if it is a desirable one. Should good project managers be promoted away from producing successful projects? We should make careers in the project management field more attractive.
- Managers are more likely to visit their superiors' projects than those of their juniors.
- The chart below shows that project managers working for a client are more likely to have a personal development plan (PDP) than their colleagues. This may be an indication that clients place a higher priority on developing their personnel. This difference was also observed between public and private employers. Aside from these categories, the study showed that approximately half of the respondents do not have a PDP. We should note, however, that a PDP is no guarantee for actual personal development, as there is no literature that shows any actual correspondence between the two.



- Despite the problems involved, the complexity of the work and the responsibility involved, project managers as a whole enjoy their work. They give their job an average score of 4.4 out of 5. 80% of the respondents state that they hope to continue working in the sector, 20% are undecided and none have any concrete plans to leave the construction industry in the future.

Some recommendations

The study was primarily descriptive, providing a sketch of the most important job in the construction industry - the project manager. And yet we can still formulate the following recommendations:

- A good project manager does not always have to be a male engineer! Women function well in innovative contract forms and in complex project environments. Organisations that do not recognise this fact are not doing themselves a favour.
- Contractors in the construction sector should pay more attention to developing their personnel. This may include more internal training courses, mentorships and personal development plans. Only 34% of the respondents work for an organisation that spends more than one day per month on personnel development. Only 18% of the respondents have a mentor.
- Educational institutions should examine whether they provide people with the proper competencies. Technical training has traditionally been very important in the sector, but the reality in the field shows that it may be desirable to reconsider the skills necessary for success. Notably: industry tends to critique the PBL forms, which especially train people skills.

CONCLUSION

In this paper, we asked whether project management is a discipline that is primarily characterised by a hard, instrumental approach and whether there are developments toward a more human- or culture-oriented approach.

We realise that this paper does not provide any definitive answers to this question, as the scope is too broad and the subject is too new. We then examined the literature on the subject and presented two studies. These studies, how valid they may be, are applicable only to the Dutch context. We are curious as to the experiences in other countries correlate with our findings. Based on the information above, we can present the preliminary conclusions below:

- In the years of reconstruction following World War II the project management field developed towards a hierarchical, instrumental management model. Procedures, systems and checklists were combined with a Taylorian management style; PRINCE2 and PMBOK are still popular project management models. One could say that this was a logical development considering the serial, quantitative assignments then common.
- Building has rapidly become more complex and project managers see that their environment has rapidly become more complex as well, which has made their job more difficult.
- An instrumental management model is ideal for simple, serial production methods, but this method is less suitable for more complex assignments. Project managers must be able to adapt to changing circumstances.

- One can conclude that these new construction assignments require new management paradigms, but that the existing paradigms are tenacious in their hold on managers' thinking (Doree, 2005). The dominant form of management is still Taylorian, hierarchical and instrumental. The dominant culture is still task- and results-oriented.
- The study shows that people from different cultures working within the same project still do not automatically cooperate well. There is often a lack of tolerance for other cultures. In fact, managers are often completely oblivious to the existence of other cultures. Each party expects the other to adjust to their culture, resulting in less than optimal cooperation.
- And yet there are some developments in the field. 'Lean' or 'agile' project management is clearly on the rise, at least in the literature on the subject. Within this 'movement', the human aspect takes precedence over the structure. Interaction is more important than process management and tools. Agile management is best coupled to the complexity of the project.
- The average project manager is satisfied with his competencies. Project managers on average give themselves a low score for the 'human' or 'social' aspects of project management. That is also the facet they would most like to improve about themselves; especially with regard to competencies such as negotiation, conflict management and leadership. This indicates a general trend towards more social competencies and away from purely technical expertise. Older project managers in particular place more value on a proper technical background, and men consider it more important than women. The issue is not who has the right idea. The technical side is and will remain important, but it is no longer the only solution. This implies that project managers do not necessarily have to be engineers. The project manager of the future will also have to have social skills. According to the project managers themselves, they still have a long way to go to achieve this goal.

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SUSTAINABLE RETROFIT POTENTIAL IN LOWER QUALITY OFFICE STOCK IN THE CENTRAL BUSINESS DISTRICT

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ABSTRACT

Given the relationship between energy consumption, greenhouse gas emissions and climate change, the built environment has significant potential to lessen overall emissions. With around half of all greenhouse gas emissions attributed to the built environment; it has a significant role to play in mitigating global warming. With large percentages of office stock structurally vacant in some city centres and only 1 or 2% of new buildings added to the total stock each year; the scope for reductions lay with adaptation of existing buildings. The stock with the highest levels of vacancy and obsolescence offers the highest potential of all.

Many cities are now aiming to become carbon neutral. Successful retrofit demands that social, technological, environmental, economic and legislative criteria are addressed. Buildings have to meet user and community needs. City centres comprise a range of different type of office stock with regards to age, size, location, height, tenure and quality. All buildings present challenges and opportunities with regards to retrofit and sustainability and integrating retrofit measures that reduce energy, water and resource consumption.

Using a selection of low grade office buildings to develop retrofit profiles, this paper addresses the questions; (a) what is the nature of retrofits in relation to low quality office building stock in the Central Business District (CBD) and, (b) what is the extent and scope for sustainable retrofits to low quality office buildings. Using Melbourne CBD retrofit events of low quality office buildings were analysed between 1998 and 2008 to identify the scope and extent for integrating sustainability into retrofits projects.

Keywords: office buildings, sustainability, refurbishment, building adaptation, Australia

Introduction

Building owners increasingly look to retrofit existing stock as a means of delivering sustainability in the built environment. Akin to many developed countries, Australia needs to increase the retrofit of existing office stock to reduce building related greenhouse gas emissions (Garnaut, 2007). This is recognised by the City of Melbourne who aim to bring about a carbon neutral city by 2020 with a goal of 1,200 building retrofits to deliver greenhouse gas reductions through sustainability measures (AECOM, 2008). Clearly not all buildings are the same, for example there is a great variance in building quality and some properties may experience greater levels of retrofit and greater frequency of adaptation (Wilkinson & Remøy 2011). The questions this paper addresses are: *(a) what is the nature of retrofits in relation to low quality office building stock in the CBD and, (b) what is the extent and scope for sustainable retrofits to low quality office buildings.*

Defining Retrofit

The definition of retrofit is derived from Douglas's (2006) definition of adaptation as: "*any work to a building over and above maintenance to change its capacity, function or performance' in other words, 'any intervention to adjust, reuse, or upgrade a building to suit new conditions or requirements";* it is a broad definition. Retrofit can occur to a whole building or to part of a building; for example, to one or more floors of high rise buildings. The definition encompasses within use and across use retrofits. The term 'retrofit event' includes all activity related to individual building permits on existing buildings. In the case of tenanted buildings, events can be referred to as alterations and extensions, upgrade, change of use and renovation; as such multi-tenanted buildings will experience multiple events in the one building. High rise buildings experience a greater number of retrofit events, though the value of scope of those events may be smaller. There are a plethora of terms used to cover retrofit such as adaptation, refurbishment, upgrade, conversion, renovation – all of which often exist in a 'state of happy confusion' (Markus 1979, Mansfield 2002). This paper examines the lower quality office buildings, the need to retrofit existing stock and the scope for enhancing sustainability through retrofit. One reason buildings are retrofitted is to meet tenant and owner requirements and low grade office buildings particularly need to adapt to changing preferences if they are to compete with newer sustainable buildings.

Building quality and office stock in the Melbourne market

Office stock comprises a wide range of different attributes such as size, age, space plan, configuration and physical condition which are taken as measures of quality. Office buildings are classified in the Australian market using the Property Council of Australia building quality matrix. The matrix uses different measures such as size of floor plate, number and speed of lifts; environmental rating under Green Star and or NABERS, quality of the entrance foyer and so on to determine the level a building is rated at. Buildings are rated from Premium, the best quality, sequentially through A, B, C and D. The lowest levels of building quality measured in the matrix are C and D grade. 'Premium' office buildings typically attract the highest rental levels with the highest capital values. However many office buildings do not have the Property Council of Australia rating and such buildings are likely to be owned by private individuals and do not form part of property investment portfolios. Initial analysis of retrofit activity in Melbourne CBD showed that action is largely focussed on the superior quality offices and that the C and D grade stock has the least activity (Wilkinson & Remøy, 2011). Given that C and D grade office buildings typically have the lowest levels of building quality, equipment and amenity there is a great scope for stakeholders to implement sustainability improvements The Melbourne CBD office market contains 3,608,258 square metres of lettable space, of this, 55.6% is Premium and A Grade quality, with 26.4% of Grade B quality with the remaining 18% being Grade C and Grade D (Savills, 2010). The situation is that a significant minority of offices is lower grade and less likely to undergo retrofit than its contemporary higher grade offices.

Sustainable retrofit measures

Sustainability is defined in the context of the triple bottom line where three components of economic, environmental and social sustainability are perceived as equally important. With buildings the emphasis is placed often on the environmental sustainability of the structure and fabric and the operational phase of occupation, with thought also to deconstruction and recycling opportunities at the end of the building lifecycle. Langston (2010) noted building

retrofit can deliver economic, environmental and social benefits to society, which should be at the forefront of thinking about existing stock.

The key environmental sustainability measures that can be considered in the retrofit of office buildings are energy efficiency, water efficiency, the reduction of waste, recycling and waste management, specification of low environmental impact materials and effective building operation and facility management (GBCA, 2010). Energy efficiency and reductions in building related greenhouse gas emissions may be improved by using high efficiency luminaires, high frequency ballasts and energy efficient lighting controls and purchasing 'green power' (Arup, 2008). Tenancy sub-metering enables the improved management of energy use. Depending on the individual building substantial improvements can be made with minimal costs through a housekeeping review, energy purchase, improved maintenance and re-commissioning building's services (Arup, 2008). Furthermore reusing existing buildings allows owners to capture the embodied energy already invested in the existing structure and fabric of the building, rather than commit new resources.

Water economy measures include installation of waterless urinals and 3/6 litre dual flush toilets, water efficient fixtures and water tanks to collect rainwater to flush toilets (GBCA, 2010). Such measures can reduce the environmental impact of buildings and are recognised by their inclusion in the environmental assessment tools used to evaluate the sustainability achieved in green buildings such as Building Research Establishment Environmental Assessment Method and the World Green Building Council's Green Star (Langston, 2010).

Other sustainability measures that may be adopted include reusing timber and using timber from renewable certified sources. Furthermore using carpets, paints, sealants, glues and adhesives with low Volatile Organic Compounds incorporates sustainable materials into buildings (GBCA, 2010). The provision of bicycle storage and shower facilities promotes the adoption of more environmentally friendly transportation. Clearly there are a range of measures which may be adopted and the list above is not exhaustive, however each building has to be assessed on its merits to identify specifically those parts which may be retrofitted with sustainability measures.

Social sustainability is a broader concept and relates to society, the community and /or individual people. The social sustainability of the building is considered by stakeholders and within environmental assessment tools. An illustration of social sustainability is the notion that sustainable buildings are healthier for users due to the specification of materials that do not contain chemicals detrimental to human health (Clements-Croome, 2006). Another example of social sustainability is building aesthetics where buildings having pleasing aesthetic qualities enhance surrounding areas and the environment in which they are sited (Ohemeng 1996, Zunde 1989).

A powerful argument for economic sustainability is the view that sustainable buildings are healthier buildings which result in less employee absenteeism due to sickness and higher productivity thus increasing the overall profitability of business occupiers (Clements-Croome, 2006). Given that typically businesses attribute about 85% of all costs to staffing; it is a powerful case. Lower operating costs within sustainable buildings are a further driver and potent reason for implementing sustainability, given increasing energy costs. It is evident that there is a close and often overlapping relationship between the three components of the triple bottom line.

Whilst it is possible, with a well planned retrofit, to increase the office quality grade and simultaneously increase the rental and capital value of the building; previous studies concluded that this is largely dependent on the condition and location of the building (Boyd et al 1993, Sinclair, Isaacs *(in Baird et al)* 1996, Swallow 1997, Snyder 2005, Kersting 2006). With regards to sustainability improvements, one UK study showed that post retrofit office buildings typically had lower running and operating costs than prior to the retrofit even if the retrofit did not have sustainability as a priority (Kincaid, 2002). Kincaid (2002) confirmed Wilkinson's global study of thermal improvements in office refurbishments (Wilkinson, 1997). The lower running costs accrue as a benefit of technological advances in building services since the original installation was provided. This reduction in running costs is a positive economic outcome for the party which pays for the operating costs, which can contribute to higher rental levels or higher capital values (Kincaid, 2002). Lower running costs result in less greenhouse gas emissions thereby reducing the overall environmental impact of the building. The potential for integrating a broad range of economic, environmental and social sustainability measures are explored in the context of the type and extent of retrofits that have been undertaken to C and D grade buildings from 1998 to 2008 in the Melbourne CBD.

Building attributes in retrofit

Earlier work identified attributes which are important or affect retrofit (Kincaid 2002, Snyder 2005). For a fuller discussion on building retrofit and building attributes readers are referred to Wilkinson et al (2009). This paper focuses on selected important attributes in the context of C and D grade buildings, sustainability and retrofit; the number of retrofits overall, trends over time, age, location, building quality, aesthetics, plan shape and operating and energy costs. Some of these attributes are associated with sustainability such as building quality as defined by the Property Council of Australia and described above. Premium grade offices typically have the best quality services for example the fastest lifts and air conditioning which results in high operating costs per metre squared and consequently high greenhouse gas emissions. However it is also true to say that lower grade offices with older services installations can have higher running costs on a per metre squared basis (PCA, 2008). Aesthetic qualities are a measure of social sustainability in the context of this research.

Age has an important affect on retrofit; as buildings age they wear out and need components repaired or replaced (Douglas, 2006). Barras & Clark (1996) and Baum (1991) argued the correlation between time and building obsolescence, establishing that as time passes retrofit of some form is necessary to avert a decline which otherwise leads to demolition. Previous studies considered location and its affect on retrofit as important; with some properties sited in favourable locations which enhances the frequency and likelihood of retrofit (Kincaid, 2002; Douglas, 2006; Highfield, 2000). Building location within a geographical area can be interpreted into zones, in Melbourne the CBD has five zones from Prime, Low Prime, High Secondary, Low Secondary to Fringe. The best location is Prime where the highest rental and capital values are found and there is a view that buildings in better locations are likely to undergo more retrofit (Swallow 1997, Ball 2002). Building quality is measured in various ways, it can be either provision of a greater number of amenity features, attributes and, or a higher standard of services, features, fixtures and fittings.

Ohemeng (1996) found that aesthetics was an important attribute in determining whether or not a building was adapted in his UK study of 400 building owners. Plan shape was an important attribute in retrofit and that some plan shapes such as deep plan shapes were easier

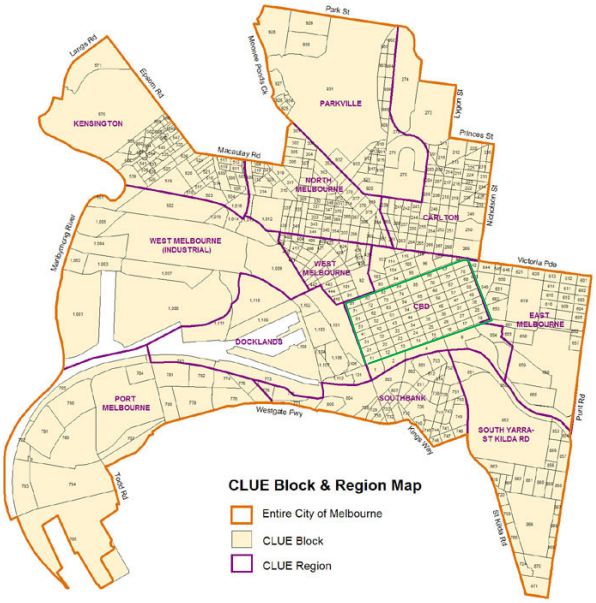
to adapt than others such as irregular shaped ones (Kincaid, 2002; Povall & Eley *in Markus*, 1979). Building height or the number of storeys in a building was found to effect retrofit in studies conducted by Povall & Eley (in Markus 1979) and Gann & Barlow (1996).

Research Approach

A database of office buildings was compiled to appreciate the nature of retrofit and the extent and scope for sustainable retrofit using multiple sources such as the commercial database Cityscope, and public databases such as PRISM (Victorian Government) and the Heritage database. In addition data from the Property Council of Australia, Google Earth and Google Streetview (www.google.com.au/maps) was used to gather building related data (PCA 2007). Information relating to retrofit events was derived from the records for building permit applications. Visual inspections and photographic records of CBD office buildings were carried out. The database contains records for 13222 retrofit events to commercial buildings from 1998 to 2008 and allows the researcher to provide an overview of what has happened on a CBD scale with retrofits to commercial C and D grade buildings.

Given the objectives; to understand the nature of retrofits to C and D grade office stock and the extent and scope for sustainable retrofit to C and D grade office buildings this stock only was extracted for analysis. The criteria used to examine the scope and the potential for sustainability in the retrofit were number of adaptations, location, building quality, aesthetics, plan shape and costs in use. As this study determines the nature of and the scope and extent for adopting sustainability in retrofits within the Melbourne CBD, details on the individual characteristics of the buildings is not examined or discussed. The results are a uni-variate and a bi-variate analysis of the data. The answer to the first question; *what is the nature of retrofits in relation to low quality office building stock in the CBD,* is given on the basis of a quantitative statistical analysis derived from the database and reflects the empirical reality. The answer to the second question is derived from the literature outlining different types of sustainable retrofit measures and their impact on building performance.

Figure 1 CLUE block and region map Melbourne



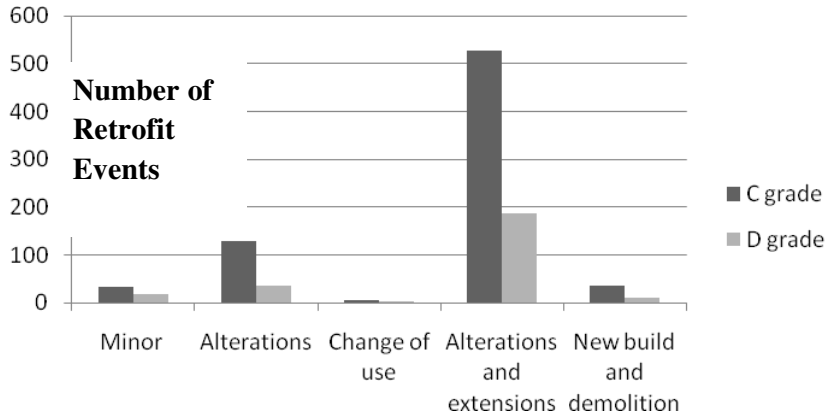
The research investigated activity in a developed, mature commercial market; the Melbourne CBD which was first set out in 1834 and has been continuously occupied. It is the most mature property market in Victoria with a diverse range of stock. The streets bounding the CBD area are as Flinders Street, Spencer Street, Spring Street and La Trobe Street highlighted in green in figure 1.

Results and discussion

All retrofit events to C and D grade buildings were analysed to ascertain the level of retrofits undertaken. A total of 978 retrofit events occurred to 197 C and D grade buildings from 1998 to 2008. Minor retrofits accounted for 5.8% of works, alterations 16.8%, change of use retrofit 0.8%, alterations and extensions adaptations, the most extensive level 72.8% and new build and demolition work accounted for 4.5% of works. This pattern maps closely figures for retrofits to all building grades. The most frequent level of work undertaken was 'alterations and extensions' retrofits which indicates a high level of confidence in the market to recoup the costs involved in the construction works, as well as the loss of income during the works in order to achieve higher rental levels post retrofit. It is indicative of the prevailing median age of 31 years of the building stock during the time period which means that buildings are at an age where retrofits are required to bring them up to market expectations (Jones Lang LaSalle 2005, Duffy in Brand 1994).

Examining the amount of all retrofits by Property Council of Australia building quality grade, Premium quality stock accounted for 12.9% of the works, with A grade at 20.7% and B grade recording the highest amount of activity at 27.3%; therefore 60.9% of the work is undertaken to the highest quality stock. Unclassified office buildings accounted for 24.2% of work, leaving work to the lowest quality stock the C and D grade stock accounting for 11.1% and 3.8% respectively. Within the Melbourne market there are lower vacancy rates for the prime quality office stock (Knight Frank, 2010) which implies that work undertaken results in higher levels of stock occupancy. Reviewing the retrofits to C and D grade stock to ascertain what level of retrofits are undertaken, more work occurs to the C grade stock overall and that alterations and extensions retrofits are most popular.

Figure 2 Retrofits to C and D grade offices and Property Council of Australia building quality grade.



Characteristics of the stock

Overwhelmingly the C and D grade stock has an irregular plan shape (48.2%), followed by deep plan configurations at 28.4%, with 17.1% having a narrow frontage and the remaining 6.3% being of a wide frontage to the street. The buildings retrofitted were purpose built for commercial usage, with only 13.8% having undergone a change of use prior to current use.

Brick was the primary façade or envelope material for 72.7% of buildings, followed by curtain walling (9.8%) and with concrete cladding and stone at 8.6% each. Opportunities exist for making changes to openings with brickwork construction and with overcladding for brick and concrete clad buildings. Brick and stone construction has high thermal mass and are relatively effective at heat retention and resisting rapid thermal gain when temperatures increase. There is scope for overcladding externally or retrofitting internally with insulated panels to improve thermal performance. Curtain walled buildings typically have poor thermal performance on the other hand, and great opportunities exist for improving energy efficiency with this stock. Significantly when visually inspected, 92.8% of the external envelope or cladding of the stock was in good or very good condition with only minor surface imperfections noted. There is little in the physical condition to drive owners to undertake alterations externally that could provide an opportunity to improve thermal performance. Furthermore when building appearance is evaluated 65.8% of events happened to buildings classified as aesthetically pleasing, with 17.2% classed as neither 'beautiful' nor 'ugly'. This result confirms Ohemeng's (1996) study that more attractive stock is retrofitted compared to less attractive buildings. However given that 17% of retrofits were undertaken to buildings classed as 'ugly'; there is scope in around one in five C and D grade retrofits to update and improve external appearance and thermal performance.

When the location of the vertical services core is considered, 48.8% of events occurred in buildings with multiple services cores, followed by 31.6% with central locations. This implies that these buildings undergoing the highest frequency of retrofit are those which are more amenable to different configurations of space plan on individual floor levels, a finding supported by (Arge, 2005).

The C and D grade stock is predominately of single land use; that is 63.5% of events occurred to buildings classed solely as offices. However a large minority of 35.3% were office and retail land use, with the remaining 1.2% classified as office and residential land use. Ownership of mixed use properties can make retrofits to the external envelope complex particularly with residential land use. Here buildings without a mixed land use undergo more frequent levels of retrofit possibly because less negotiation is required with co-owners and other stakeholders. This has implications in future as more mixed use buildings appear in city centres; especially under planning policies encouraging mixed land use combining residential and office uses.

Where regulatory requirements are concerned, 67.7% of retrofits occurred to buildings with no listing or heritage overlays. Owners of non listed stock are more likely to undertake retrofit and municipal authorities need to consider programmes to incentivise owners of heritage stock to adapt. Having stated this, older heritage stock has high levels of embodied energy and were constructed using traditional methods and materials likely to have high thermal mass and relatively good thermal performance.

Given that as buildings age, they require retrofit (Barras & Clark 1996, Langston et al 2007), the age of buildings undergoing retrofit was examined with 20.4% of all events occurred to buildings less than 25 years of age. The largest number of events occurred to buildings aged 26 to 50 years, where 48% of events were undertaken. Buildings aged 51 to 75 years accounted for 12.6% of events, with 11.3% occurring to buildings aged 76 to 100 years and the remaining 7.7% of events occurred to buildings aged 101 to 152 years. Clearly C and D grade stock undergoes most retrofit activity during the 26 to 50 year period. It is possible that owners of this lower grade stock are inclined to wait as long as possible before paying for retrofit works as opposed to being keen to maintain a position within the market place. When the whole stock is analysed the median age for retrofit was 19 years. 15.8% of events occurred to 40 year old C and D grade stock.

Arge (2005) found that the potential for lateral and vertical extension of a building greatly enhanced it's desirability for retrofit. Not surprisingly none of the Melbourne stock had potential for lateral extension because entire sites were built out. Scope for vertical extension was based on an analysis of the structural frame type and condition of the property and 25.9% of retrofit events could support vertical extension, planning permission permitted. Depending on planning density requirements there is scope to increase net lettable floor area of CBD offices in over a quarter of retrofits to C and D grade stock, whilst retaining original structure and fabric and the associated embodied energy.

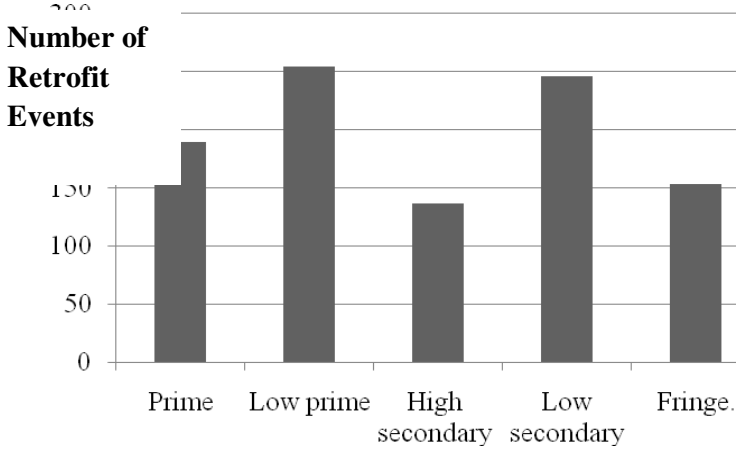
Arge (2005) noted that the degree of attachment to other buildings was important in determining the level of disruption to tenants of adjoining properties during retrofits. Most retrofits occurred to buildings attached on two sides (34.4%) closely followed by 31.9% to detached buildings. Only 15.4% of events took place to buildings which are attached on three sides and Arge's (2005) finding is supported. The authorities could consider incentivising retrofits to buildings which are enclosed by others to increase retrofit activity within this type of stock.

Access to the building was important in determining the ease of delivery of construction materials and retaining tenants in situ where necessary during retrofits (Arge 2005). No C and D grade retrofits occurred to buildings with access on all sides. Most retrofits occurred to buildings with access from the street front and side (35.2%), followed by street only access (27.3%) which contradicts Arge's (2005) findings. Fewer than one in five (19.2%) events took place to buildings which have access from street, side and the rear of the property. Finally 18.3% of events occurred to buildings having access from the street and rear of the building.

Building location is perceived as important in determining whether retrofit occurs (Swallow, 1997). Interestingly most events (25.9%) occurred in the Low Prime location which suggests that owners are conscious of the benefits of the location and strive to keep up with retrofit activity in higher quality stock (figure 3). Events in the Prime location accounted for 19.3% of all retrofits which is likely to be associated with the higher levels of activity generally in these areas. There is a distinct drop in High Secondary location activity where 14% of events occurred. However the activity rate increases in Low Secondary locations where 25.1% of retrofits took place; it is likely that these retrofits are what Chandler (1991) termed 'distress' retrofit where owners are obliged to undertake works to meet statutory requirements and to attract and retain tenants. Finally activity in the least desirable location of all, 'fringe' showed only 15.6% of events indicating that the lowest quality stock is largely unworthy of retrofit. The implication for policy makers is that incentives should target improving the stock quality

in the fringe locations where there is clear scope of improving building performance and reducing building related greenhouse gas emissions.

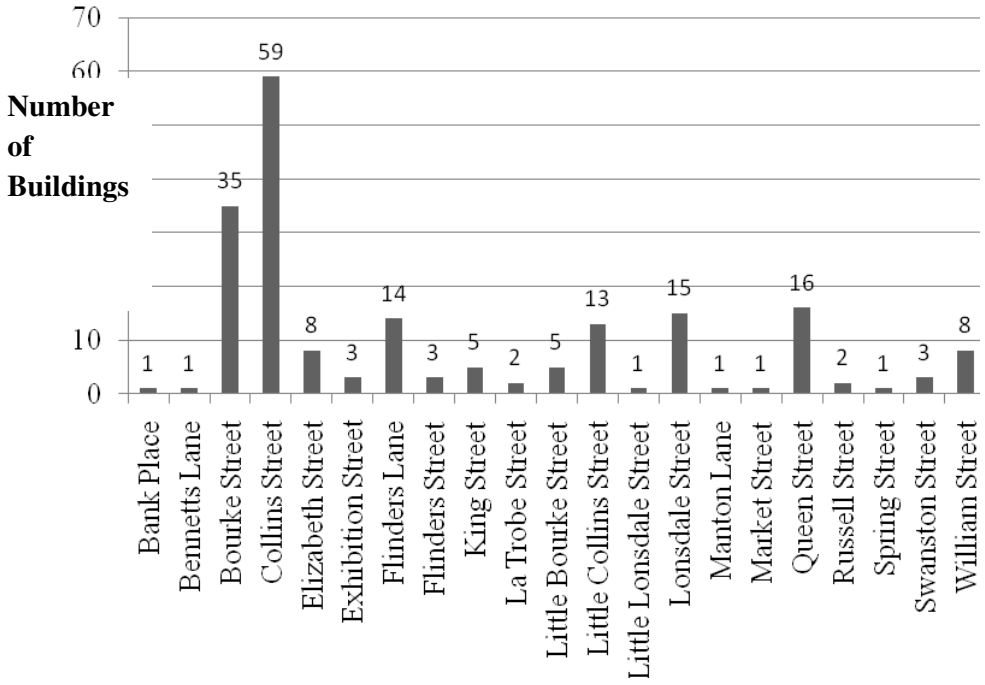
Figure 3 C and D grade building retrofits and location



CBD Location

Another way of examining location and retrofit activity is to investigate activity by street address. In this instance, the retrofits happen primarily in two streets; Collins Street and Bourke Street. Figure 4 shows retrofits to individual buildings by street address; note that many buildings experienced multiple retrofit events from 1998 to 2008.

Figure 4 C & D Grade buildings adapted by street



Street Address

Sustainable retrofit

On the basis of Property Council of Australia building quality grade, it is possible to assess cost in use. The Property Council of Australia publishes data with regards to median gross income, and the costs of operating expenses, energy and water consumption based on grade (Property Council of Australia 2008). As expected gross income on a per metre squared basis is correlated to building quality with C grade stock grossing $274.01 per square metre compared to $395.92 per square metre for Premium and A grade stock and $300.95 per square metre for B grade stock (Property Council of Australia, 2008). No data is available for D grade buildings. The gap between income for C and B grade is narrow compared to the gap between B and A / Premium stock and possibly deters owners of C grade stock from high capital expenditure on improvements which may not lead to a substantial increase in gross income.

When operating expenses are examined no data is available for D grade stock, however C grade stock is more expensive to operate on a per metre squared basis at $73.35 per square metre compared to $62.11 per square metre for Premium and A grade and $54.17 per square metre for B grade (Property Council of Australia, 2008). Clearly there is scope to retrofit the buildings with energy efficiency measures to reduce these high operating costs. It is clear that any retrofit replacing worn out services will result in significant energy saving simply because the quality of replacement fittings far exceeds that of existing fittings (Wilkinson, 1997. Kincaid, 2002).

The costs of electricity consumption is highest in C grade stock at $25.93 per square metre, compared to $21.70 per square metre for Premium and A grade buildings and $19.72 per square metre for B grade stock. Even though the level of building services amenity, such as air conditioning and high speed lifts, is lowest in C grade stock; the cost of electricity consumption is highest. This is a result of the age, condition and efficiency of existing installations. Clearly there is an opportunity to reduce electricity consumption per metre squared to levels significantly below the higher quality stock with their intensive use of building services (Property Council of Australia, 2008). A similar picture emerges where gas consumption is considered. The costs of consumption is highest in C grade stock at $3.33 per square metre, compared to $1.29 per square metre for Premium and A grade buildings and $1.55 per square metre for B grade stock. Retrofit aimed at improving efficiencies in the existing gas installations will lead to lower levels and costs of consumption. Where water consumption is concerned a similar situation exists. C Grade stock has the highest costs associated with consumption at $3.51 per metre squared, compared to Premium and A grade at $3.34 per metre squared and B grade at $2.49 per metre squared (Property Council of Australia, 2008).

Swallow (1997) stated the type of building owner was an important factor influencing retrofit. Over 60% of events occurred to C and D grade stock in private ownership, where the breadth and depth of professional advice offered to and taken up by owners is unknown. Institutionally owned stock is likely to be professionally managed and accounted for 37% of events. It is considered these owners are more likely to consider sustainable retrofit compared to private owners. There is a significant opportunity to develop a programme to educate owners of C and D grade about the benefits of sustainable retrofit in terms of increased capital and rental values and to assist them financially to implement measures. No C or D grade buildings in the database had NABERS, Green Star or ABGR environmental ratings highlighting the environmental quality gap in this stock. This gap needs to be addressed by

policy makers as it will further encourage the evolution of a two tier market of buildings perceived to be either sustainable or non sustainable.

Conclusions

The questions this paper addresses are: *(a) what is the nature of retrofits in relation to low quality office building stock in the CBD and, (b) what is the extent and scope for sustainable retrofit to low quality office buildings.* There are some clear findings from this analysis;

a) Most retrofits are extensive; alterations and extensions adaptations,
b) C and D grade is least likely to be adapted,
c) Vacancy rates are higher in C and D grade stock,
d) Most retrofits occur in Collins Street and Bourke Street,
e) Retrofits largely occurred to buildings with irregular plan shapes, brick facades and envelopes, with multiple service core locations, classed as office land only, without heritage listing or overlay issues, aged between 26 and 50 years, attached on two sides or detached and in private ownership.

With the C and D grade stock there is scope to;

a) Overclad brick facades and envelopes to improve thermal performance, though given the good condition of stock overall building owners will need encouragement.
b) Reduce the relative high operating costs, electricity and gas consumption costs through sustainable retrofit.
c) Decrease water consumption costs through sustainable retrofit.
d) Over a quarter of retrofits could support vertical extension, planning permission permitted, to increase total area whilst retaining existing embodied energy.

Additional issues raised in this study are;

a) Owners of non listed stock are more likely to adapt and authorities need to consider programmes to incentivise this group.
b) Buildings with office land use only undergo more frequent adaptations. This has implications in future as more mixed use buildings appear in city centres.
c) The gap between gross income for C and B grade is narrow compared to the gap between B and A / Premium stock and possibly deters owners of C grade stock from capital expenditure on improvements which may not result in substantial increases in gross income.
d) To educate owners of the benefits of sustainable retrofit in terms of increased capital and rental values and to assist them financially to implement measures.
e) Authorities could incentivise retrofits to buildings which are enclosed by others to increase the rate of adaptation.
f) Incentives could be targeted at stock in fringe locations where there is scope to improve performance while reducing building related greenhouse gas emissions.

There are distinct differences in the patterns of retrofit based on building quality, as there are similarities, such as the level of retrofit and the locations in which work is undertaken. Sustainable retrofit measures have been identified on a CBD wide scale with specific stock characteristics offering the best potential for retrofit affirmed. The characteristics embody the facets of the economic, social and environmental aspects of the triple bottom line identified previously. Finally the results reveal clear evidence that an environmental quality gap is

appearing in the C and D grade stock which needs to be addressed as part of an all encompassing approach to improving the entire building stock.

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PARTNERING AND THE TRADITIONAL: INSTITUTIONAL DETERMINANTS OF GOVERNANCE IN DANISH CONSTRUCTION

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Abstract
Projects have traditionally been constituted by contracts, whose enforcement is held in place by governance mechanisms that involve high degrees of surveillance. In this light, partnering is advocated as a project specific, communicative alternative to this traditional legal coordination process of the construction industry. In a Danish context partnering has, however, so far not been able to offer a well-defined alternative to this traditional regulatory governance frame. However, rather than providing a well-defined alternative, in this paper we argue that partnering can be seen as a nullification of the traditional, i.e. as a counter-concept to a juridico-discursive conception of project governance that otherwise has been instrumental in organizing and coordinating various aspects of the construction process according to a more or less taken-for-granted regulative schemata of institutional order. Accordingly, it is suggested that the effects of partnering in the first instance stem from a series of interventions in the institutional and regulative context of the construction process, and that future case studies could benefit by paying closer attention to the institutional determinants of management thinking and practice.

Keywords: Collaboration, partnering, institutional history, governance, the traditional.

INTRODUCTION: PARTNERING AND THE TRADITIONAL

In this article, we explore how the concept of partnering has emerged and become institutionalized as a certain governance form in Danish construction. Our main argument is that partnering should be seen as a thoroughly historical phenomenon that constitutes a counter-concept to a 'traditional' *juridico-discursively* institutionalized way of governing project delivery, which rests on a strong technical-rationalistic thinking. By means of an institutional history approach, we trace the development of partnering and point to the processes through which partnering has become problematized, articulated and institutionalized.

In Denmark as well as in the rest of Europe, the last two decades have seen a proliferation of change initiatives and new ways of working that have taken as their starting point and main objective to improve the industry's productivity and level of innovation by changing traditional ways of working. Flanagan *et al.* (1998: 15) have thus argued that: "*[e]veryone agrees the industry must respond to the customer's demands instead of continuing to offer the*

traditional approach" and (Fernie et al., 2006: 94) have argued that new management ideas (*cf.* Bresnen and Marshall, 2001) or change reforms are continuously and increasingly launched in an attempt to abolish: *"…the 'illnesses' of the sector […] [and the] 'traditional bad ways of both thinking and practice'"* (Fernie et al., 2006: 94).

However, what this notion of the 'traditional' refers to is somewhat difficult to get a firm grasp of, especially if we are on a quest for unambiguity and clear-cut definitions. Taking much contemporary construction management related literature as a starting point, we would argue that there are just as many understandings of the 'traditional' as there are concepts and new management ideas proposed. In fact, it would appear that each of the solutions to the construction industry's problems, *i.e.* each of the proposed treatments to the industry's illnesses, carries along with it a diagnosis and problem representation that is more or less explicitly formulated and valid in terms of its ability to mirror an actual social problem. Paraphrasing Cohen *et al.* (1972), we would argue that new management ideas at large whether BIM, partnering, lean, Business Process Reengineering (BPR), etc., are solutions looking for or indeed defining a problem.

As an example, Green and May (2003) argue that the BPR wave of the 1980s and early 1990s addressed the construction industry as a backward industry compared with other industries and constituted 'the traditional' in terms of an unresponsiveness towards the "*...customer in the marketplace."* (Green and May, 2003: 104). In the case of partnering, we are faced with a situation in which trust, openness and mutuality are constituted as the cure to the adversarial, conflict-ridden nature of the industry, where time-honored practices, process technologies, qualifications and forms of organization have established a cultural and social hegemony, which has to be broken for the sector to advance into the 21st century (ATV, 1999).

Even though we can argue that new management ideas and concepts shape industry discourses and are constitutive of social practice they do, however, not just appear from nowhere. Several different models of explanation can be applied. Some would argue that the emergence of new concepts in a given institutional field can be understood analytically as a result of a transition from one institutional 'logic' to another (Friedland and Alford, 1991), whilst others would opt for more structural or evolutionary explanations (*cf.* Geels, 2010). In this paper, we take an institutional history approach to the study of the emergence and institutionalization of the concept of partnering in a Danish context.

While there might be consensus on what partnering as a surface phenomenon entails, e.g. trust, openness, economic incentives, etc. (cf. Nyström, 2005), this paper aims at providing an understanding of how such concepts and elements in the first instance become part of an institutional vocabulary. Thus, the objective of the paper is to provide an input to how regulatory industry change takes place, and how the determinants of a certain management/ governance knowledge and practice become institutionalized in a certain context.

INSTITUTIONAL HISTORY

We take as a starting-point the notion that society and all its subsystems, including and most relevant for this paper the various national construction business systems, should be seen as institutional constructions. Following March and Olsen (1984), we observe political institutions not just as the aggregate consequences of individual behavior, but as ordering and constitutive forces; that is as shaping mechanisms for conditions of possibility and thus positions from which subjects can observe themselves as rational actors (Andersen, 1995). In

this paper we will not discuss the question of why to apply institutional theory, but address how an institutional analysis can be conducted on a specific field. In doing so, we have chosen to follow an institutional history approach as advocated by e.g. Andersen (1995; 2003).

In essence institutional history is an approach to the observation of the institutional construction and the possibilities and limitations it entails (Andersen, 1995: 258). The crux of the argument is that institutions are endowed with a certain taken-for-grantedness: *"...Institutions are taken for granted, then, in the sense that they are both treated as relative fixtures in a social environment and explicated (accounted for) as functional elements of that environment."* (Jepperson, 1991: 147).

Institutional history therefore becomes an approach with which to problematize and question contemporary institutions by referring them to the conditions of hegemony and power under which they are established (Foucault, 2001). Institutional history consists of two juxtaposed analytical constituents: a diachronic and a synchronic analytical perspective. With the diachronic analysis, we are interested in establishing the system of transformations that constitutes change, whereas the synchronic analysis is concerned with describing the unity of the system at a given point in time.

Two perspectives: diachronic and synchronic analysis

The diachronic analysis is concerned with the analysis of the constitution of institutions. Inspired by Andersen (1995) and Kjær (1998) we observe the analytics of institutional history as consisting of the following processes and elements:

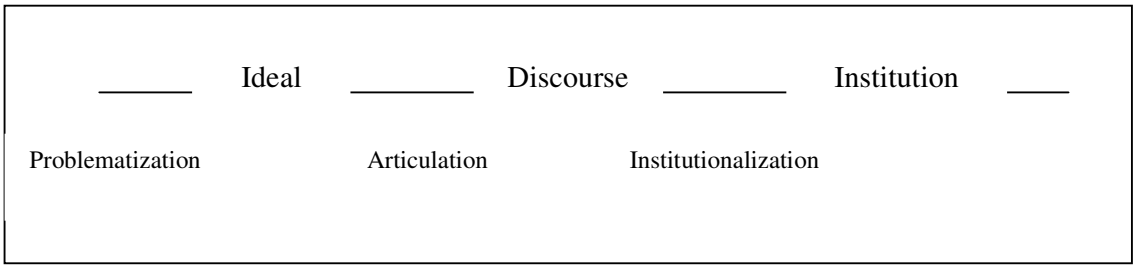


Figure 1: *Three steps in institutional history (adapted from Andersen, 1995: 263).*

An *ideal* is an anchorage point for a discourse. It is the point of convergence for the processes of problematization, or in other words, the creation of mutual awareness of a common enterprise (*cf.* DiMaggio and Powell, 1991: 65). An ideal is an idealized conception of a social field on the basis of a set of constitutive distinctions (Kjær, 1998: 7). A *discourse* is based on an ideal. The transition from ideal to discourse takes place through processes of articulation and discursive formation. A discourse can be seen as a set of rules that govern the formation of subjects, objects, concepts and strategies and constitutes: *"…the stuff beyond the text functioning as a powerful ordering force."* (Alvesson and Kärreman, 2000: 1127). The transition from ideal to discourse entails a process of autonomization of the ideal in which the relations between objects, subjects, concepts and strategies that otherwise have been articulated from another discourse become reordered. Finally, an *institution* is seen as a stabilization and formalization of the relations of power and authority constituted by discourse. According to Scott (2003) institutions can be seen as social structures that have attained a high degree of resilience and are able to inform social interaction. Institutions consist of both regulative, cognitive-cultural and normative elements. Institutionalization, then, denotes the process through which discursively articulated ideals are authorized, attain a

basis of legitimacy and secure resources. The diachronic analysis thus becomes an analysis of how new ideals are formed, articulated and institutionalized, and how of breaks and ruptures in an established discursive order take place.

Where the diachronic analysis is concerned with the deconstruction of differences, the synchronic analysis seek to create unity and pinpoint the mechanisms at play in in given social fields. The synchronic analysis of institutions, then, is the analysis of how historically constituted institutions function as a pattern or principle of organization. Or as Kjær (1998) puts it: Where the diachronic perspective *"…may bring to the fore "the conflict-laden processes that define fields and set them upon trajectories that eventually appear as "natural" developments to participants and observers alike" (DiMaggio, 1991: 268)""* (Kjær, 1998: 5), with the synchronic analysis we are interested in identifying field level mechanisms that produce sub-field effects.

Below we will apply these two perspectives of institutional history in an analysis of the development partnering. The paper sets out to analyze how partnering in Denmark the last 15-20 years has developed as a counter-concept to a traditional hegemonic *juridico-discursive* institutionalization of construction project governance. This is accomplished through a diachronic analysis of debates and controversies from 1990 to present day. Then, in conclusion, we shift focus to a synchronic analysis how a new institutional order is shaped as a result of a negation of the traditional institutional ordering of the construction industry. In the analysis, we focus first and foremost on the regulative context and on how partnering has become a legitimate practice in Danish construction while downplaying questions of how partnering become taken-for-granted on an everyday project level. These more normative and cognitive-cultural elements of the institutionalization process will, however, be illustrated by pointing to how certain hegemonic discursive elements become problematized and reordered in the development of partnering.

AN INSTITUTIONAL HISTORY OF THE DEVELOPMENT OF PARTNERING

The Danish partnering policy development was formally launched in April 1998, when the Ministry of Housing and Urban Affairs published their construction policy action plan (BM, 1998), which for the first time mentioned the term partnering as a new form of cooperation in an official government document. However, the emergence of partnering dates back a few more years, at least to 1990 where a number of actors attempted to put the inter-linked problem of cooperation of productivity on the political agenda. The following analysis will thus start in 1990 and continue up to 2007, where partnering has become rather stabilized and formalized as a regulative phenomenon. The analysis will focus exclusively on the Danish establishment of partnering, and not take into consideration the progress in other Nordic or European countries, neither when discussing international influences on the Danish development, nor in relation to the 'cultural traffic' of national principles and recipes across nation states.

The analysis will be presented in three sections, analogous to the analytical framework presented above. First, an analysis of the policy development in the early 1990s leading to a description of how productivity was problematized and collaboration seen as an ideal. Second, we highlight how certain conceptions of the solutions to the problems were articulated and established. This account will also point to the central actors in the national debate on new forms of collaboration. Third, we focus on how various institutional

arrangements have been set up and become stabilized to deal with the problems of collaboration in guise of the concept of 'partnering.'

Problematizing productivity and the 'traditional'

The last 20 years the Danish construction industry has been subjected to a series of industry level development initiatives, one of which is partnering. The precondition for the different initiatives was an industry level problematization in the early 1990s, which framed the Danish construction industry as a coherent institutional field in need of strategic intervention.

This problematization was initiated by the Danish Building Development Council (BUR, 1990) who released a report on the productivity of the Danish construction sector. This report, which played an integral part in the following year's debate on the problems of the sector, documented that the resource use in the construction of a housing project had almost doubled from 1969 to 1986. Based hereon, it was concluded that although the complexity of the construction process had drastically increased, something had to be wrong with the way in which the construction industry in its totality was organized. The report thus rejected more local interpretations of the productivity problem, by framing productivity as a problem pertaining to the overall sectoral organization of the industry.

This field level problematization was further strengthened in 1993, when a series of working groups under the Ministry of Business and Industries published eight resource-area analyses, which said to: *"…draw a picture of the Danish business conditions and put the development opportunities in the 90's into perspective."* (EfS, 1993: 7). The aim of these analyses was to establish a new and forward-reaching basis for the future business policy in Denmark. The work triggered a series of attempts to put productivity and innovation on the agenda, and perhaps more important: to do so from a resource area perspective. The construction/housing area was identified as one of these resource areas, and it was described as rather peculiar or idiosyncratic when compared to other industries, most prominently the manufacturing industry.

A distinctive trait identified in the analyses was that the production in the on-site construction-market segment was said to be characterized by fragmentation and discontinuity in the form of changing collaborative constellations at different locations each time. The construction sector was furthermore characterized as a distinct home-market business with great dependency of the public sector both as a purchaser and as regulative authority. The analysis therefore pointed to the need of increased competitiveness of the industry through a streamlining of the construction process and vertical collaboration in the delivery system (EfS, 1993: 13). In summary, four central problems were identified pertaining to:

- Internationalization: Companies lack competencies and capital strength to enter foreign markets.
- Transition: Companies lack the abilities and production methods to operate within more than one market segment.
- Collaboration: Increasing future price competition leads to demands to increased long-term collaboration between companies in order of developing the industry's productivity.
- Innovation: Limited strategic process and product development and collaboration between manufacturers and construction firms.

In essence, the problematization processes of the early 1990s established a distinct industry level perception of the innovation and productivity challenges, and in the following decades

this problematization framed and catalyzed multiple activities aiming at producing coherent industry level solutions to the four challenges.

One of the most influential political measures utilized in these activities was the idea of the public sector as purchaser. The public sector was envisioned to use its collective buying power to force new technologies onto the market, as the current technological totality of the construction sector, comprising *"…the complex of scientific knowledge, engineering practice, process technologies, infrastructure, product features, qualifications, and procedures"* (EfS, 2001b: 71, own translation), had created a lock-in situation, which the primary actors themselves were unable to exceed. A prevailing conviction was accordingly the need for strong governmental involvement, and rather than working from the premises that the market could regulate itself, the basic point-of-departure was that there was the need for strong public intervention - much as it was the case in the immediate post-WW2 period (Gottlieb, 2010).

Articulating the ideal of collaboration

While the problematization processes of the early 1990s succeeded to establish a distinct industry level perception of the innovation and productivity problems, more challenges were encountered as the industry level diagnosis had to be translated into organized development efforts at local levels. The immediate effect of the industry level problematization led to a proliferation of largely uncoordinated and experimental articulation and development processes, and although these activities represented largely uncoordinated responses in relation to the industry level problematization, they also generated a series of discursive elements, which later became a resource for the articulation of more coherent responses to the problematization.

Utilizing the discursive elements as resources, several ideals thus were mobilized - each claiming to deliver an integrated industry level response to the challenges of productivity and innovation. Beside the ideal of collaboration, which is analyzed in more detail below, the elements included different types of industrialization and digitalization efforts. The immediate effect of the industry level problematization was, however, a strategy to launch three large scale development programs: Project Refurbishment, Project House, and Project Productivity with the below foci:

	Project Refurbishment	**Project House**	**Project Productivity**
International market development			
Demonstration projects	x	x	
The public sector as purchaser			
Development contracts	x		x
Development projects		x	x
R&D and information-infrastructure			
Strategic research program for construction	x	x	x
Other ministries	x	x	
Integrated business promotion			
Business support	x	x	x

Figure 2: *Main areas of action in the three core programs (EfS, 1993: 16).*

In effect, the most important of these programs turned out to be Project Productivity whereas the other programs had less effect. Project Refurbishment was highly experimental and

consisted of approximately 100 individual demonstration projects; however, due to the experimental design of the program, the strategic effects were marginal. Product House, on the other hand, was oriented towards a large-scale strategic intervention, but was never fully realized, and after an initial idea phase, the initiative was terminated.

It was therefore Project Productivity, whose 'public sector push' strategy, combining issues of productivity with collaboration that paved the road for the initial development of partnering as a strategy for increasing the productivity of the sector. This initiative was initiated in March 1994 when the Ministry of Housing and Urban Affairs invited the actors of the building industry to take part in a competition on process and product development (Clausen, 2002: 108). By November 1994 four consortia were appointed to participate in the program and carry out the suggested development programs and demonstration projects.

One consortium in specific can be seen as the paradigmatic case for the introduction and development of partnering in a Danish context: the so-called PPU-consortium. This consortium set out to make the building process more efficient by realizing vertical integration between project designers and contractors (EfS, 1997: 5). The central contribution from the PPU-consortium was the development of a new 3-stage phase model (see Figure 3) to replace the traditional phase-model, which was introduced by the association of engineers and the architect's association in a white paper in September 1968 as a response to the Ministry of Housing's launch of a fixed price/time circular that effectively subordinated the engineers and architects to the control of the client (Gottlieb, 2010: 172).

Traditional process	PPU-process
Construction client's program	**Construction client's program**
1. Project disposition suggestion	**1. Program project**
Collaboration between client, consultants and authorities	Collaboration between client, consultants, contractor and authorities
2. Project proposal	**2. Project proposal**
Collaboration between client, consultants and authorities	Collaboration between client, consultants, contractor, subcontractors, manufacturers, suppliers and authorities
3. Scheme design	**Contracting**
Collaboration between consultants and authorities	
4. Final design	**3. Execution project**
Collaboration between consultants	Collaboration between consultants, contractor, subcontractors, manufacturers and suppliers
Call for tender – Award – Negotiation	
Contracting	
Execution	**Execution**

Figure 3: *Differences between the traditional project design process and the PPU-process (EfS, 2001b: 29)*

The 3-phase model was formulated as an attempt to establish an overarching and systematic frame for all relevant parties in the project design phase. This included e.g. a staged contract formation with the construction client and most importantly a focus on economic clarification in the very early parts of the project. In contrast to the traditional phase-model, the recast 3-phase model was articulated as a means to ensure integration between the consulting and the

producing parties and as a means of involving clients and contractors more actively in the design process.

In the debate of this new conceptual model concerns were, however, raised by clients, contractors and architects alike in relation to areas of responsibility (EfS, 1998). The 3-phase model was articulated as a dilution of the certainties required for rational governance that had been the rationality of the traditional phase model with its unequivocal assignment of roles, tasks and responsibilities. Thus, where the traditional phase-model, with its fixed and *juridico-institutionalized* responsibilities, previously had been seen as the ideal political technology needed for the unequivocal and effective production of projects, the proposed 3-phase model was put forward as an attempt to recast the functionally differentiated construction industry that had evolved as a consequence hereof. Other principle concerns were, however, also raised towards the consortium's remuneration scheme, price formation model and use of open project finances, which were said to bypass all safeguarded 'good practices' of project governance.

Moreover, where the PPU-consortium succeeded in empowering the contractor in the early phases of the process, to such an extent that vertical integration was articulated as turnkey contracting in a new guise (EfS, 1998: 3-7), the client was not placed in the central role envisioned from the outset of the program. The reason for this was argued to rest on the fact, that the client's role was not formulated in binding terms (EfS, 2001a: 6). In contrast to the 1950s and 1960s construction development agenda, which to large extent had dictated the clients' room for maneuver through laws, executive orders and circulars, requiring the clients to conform to certain requirements and conditions in order to achieve finance (*cf.* the 1953 circular on state loans for non-traditional buildings (Indenrigs- og Boligministeriet, 1953)), a turn can be observed in the Project Productivity program. Here the client was discursively constituted as an active player in the creation of new markets and products. This turn was instigated as a response to the drastic decrease in public expenditures for social housing, which was experienced from the 1980s onwards, where the ratio of social housing to total building volume dropped from 26 pct. to 10 pct. Thus, productivity could not be coded in terms of capital intensification, mass production and expansive economics in the housing segment as was the case previously. Rather, with the absence of a regulated market absorbing mass commodities, a strategy of co-production was articulated as a way of breaking the deadlock.

Interestingly, all of the above discursive elements that were articulated as cause and solutions to the lock-in situation represent a move away from traditional, safeguarded *juridico-discursive* governance mechanisms. As such, we argue that the discourse underlying the development process was based on discursive negation of the hitherto predominant practices of construction.

Partnering: institutionalizing collaboration

Based on the preceding analysis of the problem of productivity and the articulation of the ideal of collaboration, in this section we discuss how the institution of partnering has emerged. We outline three events in the institutionalization of partnering in Denmark: (i) the Construction Policy Action Plan from the Ministry of Housing and Urban Affairs from 1998; (ii) the establishment of 'Project New Forms of Collaboration' in 2001; and (iii) the development of a governmental guide to partnering for public clients and the passing of a statutory order on partnering in 2004. These three events are chosen as they provide a view

into the process through which the discursively articulated ideal of collaboration was authorized, secured resources and attained a basis of legitimacy.

Authorizing collaboration: The ideal of collaboration opened up for a process of articulation in which it was made possible for a variety of different actors to discuss and account for the problem of productivity from a common conceptual ground and theorize the relationship between productivity and collaboration. This grounded the current institutional basis for partnering in Denmark. Based on the work conducted in the wake of the 1993 business economic analysis of the construction sector, the government presented a policy action plan in April 1998 highlighting the practical implementation of the political initiatives within the construction political area in the years ahead. A total of 13 specific initiatives were specified, three of which located within the area of 'The construction sector's productivity and collaborative conditions.' Here it read that the future efforts to increase the productivity of the sector should be focused on the development of new, more flexible forms of collaboration and precautions to improve the planning and management of the building process. In the description of actual initiatives, the term 'partnering' was mentioned for the first time in a public policy report. Partnering was presented as one of three new modes of collaboration, which were to be tested through a series of demonstration projects. The other two collaborative models proposed in the action plan was 'horizontal industrialization', focusing on better collaboration and organization at site level through use of planning principles from the stationary industry, and 'in-between tender' being a form of tender procedure based on outline proposal rather than on main project proposal as most often is the case in design and build contracts. Both of these other collaborative models have later been articulated as elements in the Danish partnering and Lean Construction discourse, where the latter often is argued to be an extension of the former at a craftsman-level, notwithstanding that partnering could be argued to represent a substantive rationality whereas Lean Construction is basically procedural.

Securing resources: In order to pursue the objectives in the governmental action plan, resources were given to a series of demonstration projects under a newly established program was instigated in 2001. These projects build on the foundation laid in the Project Productivity program and focused more specifically on the concept of partnering. During the four years of operation, a total of nine projects were completed and documented, however, in addition to these projects the report concluded that the construction sector had undergone a quite substantial change, in that the use new forms of collaboration had increased remarkably. Partnering was here used as a collective designation for a series of new forms of collaboration (*i.a.* framework agreements and strategic partnerships) in which dialogue and trust played a decisive role. The report noted that 'Project New Forms of Collaboration' had documented the following results:

- Substantial economic savings (5 – 20 pct.) in design and construction coupled with the prospect of increased contribution margins for the companies.
- Increased product quality through closer and more trustful collaboration.
- Fewer resources tied in disputes and no settlements in arbitration.
- Better working climate throughout the entire construction process.

On this basis, it was concluded that the good results were positively correlated with a change in the mode of collaboration towards dialogue and trust instead of the traditional opposition and distrust. Thus, to further extend and capitalize on these argued benefits on a wider sectoral level, a construction clients' network was established in 2001. This network, consisting of major construction clients within the public sector, was in the following six year

responsible for the completion and evaluation of 30 demonstration projects testing new forms of cooperation. The results from the 30 projects were used in the development of a series of guidelines on the topic of new forms of collaboration and procurement that eventually formed the basis for the development of a governmental guide to partnering for public clients in 2004 (EBST, 2004). This will be discussed further below.

Basis of legitimacy: Let us, however, first observe why a *quasi-public* organization could provide the basis for the formulation of a governmental guideline and later a statutory order on partnering. Following the Danish 2001 national election, the newly elected government chose to abolish the Ministry of Housing and Urban Affairs that otherwise had been the cornerstone in the efforts to develop the Danish construction sector since WW2. Instead, the collective construction/housing resource area was split up and placed at several independent ministries and authorities each governing their own discrete part of the complex. Thus, in order to secure some kind of concerted action across the different segments of the construction industry, a new brokering agent or institution had to be established. Accordingly, it was envisioned that the development activities by the construction clients' network should provide the 'nodal point' in a partnership between the Danish Enterprise and Construction Agency, the Ministry of Social Affairs and construction clients from the public, private, and social housing sector.

The primary drivers of this partnership were the administrative authorities commissioning various demonstration projects to be evaluated and 'translated' into policy proposals or recommendations by the construction clients' network. As an example of this process we can turn to the aforementioned governmental partnering guidelines to public construction clients (EBST, 2004), which was developed on the basis of the work of the network. The partnering guidelines stipulate the legal as well as practical foundations for the completion of partnering projects within the public sector. The purpose of the guidelines were to (EBST, 2004: 7):

- Provide the public client with an outline of the contents of partnering.
- Assign a systematic basis on which to assess whether a project should be completed under a partnering scheme.
- Assign a set of practical procedures and describe tools that can be used to support a partnering process.

Furthermore, the guidelines provide the legal implications of a partnering approach, including the linkages to the statutory orders and consolidated acts that have been passed as a result of the activities conducted in this network. The most important of these are statutory orders no. 1135, 1394 and 948 (OEM, 2003; 2004; 2006) and consolidated act no. 338 (OEM, 2005). Speaking from the perspective of the traditional regulative foundations of project procurement and execution, we argue that all of the above legal documents can be seen as regulative mechanisms, which exempt the actors from certain safeguarded *juridico-discursive* obligations that otherwise frame their actions. We thus argue that the formal rationality of the traditional governance mechanisms is substituted with a substantive rationality in which an orientation towards values, performativity and actorial pluralism is preferred over correspondence, surveillance and standardization (*cf.* Clegg *et al.*, 2002: 324-326). This can e.g. be seen in the remarks to consolidated act no. 338 on framework agreements, where it reads that strategic partnerships and framework agreements will lead to a more efficient process and lower prices as suppliers will have economies of scale and the opportunity to learn from one another as well as from project to project. Importantly, the act does, however, not contain any explicit procedures for how to develop innovative capabilities in firms, nor does it promote any specific construction technologies or standard procurement methods and

procedures to follow. The primary actors of regulation are, in other words, expected to be able to act autonomously in order to realize any benefits of establishing collaborative relationships.

In summary, it can be said that the construction clients' network assumed a pivotal role in acting as a nodal point in relation to construction process development and innovation within the field of new forms of collaboration. The network was central in the process of authorizing, securing and delegating resources and providing a basis of legitimacy for partnering. This *i.a.* included overseeing the transition of partnering from a policy focus area, in need of strong governmental intervention and control, to a more or less well-established regulative phenomenon, which has achieved a specific conceptual form and direction based on a turn away from *juridico-discursive* governance mechanisms towards a much more dispersed image of rational agency.

CONCLUSION AND FUTURE DIRECTIONS

So far, we have focused on the diachronic dimension in the institutionalization of partnering in Denmark, illustrating how the ideal of collaboration has been articulated as partnering discourse that has become institutionalized as a regulative macro-level phenomenon. We will now turn our attention towards pinpointing the mechanisms at play in construction, when observed from the perspective of partnering.

In the foregoing diachronic analysis:

1. We have shown how partnering since 1990 has emerged as a response to a sectoral problematization of the construction industry's insufficient productivity development due to a lock-in to *traditional* ways of thinking and practicing.
2. It is demonstrated that the discourse on partnering is based on an ideal conception of collaboration as a means of breaking the lock-in.
3. We have attempted to illustrate that even though the various activities in the development of partnering have focused on providing tools with which to manage and facilitate collaboration at a project-level, partnering has primarily been stabilized and formalized in the legal and regulative apparatus of the Danish construction industry.
4. We have argued that this institutionalization of partnering has followed a trajectory based on a discursive negation of the notion of the traditional, which has constituted partnering not as a new well-defined operational alternative, rather as a regulative mechanism with strong normative and cognitive-cultural underpinnings (Scott, 2003).

On this basis we conclude that the central element in the institutionalization of partnering has been a specific de-institutionalization or rather politicization (cf Laclau and Mouffe, 1985), of the notion of the traditional as a *juridico-discursive* governance phenomenon. This problematization of has taken several forms: both as (i) an ideal in favor of a new order of project governance based on negotiation and trust, and as (ii) a series of negations to the *juridico-discursive* institutionalization of project governance.

Observed in a diachronic perspective, partnering seemingly forms a *counter-concept*, i.e. a concept that is in constitutive opposition to another concept from which it obtains its meaning. In this particular case, we suggest that partnering forms a counter-concept to what we have termed *juridico-discursive* governance. We further argue that the predominantly regulative-institutional (Orr, 2004) constitution and stabilization of partnering as a continuous critique and negation of *juridico-discursive* means of project governance entails a series of

distinct consequences for how expedient governance and management is thought and understood in a project practice setting. In essence, we argue that the emergence of partnering has radically altered the basic "*rules of the game*" (North, 1990: 3) in the very institutional foundations or determinants of management and governance:

The development of partnering does thus not represent an institutionalization of a new practice. Rather, partnering should be seen as an institutionalized critique of the traditional in guise of the *juridco-discursive* complex of project governance. In this perspective, partnering has not emerged, once and for all, on the horizon of management thinking as a finite or *centered* system of signs. Partnering like any other concept should be seen as a condensation of a wide range of social and political meanings that only through a historical awareness and deconstruction can be unraveled. Based on such a conceptualization of the institutional determinants of partnering, we believe that further synchronic studies, e.g. ethnographic case studies, can shed renewed light on several 'sticky' as well as topical problems in partnering research, including questions of what partnering actually involves, why it is so difficult to implement partnering in practice, and not least how to understand the relationships between macro-level industrial change and local project-practices.

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THE CONSTRUCTION INDUSTRY AND THE CHALLENGES OF THE MILLENNIUM DEVELOPMENT GOALS

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Abstract
It has long been recognised that the role of the construction industry in socio-economic development goes beyond its share in national output. A number of studies have focused on the issue of employment creation others have emphasised its multiplier effect on other sectors of the economy. The role of construction infrastructure in the process of development has gained a new stimulus following the United Nations Millennium Declaration at the Millennium Summit in New York in September, 2000. Eight Millennium Development Goals (MDGs), measured through 21 targets, were devised. According to international development agencies, the services provided by infrastructure have a pervasive effect on the economic and social targets related to the MDGs. Using data obtained from World Bank and United Nations publications, and making use of an analysis developed in previous works, this study presents some prospects of the pattern of development of the construction industry in two groups of countries in Sub-Saharan Africa, according to their level of economic development. Some insights for the growth strategies of the construction industry in the groups of countries are also presented.

Keywords: construction industry, economic development, MDGs, Sub-Saharan Africa.

INTRODUCTION

The relationship between a country's stage of development and the level of activity in the construction sector is one, which has received great attention at the macroeconomic level for a number of years. For instance, Turin (1973), World Bank (1984) and Wells (1986) have attempted to model the relationship and found a positive correlation between several measures of construction output and the level of income per capita. These findings have been the subject of much argument due to problems related with the reliability of data, limitations of the coverage and methods of analysis employed.

Existing paradigms on the structural change in the construction industry, as a national economy develops over time tend to be based on cross-sectional data across countries rather than longitudinal studies based on one country's time-series statistics. However, longitudinal studies pertaining to developing countries of Africa have been developed in Lopes and Ruddock (1997) and Lopes *et al.* (2002). Bon (1990) also made use of a longitudinal analysis to present a development pattern for the industry, at a global scale, also based in the stage of economic development of a country's economy. Bon's 1990 study covers the period 1970-1985 and a vast number of countries from all the continents. The arguments were further developed in Bon (1992). An important aspect of the proposition was that, in the early stages of development, the share of construction increases but ultimately declines, in relative terms, in industrially advanced countries - and even at some stage, the decline is not only relative but also in absolute terms i.e. 'volume follows share'.

The positive association between construction (indeed physical infrastructure) and economic growth has been subject of debate for the part of the proponents of endogenous growth theory and international organisations such as the World Bank in the *Structural Adjustment Programme* for Africa. Indeed, in the aftermath of the 1979-980 oil-shock and the international financial crisis that followed in 1981, most of Sub- Saharan African countries experienced until the late 1990s a decreasing growth in per capita income (see Table 1) despite heavy investment in construction and other physical capital over the period 1970-1980. World Bank (1994) posited that rather than the quantity of infrastructure the main concern in developing countries should be the improvement of the quality of infrastructure. It could be argued according to this reasoning that this would be achieved through an adequate maintenance and upgrading of existing infrastructure stocks and by prioritising investments that modernise production and enhance international competitiveness.
The argument above brings about the other side of the construction sector and ancillary industries. Construction projects, particularly public infrastructure projects, require a vast amount of national resources. In less developed countries, quite often, the "real costs" of a major construction work are understated if one looks at the figures presented in the national account tables. Technical assistance (usually paid in foreign currency) and some other unexpected costs can inflate significantly the costs of a construction project. Thus, it could be argued that in the resource-constrained developing countries, part of the scarce resources available devoted to construction investment projects could alternatively be used in other important sectors of the economy (e.g. health, education and agriculture).Thus, African governments and their development partners shifted economic policies away from infrastructure investment to macroeconomic stabilisation accompanied by social intervention.

In the early 2000s, international organisations and development agencies started to become aware of the important role infrastructure would play for attaining all the Millennium Development Goals (MDGs) in Sub-Saharan Africa (Organisation for the African Unity, 2001; Commission for Africa, 2005, cited in World Bank, 2009a). An important question which should be the concern of the construction economics research community and national and international development agencies is how a well functioning construction industry could contribute to a sustainable economic growth and development (Lopes, 2011, forthcoming).

The structure of this paper is as follows: the next section discusses the role of the construction sector in the process of economic growth and development. The third section presents quantitative analyses of the relationship between the measures of construction output and those of the national aggregate in two groups of countries in Sub-Saharan Africa according to their stage of economic development: Low Income Countries (LICs) and Middle Income

Countries (MICs). The statistical sources and data are presented and commented on, and the analysis and discussions of the results are elaborated upon. The fourth section explores the link between construction investment and economic and social targets related to the Millennium Development Goals (MDGs). A concluding remark finalizes the analysis presented in this paper.

THE ROLE OF CONSTRUCTION IN ECONOMIC DEVELOPMENT

The construction industry has historically been linked with the process of industrialisation and urbanisation, particularly since the advent of the Industrial Revolution. Railways systems and canals played an important role in the connection of different regions of Europe, North America and in some parts of Latin America (Rostow, 1963). Transport infrastructures facilitated trade and co-operation between countries and also the diffusion of technical innovations from the most advanced to the less advanced areas of the globe. The construction industry played a key role in the reconstruction of the war-ravaged Europe. The heavy programme of construction improvement of housing and social infrastructure, beside its contribution to the national output, was also a reflex of a better re-distributive economic policy in Europe post World War II. The importance of the construction industry has also been recognized in the context of countries affected by natural hazards (Ruddock *et al*, 2010; Amaratunga and Haigh, 2010). Besides its multiplier effect on other sectors of the economy, a well-devised reconstruction programme of building and community service infrastructure can contribute to sustainable development and protect the natural and built environments.

With regard to the relationship between construction and economic development, Turin (1973), using cross-country comparisons, found an association between construction investment and economic growth. That finding was consistent with the classical approach in growth theory in which physical capital formation is the main engine of economic growth and development. Turin's argument about the pattern of the construction industry contrasts with the argument advanced by Bon (1992; 2000). In Bon's 1992 paper, the link between economic development and construction is discussed and Bon points out the problem with Turin's analysis, which is largely focused on developing countries. As the share of construction in total output first increases and then decreases with economic development, this is called the inverted U-shaped relationship, following Maddison, who, in his seminal study of economic development (Maddison, 1987), tracked several key advanced industrial countries (AICs). Bon's 1992 argument concerns the entire path from LDC (least developed countries) to NIC (newly industrialised countries) to AIC status.

In the aftermath of the 1979-980 oil-shock and the international financial crisis that followed in 1981, most of Sub- Saharan African countries experienced until the late 1990s a decreasing growth in per capita national income, despite heavy investment in construction and other physical capital over the 1970-1980 period (Lopes, 1998). Following the *Structural Adjustment Programme for Africa* that started in the mid-1980s, World Bank (1994) took the view that, for the developing countries, the emphasis should be on the improvement of the quality of infrastructures rather than the quantity of infrastructures. Thus, it is reasonable to argue that this would be achieved through an adequate maintenance of existing infrastructure stocks and by prioritising investments that modernise production and enhance international competitiveness. Lopes (1998), discussed the role of construction in the economic development of countries in Sub-Saharan Africa. The development patterns of construction and related sectors were modelled based upon data from the period 1980-1993 and a sample

of 15 countries comprising two different patterns of growth in that period. It was argued that construction and the national output grow at the same rate only in a declining economy, and that in a growing economy, the volume of construction, typically, would not grow faster than the rest of the economy.

THE CLOUT OF THE CONSTRUCTION INDUSTRY IN SUB-SAHARAN AFRICA

Data Sources and Methodological Issues

The main statistical sources used in this analysis are the 2010 edition of the *Yearbook of National Account Statistics: Main Aggregates and Detailed Tables* from the United Nations, *Africa Development Indicators 2008-2009* and *World Development Report 2010* from the World Bank. The internet site of the UN statistical office presents data on gross domestic product (GDP) and its components both in the expenditure and production approaches. This publication presents various sets of economic series detailing the evolution of GDP and its components in different statistical formats over the long period 1970-2008, at the world, world regions and country levels: at current prices in national currencies; constant 1990 prices in national currencies; current prices in US dollars; and constant 1990 prices in US dollars.

The indicators of economic activity analysed are: GDP and construction value added (CVA) both in constant 1990 prices in US dollars. Unfortunately, data on gross fixed capital formation in construction (GFCFC) are not provided in the UN publication. Thus, CVA is used as a proxy for analysing the evolution pattern of construction investment in two groups of countries in Sub-Saharan Africa. As CVA is roughly a half of GFCFC, it appears reasonable that the former indicator can be used as a surrogate measure of construction investment. In order to facilitate international comparisons as well as for aggregation purposes, constant 1990 prices in US dollars are used. In order to place the two country groups in the economic development arena, gross national income (GNI) per capita for the bench mark year 2008 has been chosen. This is provided by *The World Development Report 2010* (World Bank, 2009b). This report presents the following definitions of the income groups of countries according to the 2008 GNI per capita: low income countries (LICs), US$ 975 or less; lower- middle- income (LMICs), US$ 976-3,855; upper-middle-income (UMICs), US$ 3,856 -11,905; and high income countries (HICs), US$ 11,906 or more.

Data on the evolution of economic indicators in the period 1980-2006 were obtained from the *Africa Development Indicators 2008-2009* (World Bank, 2008). Thus, because of data consistency, the quantification of the relationship between the construction sector and GDP is only analysed for the period 1980-2006. Using data obtained from the *UN Yearbook of National Accounts Statistics* (United Nations, 2010 internet edition), data are presented for the share of construction in GDP (at constant1990 US dollars) for the period 1980-2006. GNI per capita is presented for the year 2008. The evolution of GDP per capita, both of Sub-Saharan Africa as a whole, as well as excluding two important economic players of that region, South Africa and Nigeria, are presented for the period 1980-2006 (Table 1).

Cross-matching sources, data are available for 45 countries and these can be split into two groups according to the level of GNI per capita in 2008. Tables 2 and 3 illustrate these two groups: Group I - low income countries (LICs); Group II- middle income countries (MICs). Thus, Group II comprises both LMICs and UMICs, and only Equatorial Guinea could, in theory, be considered a HIC, owing to its high GNI per capita.

Table 1: *GDP per capita in Sub-Saharan Africa (SSA) in 1980-2006, real*

	Constant prices (2000 US$)				Average annual growth (%)		
	1980	1990	2000	2006	1980-	1990-	2000-
SSA	593	532	508	580	-1.0	-0.6	2.4
SSA exclud. South Africa	371	339	332	368	-0.9	-0.3	2.6
SSA exclud. South Africa and Nigeria	348	331	323	379	-0.3	-0.2	2.3

Table 2: *GNI per capita and Share of CVA in GDP (%) for Selected Years (Group I)*

Countries	GNI per capita current US$ (2008)	CVA/GDP (1980)	CVA/GDP (1990)	CVA/GDP (2000)	CVA/GDP (2006)
Benin	690	3.65	3.11	3.56	3.91
Burkina Faso	480	2.90	4.67	5.05	5.49
Burundi	140	3.29	3.35	4.37	3.11
C. African Rep.	410	1.77	2.81	2.57	2.97
Chad	530	1.02	1.69	1.32	1.31
Comoros	374	9.39	3.17	5.38	6.01
Congo, D. Rep.	150	3.65	5.00	3.27	4.24
Gambia, The	390	4.86	4.51	4.05	4.77
Ghana	670	3.30	3.30	3.48	3.56
Guinea	390	10.23	10.20	11.49	12.41
Guinea-Bissau	250	13.71	9.99	6.76	10.63
Kenya	750	3.74	2.92	2.66	2.53
Liberia	170	3.89	3.33	2.07	3.45
Madagascar	410	1.69	1.11	1.45	2.83
Malawi	290	6.81	4.96	3.84	5.10
Mali	580	2.00	2.91	5.14	4.92
Madagascar	410	1.69	1.11	1.45	2.83
Mauritania	840	3.42	4.78	6.27	8.95
Mozambique	370	9.65	5.19	8.40	7.37
Niger	330	2.63	2.45	2.30	2.55
Rwanda	410	6.82	6.78	7.97	9.18
Senegal	970	2.82	3.29	3.94	5.13

Sierra Leone	320	3.31	2.12	2.07	3.96
Tanzania	430	3.57	4.76	6.84	7.81
Togo	400	5.84	5.14	4.44	5.20
Uganda	420	3.51	4,84	6.39	7.58
Zambia	950	2.71	2.56	2.15	3.40
Zimbabwe	340	3.88	2.86	2.22	0.86
Group I (mean average)	-	4.49	4.03	4.19	5.08

Table 3: *GNI per capita and Share of CVA in GDP (%) for Selected Years (Group II)*

Countries	GNI per capita current US$ (2008)	CVA/GDP (1980)	CVA/GDP (1990)	CVA/GDP (2000)	CVA/GDP (2006)
Angola	3, 450	4.64	2.92	2.73	3.45
Botswana	6,470	9.11	7.28	5.88	5.13
Cameron	1,150	6.92	4.59	3.57	3.58
Cape Verde	3,130	10.39	11.92	8.47	8.76
Congo, Rep.	1,970	7.23	2.99	4.44	5.01
Cote d'Ivoire	980	3.63	1.79	4.04	3.29
Djibouti	1,130	4.19	9.62	5.89	6.84
Equatorial	14,980	7.25	4.51	3.05	3.38
Gabon	7,240	5.70	6.71	6.37	6.54
Lesotho	1,080	9.63	14.69	13.84	12.45
Mauritius	6,400	5.74	5.62	5.88	5.96
Namibia	4,200	6.51	2.30	2.33	3.20
Nigeria	1,160	3.90	1.69	2.14	2.40
Seychelles	10,290	9.26	4.79	8.51	9.14
S. Africa	5,820	3.82	2.98	2.29	2.62
Sudan	1,130	5.56	6.04	5.01	5.00
Swaziland	2,520	5.84	2.49	6.39	6.70
Group II (mean average)	-	6.43	5.47	5.34	5.50

Analysis and Discussion

Table 1 shows the evolution of GDP per capita in Sub-Saharan Africa as well as that of Sub-Saharan Africa excluding South Africa, and then Sub-Saharan Africa excluding South Africa and Nigeria. The division shown in Table 1 is a reflection of the clout those two countries represent in the Sub-Saharan African economy. According to World Bank (2009b), South

Africa's and Nigeria's GDP in nominal prices comprised over fifty percent (51.4 percent) of Sub-Saharan Africa's GDP. The reasons for this dominance are not the same for the two countries. Nigeria plays a big role because it is, by far, the most populous country in the region, whereas South Africa is important owing to its unmatched industrial structure and technological development that makes it the economic pole of Sub-Saharan Africa.

Table 1 shows that both the region and its subdivisions, in terms of GDP per capita, experienced decreasing growth in the period 1980-2000 and a reasonable upturn in the period from 2000 onwards. According to data constructed from World Bank (2008), the LICs, as a group, experienced dramatic decreasing growth in GDP per capita in the period 1980-2000, and an average annual rate of growth of almost 2% in the period 2000-2006. The striking aspect worthy of note concerning Group 1 is that GDP per capita in the LCIs in 2006 (measured as an average for the group) was lower than that in 1980. Again, data constructed from World Bank (2008) show that the countries comprising Group II (MICs), in terms of GDP per capita, grew slightly in the period 1980-2000, with an average annual growth rate of about 1%, and notched up a spectacular rate of growth of an annual average rate of more than 4% in the period 2000-2006.

Now, looking at the relationship between the construction sector and the national economy, Tables 1 and 2 show that the evolution pattern of the share of CVA in GDP in the developing countries of Sub-Saharan Africa is markedly different according to the country's stage of economic development as determined by GNI per capita. The share of CVA in GDP in the low-income countries (Group I), despite differences across countries as well as taking into account annual fluctuations, varied, in general, from 4% to 5% of GDP, as is illustrated in Table 2. In terms of the evolution in the period, the share of that indicator was in line with the development pattern of GNI per capita: it decreased in the period 1980-1990 (from 4.49% to 4.03 % b, measured as an average for the group), remained practically stagnant in the period 1990-2000, and grew at a reasonable rate in the period 2000-2006 (from 4.19% to 5.08%, again measured as an average for the group). It is worth noting that in the latter years of the period, the share of CVA in GDP was higher than that in the earlier years of the same period. That is, in the first stages of economic development, and in an increasing growth pattern, the construction industry tends to grow faster than national output. Conversely, in an economic downturn, the industry tends to decrease not only absolutely but also relatively.

Regarding the middle-income countries (Group II), Table 3 shows that the share of CVA in GDP varied, in general, from 5.0 % to 6.5% in the period 1980-2006, also disregarding differences across countries as well as annual fluctuations. Table 3 also shows that the share of CVA in GDP decreased from 6.43% in 1980 to 5.47% in 1990 (measured as an average for the group) despite a growth in GDP per capita, as already pointed out, at an average annual growth rate of about 1% in the period 1980-1990. From then onwards, the share of construction in GDP remained practically stagnant at around 5.5% of GDP. The pattern experienced by the MICs is worthy of note: despite a significant increase in national income per capita, particularly in 2000-2006, the share of CVA in GDP in the late years of the period did not reach the value attained in the beginning of the period. It could reasonably be said that the construction industry activity in the MICs reached a peak, in relative terms, in the early 1980s. These results presented here seem to corroborate those of a previous work concerning the developing countries of Africa (Lopes, 1998) that found that in the developing countries of Africa that have middle-income status or are in a sustained process of reaching it, and have achieved a certain level of the construction industry activity (say 5 to 6 percent of GDP, depends upon the year taken as basis), the proportion of construction in GDP tends to remain

stagnant, i.e. the rate of growth of construction volume follows that of the national economy.

CONSTRUCTION INFRASTRUCURE AND THE CHALLENGE OF THE MILLENNIUM DEVELOPMENT GOALS

This section considers the role of construction in socio-economic development, particularly by exploring the link between construction infrastructure and economic and social targets related to the Millennium Development Goals (MDGs). Much of the material in this section is drawn from Lopes (2011, forthcoming).

As pointed out earlier, the construction industry has historically been linked with the process of industrialisation and development. Railway systems and canals played an important role in the connection of different regions of Europe, North America and in some parts of Latin America. Transport infrastructure facilitated trade and co-operation between countries and also the diffusion of technical innovations from the most advanced to the less advanced areas of the globe (Rostow, 1963). The construction industry played a key role in the reconstruction of war-ravaged Europe: the heavy programme of construction improvement of housing and social infrastructure, besides its contribution to the national output, was also a reflex of a better re-distributive economic policy in Europe after World War II. Following the UN Millennium Declaration in 2000, the Heads of State and Government of Sub-Saharan Africa have emphasised the role transport infrastructure can play in enhancing inter-regional cooperation and foster economic and social development (Organisation of African Unity, 2001).

In the early 2000s, the physical infrastructure in Sub-Saharan Africa was in a very poor state. External capital flows (particularly from donor countries pertaining to the Development Assistance Committee of the OECD) for African infrastructure had reached a historic low. As already mentioned, African governments and their development partners sharply reduced, over the 1990s, the share of resources allocated to infrastructure, and in the aftermath of the Asian financial crisis, in the early 2000s, private capital flows declined sharply. The Commission for Africa, in 2005, in line with another policy shift on the part of the international development agencies, singled out infrastructure as one of the continent's central development challenges (World Bank, 2009a). In the same line, a report of the UN Millennium Project (UN, 2005, cited in Easterly: 2006, p. 290) argued that poor countries were in a poverty trap: Escaping the trap requires:

"A big push of basic investments between now and 2015 in public administration, human capital (nutrition, health, education) and key infrastructures (roads, electricity, ports, water and sanitation, accessible land for affordable housing, environmental management)"

The Group of Eight summit at Gleneagles in 2005 called for action by the major economies and multilateral donors in the financing of Sub-Saharan African infrastructure. This led to the formation of the *Infrastructure Consortium for Africa.* This consortium would constitute a forum where major donors could work with continental and regional institutions to spearhead economic integration (World Bank, 2009a). One of the practical results of this political arrangement was the publication of the flagship report "*Africa's Infrastructure: A time for Transformation*" in 2009. This publication diagnosed the infrastructure needs of Sub-Saharan Africa, addressing the twin challenges of financing and sustainability, particularly the attainment of the millennium development goals (MDGs).

Table 4: *Overall Infrastructure Spending Needs for Africa, 2005-2006*
(US$ billions annually)

Sector	Capital expenditure	Operation and maintenance	Total needs
ICT	7.0	2.0	9.0
Irrigation	2.7	0.6	3.3
Power	26.7	14.1	40.8
Transport	8.8	9.4	18.2
WSS	14.9	7.0	21.9
Total	60.4	33.0	93.3

Source: World Bank (2009a)
Note: ICT- information and communication technology; WSS- water supply and sanitation

Table 4 indicates that the estimate for the overall cost to build, maintain and operate Africa´s infrastructure is US$93 billion annually over the period 2006-2015, approximately 15% of Sub-Saharan Africa's GDP in 2006. Of this total, about two thirds are for investment and about one third for operation and maintenance. In sectoral terms, about 40% is allocated to the power sector. The second-largest component is water and sanitation – a key sector for meeting the MDGs – with about 23% of the total and the third largest share of the cost is associated with transport, which is approximately 20% of the overall spending needs. In terms of regional groups, the burden of the price tag relative to the countries' GDP is markedly different across groups (World Bank, 2009a). For middle-income countries and resource-rich countries, the amount is in the range of 10% to13% of their respective GDPs. For low-income countries, as much as 25% of GDP would be needed, and for a particular sub-group of the latter-fragile states (war-ravaged countries), the burden would be an astonishing 37% of GDP. If one takes into account that the middle-income countries already spend a reasonable share of their wealth in investing in infrastructure and the spending needs are almost equally divided across groups, one can envisage the implausibility for the poorer countries in Africa to finance the funding gap of their estimated spending needs. As Table 5 shows, the funding gap for the infrastructure in Sub-Saharan Africa is US$ 31 billion or about 5% of GDP, taking into account efficiency improvements. About US$ 23 billion a year, or over 70% of the funding gap, is for the power sector. The other significant component of the gap, representing a shortfall of US$ 11.4 billion is associated with water supply and sanitation (WSS). The funding gap in the latter sector in the low-income countries, particularly in fragile states looks like an unattainable target in the foreseeable future in the light of the present economic situation and prospects of the countries themselves, and the challenges posed to the development partners by the recent global financial crisis.

***Table 5.a**: Funding Gaps, by Sector and Country Group*
(US$ billion annually)

Country Type	Power	ICT	Irrigation	Transport	WSS	Potential for reallocation	total
Middle income	10.7	(0.9)	0.1	(0.3)	0.0	(4.1)	5.5
Resource rich	4.5	0.5	1.8	(1.4)	3.7	(0.8)	8.2
Low-income non fragile	4.7	(0.2)	0.7	(0.5)	5.2	(0.4)	9.5
Low-income fragile	2.7	0.7	0.0	2.0	3.9	0.0	9.4
Sub-Saharan	23.2	1.3	2.4	(1.9)	11.4	(3.3)	30.6

Africa

Source: World Bank (2009a)

Table 5.b: *Funding Gaps, by Sector and Country Group (percentage of GDP)*

Country Type	Power	ICT	Irrigation	Transport	WSS	Potential for reallocation	total
Middle income	3.9	(0.3)	0.0	(0.1)	0.0	(1.5)	2.0
Resource rich	2.0	0.2	0.8	(0.6)	1.7	(0.4)	3.7
Low-income non fragile	4.2	(0.2)	0.6	(0.4)	4.7	(0.3)	8.6
Low-income fragile	7.1	1.9	0.1	5.3	10.2	0.0	24.6
Sub-Saharan Africa	3.6	(0.2)	0.4	(0.3)	1.8	(0.5)	4.8

Source: World Bank (2009a)

As pointed out above, international development agencies and bilateral donors have underscored infrastructure (more precisely the services provided by the infrastructure) as the key factor for the attainment of the MDGs. The MDGs are the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions – income poverty, hunger, disease, lack of adequate shelter, and exclusion – while promoting gender equality, education, and environmental sustainability (UNDP, 2005). Following the adoption of the UN Millennium Declaration at the Millennium Summit in New York in September 2000 (UN, 2000), eight MDGs, measured through 21 targets, were devised. Most of the MDG targets have a deadline of 2015, and 1990 is the baseline against which progress is quantified.

Restricting here the analysis for those infrastructure items which incorporate mainly construction investment (WSS, transport and electricity – note that a significant part of the investment in the power sector is for multi-purpose use), construction infrastructure has an important role to play in the process of attaining the MDGs in Sub-Saharan Africa. The MDG Goal 7 – ensure environmental sustainability – is particularly relevant to the construction industry. This goal is translated into the following targets: i) integrate the principles of sustainable development in country policies and programmes and reverse the loss of environmental resources; ii) halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation; and iii) have achieved by 2020 a significant development in the lives of 100 million slum dwellers.

Table 6: *MDGs in Sub-Saharan Africa: Goal 7- Ensure Environmental Sustainability*

Proportion of people using an improved water source (%)		Proportion of people with access to improved sanitation facilities (%)		Proportion of urban population living in slum areas (%)		Forested area as a percentage of land area (%)		Emission of CO2 (billions of metric tons)	
1990	2008	1990	2008	1990	2010	1990	2010	1990	2007

49	60	28	31	70	62	31	28	0.5	0.7

Source: United Nations (2010b)

Table 6 suggests that Sub-Saharan Africa, as a whole, is unlikely to achieve, by the deadline of 2015, the targets related to access to safe drinking water and basic sanitation. However, some middle-income economies of Africa such as Cape Verde, South Africa, Botswana, Namibia, Seychelles and Mauritius are either on track or experiencing good progress towards achieving the targets, particularly in access to safe drinking water (WHO/UNICEF, 2010). Regarding the urban population living in slum areas, whereas some progress was noticed in relative terms, the absolute number of slum dwellers has actually been growing and will likely continue to increase in the near future.

With respect to the emission of CO2, Sub-Saharan Africa registered 0.9 metric tons per capita in 2007 compared with 12 metric tons per capita in the developed world, and, in deforestation, the rate of increase started to decelerate in the period 1990-2010.

The WSS sector, besides its direct effect on the provision of water and sanitation services, has a pervasive impact on other social targets, namely in the prevention of disease, improvement in education and promotion of gender equality so that women save time when they begin using an improved water source. Transport fosters trade by reducing the cost for transporting goods and passengers, reduces child/maternal mortality and improves access to education services. Electricity enhances productivity, eradicates poverty by fostering economic growth and reduces child/maternal mortality.

One important area related to the construction industry which needs special attention on the part of government agencies is urban planning. The rate of urbanization in Sub-Saharan Africa is increasing sharply. This has its merits. For example, higher population densities lower the per capita costs of providing safe water, sewer systems, waste collection, and most other infrastructure and public amenities. Moreover, sound urban planning restricts development in flood-prone areas and provides critical access to services, and infrastructure developments can provide physical protection for the natural environment. On the other hand, most of the urban areas have been unable to cope with the increasing populations, and large numbers of their inhabitants have a poor quality of life. As pointed out by the World Bank (2009b), overcrowding, insecure tenure, illegal settlements sited in landslide- and flood-prone areas, poor sanitation, unsafe housing, inadequate nutrition, and poor health exacerbate the vulnerabilities of the population in urban slums. These are the realities for millions of people in Sub-Saharan African countries. An efficient construction industry can contribute to the efforts to tackle these problems. For example, it can address the vulnerabilities of slum dwellers by devising labour-intensive and cost-effective technologies, and by implementing practical sustainable measures in the framework of the *Agenda 21 for Sustainable Construction in Developing Countries* (International Council for Research and Innovation in Building and Construction (CIB) and United Nations Environment Programme (UNEP), 2002) This framework for a coordinated response to the challenges of limiting the impact of construction puts an emphasis on collaboration among different stakeholders of the construction industry. Indeed, it is the flexibility of the construction industry in being able to adjust to different framework conditions that makes it such a great contributor to the process of economic development.

CONCLUDING REMARKS

The picture that emerges from the analysis of the evolutionary process of the construction industry and its role in national socio-economic development suggests that the share of construction in gross domestic product tends to increase with the level of per capita income in the first stages of economic development. When countries reach a certain level of economic development, the construction output will grow slower than national output in the later stages of their development. That is, it decreases relatively but not absolutely. Thus, it is reasonable to assume that when a certain level is achieved (say the share of CVA in GDP at around 5% to 6%) and countries enter into a path of sustained economic growth and development, the construction output tends to grow, in general, with the same rate of growth as that of the general economy.

The results of the study also underlie the twin challenge of finance and sustainability in Sub-Saharan Africa in the effort towards attaining the MDGs, and the situation is particularly acute in the low-income countries in the light of the countries' own economic circumstances and prospects, and the current global financial crisis. The results of the study may have some implications for public policies. Given the experience of the growth process in Sub-Saharan Africa, what should be the focus of growth-enhancing policy in the two groups of countries? How can the construction industry contribute to this end, and help a country in Group 1 to move to Group 2? For example, further investment in construction infrastructure might be recommended for countries in Group 1 but might not necessarily be a growth priority for countries in Group 2. Most recent data indicate that there is no significant funding gap in infrastructure investment in the middle-income countries of SSA in order to achieve the economic and social targets of the MDGs. These countries should prioritize their investment projects by balancing economic and financial factors with social targets. For the low – income countries, taking into account the dire financial stress facing these countries, the analyses suggest that most of the effort should be directed at construction investment projects in order to achieve a level of the construction industry activity of, say, 5 to 6% of GDP which is required for a reasonable functioning of the economy. The priority should be given to construction investment projects that have high multiplier effects in the economy, particularly transport and multi-purpose (power and water) infrastructures. A concerted effort to implement sub-regional infrastructure projects seems also to be the way forward.

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PATTERNS OF STRUCTURAL CHANGES IN CONSTRUCTION?

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Abstract

The changing role of construction at various stages of development has been at the core of debate in the field of construction economics. It has been argued that the construction industry should follow the pattern of manufacturing, its primary supplier, rather than services, even if early studies suggested an S-shaped relationship with GDP per capita. The presented analysis stems from this well known literature and again it focuses on the link between construction share in value added and development measures. The conventional view that GDP per capita suffices is critically discussed and new variables that help the explanation of such a relationship are introduced. Discussion builds upon the comparison of standard cross country regressions in the 1970 and in 2005. Even if explicative power is quite weak it is shown that in recent years construction has been linked with new variables such as market size and population density.

Keywords: Construction, development stages, structural change.

INTRODUCTION

Structural analysis is a central tenet in growth economics since the seminal work by Lewis (1954) and the many contributions by Kuznets (1956, 1957), and Chenery and his collaborators (Chenery, 1960, Chenery and Taylor, 1968, Chenery and Syrquin, 1975). One research thrust follows a micro approach that focuses on market structure, income and resource allocations among individuals or price differences (Leamer, 1984). Differently most of early literature focused on macroeconomics and long run processes (Chenery, 1986). Chenery and Syrquin referred to development pattern as "any significant aspect of the economic and social structure associated with a rising level of income or other index of development" (1975, p. 4). For instance, Agénor and Montiel (2008) argue that developing countries tend to be more open and capital importers, while advanced ones have a larger public sector. Furthermore, as development develops further, current account deficits and capital account surpluses usually decrease, while openness increases. Value added and employment growth and shares, in addition, have been extensively analyzed. Fisher (1939) and Clark (1940) predicted a sequence of stages in the course of development. First of all, the share of agriculture should decrease as industrialization takes place. The primary sector produces basic goods whose demand is quite income inelastic. When an economy takes off

Engel curves show how demand is diverted from basic to luxury goods as durables. The potential of service industries in modern society is also reputed to be very good. Therefore even in the early stages of development, manufacturing and informal sectors begin rapidly to grow as a result of the rural-urban migration. Some sectors can absorb this new urban labour supply in basic service and manufactured good production. In this embryonic stage, food production and housing should meet most of the basic needs of these low income migrants. At the intermediate stage, a network of production and consumption linkages start developing with increasing final and working capital demand. Agglomerative economies push urbanization further. Construction would continue to play a relevant role in this phase, maybe with a decreasing rate of growth. Only in the last stage, when deindustrialization takes place, smokestack industries start moving to less developed regions or countries, and urban areas change their shape with new landscapes and construction technologies.

BASIC MODELS AND STYLIZED FACTS

The very first issue is to define economic development. The most widely used measure is either GDP or GNI per capita. Country data can be made comparable by converting them into in a single currency, say US dollars, by using exchange rates. Current exchange rates are an imperfect measure of the purchasing power of the various national currencies. The alternative to market rates is to re-price the local components of income in every country at a uniform set of prices. Hence, non tradable goods are reflected in these conversion factors. This approach uses the Purchasing Power Parity (PPP) that is the weighted average of the ratio of domestic price to the price of the very same good in the considered country, say the USA. An alternative is the Atlas conversion factor, which uses the three-year average of exchange rates to smooth the effects of transitory exchange rate fluctuations, adjusted for the difference between the rate of inflation in the considered country (using this country's GDP deflator), and that in a set of developed countries (using the weighted average of the countries' GDP deflators in Special Drawing Right terms). According to the World Bank differences between PPP and Atlas figures are not remarkable.

Nonetheless, the use of GDP as a measure of development has been widely questioned (Stigliz and Fitoussi, 2009). The best alternative perhaps is the Human Development Index (HDI) developed by the United Nations (2010) or the Physical Quality of Life Index (PQLI) by Larson and Wilford (1979). The HDI was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, rather than economic growth alone. For instance, the Bahamas and New Zealand have similar levels of income per person, but life expectancy and expected years of schooling differ greatly between the two countries. HDI is a composite index that measures progress in the three basic dimensions: health, knowledge and income. At first, health was measured according to life expectancy at birth; education according to adult literacy rate, and income or standard of living according to GDP per capita adjusted for purchasing-power parity (PPP US$). Currently level of education is measured according to the expected years of schooling for a school-age child in a country today with the mean years of prior schooling for adults aged 25 and older. Income measurement also has changed from purchasing-power-adjusted per capita Gross Domestic Product (GDP) to purchasing-power-adjusted per capita Gross National Income (GNI). However problems remain. Consistency is hardly achieved among countries and over time. The availability of comparable time series and likely correlation between in built variables pose well known statistical problems. The PQLI is the average of basic literacy rate, infant mortality, and life expectancy at age one, all equally weighted. This is not a meaningful alternative as there is a considerable overlap between infant mortality and life expectancy and there is no measure of income.

Defining economic structure is far from being easy. We follow the traditional approach stemming from the path breaking Clark's contribution (1940), who considered labour force, consumption patterns and income distribution, while Kuznets (1957) added the shares of GDP. We address the latter by focusing on the contribution of construction to value added. This study revisits the classical analysis that was initiated by Turin (1969) and Strassman (1970). According to this last scholar, construction is a major force that replaces manufacturing in driving economic growth after the first stage of development (the so called "middle-income country bulge"), while Turin postulated a causal relationship between construction and economic growth. In his first study Turin (1969) did not find any statistically significant link. This result perhaps reflected the rather small considered sample (46 countries in 1958). In his subsequent study (1978) Turin claimed that an S-shaped curve fitted better the new data set (87 countries). This is to say that construction share in GDP is always positively related with GDP per capita, initially at an increasing rate and later on at a decreasing pace. Size matters too as construction accounted for between 3 and 5 per cent of GDP in most developing countries, whilst it was twice as much (5 - 9 %), in advanced ones. Lewis (2009), however, shows that this pattern is no longer the case, while Bon (1992) argued that the inverted U-shaped relationship should hold for both the share of construction in GDP and its volume. In other words, there is an absolute decline of this industry in the very long haul. These issues have been extensively discussed in the literature and there is a growing consensus about Bon's conjecture. Analyses by Wells (1985), Crostwaite (2000) Yiu, et al. (2004), Ruddock and Lopes (2006) support his view. Most of these contributions are rather descriptive and only few consider an appropriate statistical model in the Chenery's style. This model is based on a reduced form of a general equilibrium where domestic production in each sector is due to intermediate and final demand, including net export. Since a large sample is needed and each demand component is a function of income level Chenery decided to adopt single functions of income and population. His main specification is a linear logarithmic regression equation as the following one:

$$\ln C = \beta_0 + \beta_1 \ln Y + \beta_2 (\ln Y)^2 + \beta_3 \ln N + \beta_4 (\ln N)^2 + \beta_5 \ln X \qquad (1)$$

where C is the dependent variable that, in our case, is construction value added over GDP, Y is the income level measured as GDP per capita, N is the country's population and X is another exogenous variable to be addressed later on in the paper. If we eliminate the quadratic terms, parameters β1 and β3 can be interpreted as growth and size elasticities. When these factors are considered, multi-collinearity and parameter interpretation arise, but β2 and β4 are useful to detect non linear income and size effects and assess upper and lower asymptote in Turin's fashion. Crostwaite (2000) presents a similar specification where construction spending over GDP is regressed over income alone. Actually Crostwaite acknowledges that there is no linear relationship between C (he does not take into account ln C) and ln Y and only when the quadratic term is included, both parameters become (weakly) significant at 5% confidence. However the model specification suggests that the least square estimator provides biased and inconsistent results by casting doubts on parameter estimates and, above all, the coefficient of determination (R^2) is close to zero (only 2,7%). It is pretty clear that more regressors were needed in his sample. The most obvious one is the population that was supposed "to allow for effects of economies of scale and transport costs on patterns of trade and productions" (Chenery and Taylor, 1975, p. 17). Actually controlling for size

through population is questionable as the size of a country can be measured by land area o resource availability. However, population appears to be an important source of housing demand, thus it should be included in our setting. Kessing and Sherk (1971) suggested that population density serves as an imperfect proxy for the availability of natural resources per head. According to these authors, densely populated countries are expected to have economies more oriented toward manufactured than primary goods, along the lines of a land-labour Heckscher-Ohlin theory. Even if this statement is disputable, there is no doubt that land scarcity can constrain building activities and we include it as a candidate regressor. Economic deepening, in fact, differs from primary factors availability. Hence we would like to differentiate between large and small countries by using another size variable, not including population. A simple solution is to introduce an output measure. Lastly we follow Branson et al. (1998) and regress separately an equation with quadratic terms only in order to avoid multi collinearity. This is to say that the explanatory variables, ln Y and $(\ln Y)^2$, are in two separate regression specifications, as our task is to provide evidence about non linear elasticities only.

DATA AND FEW SIMPLE EXAMPLES

In the past empirical research was constrained by data availability. Early studies assessed of long-term series in developed countries and later on shifted the focus on cross country analyses of less developed economies. In comparing the results of time series and cross countries it is customary to interpret the latter as partial short term adjustments and the former as long term changes in exogenous variables. However, lack of data forced scholars to use a sample of countries in a given year with the hope that it was a good substitute for relations within countries over time, as they add "an insight into current structural differences, viewed partly as points in the process of growth, caught, as it were, at different stages and phases" (Kuznets, 1959, p. 174). Kuznets himself was aware that cross section estimates tend to underestimate inter-temporal trends because they "are not likely to provide a firm basis for estimating the relevant inter-temporal pattern (1959, p. 197). This is due to the "vast and rapidly changing flow of innovations in material and social technology (1959, p. 179). Additional reasons for these differences are institutional settings, the impact of varying policies and, above all, omission of dynamic effects as propagation mechanisms. These differences explain diverse levels of development. Since the task of this study is to provide a stylized fact and not to clarify why more advanced countries have larger or smaller construction sectors, the Kuznets methodology is used. In a future paper the authors will focus on the joint estimation of cross-section and time series analysis in order to improve the efficiency of estimates and develop a dynamic model. For time being, only the two extremes of the considered sample are considered to test differences that are to be explicated in future research. Population, construction and total gross value added are obtained from the UN data developed by the United Nations Statistics division. Urban population and population density are drawn from the WorldBank database, while GDP per capita (in constant terms) is based on the PennTables. As stated above, only cross section data of the years 1970 (or 1971 when 1970 are not available) and 2005 are used. The first data consists of 139 countries. First of all, it is difficult to detect any relationship between the (log) of GDP per capita and value added construction share. Actually only when advanced countries are considered, a negative relationship seems to appear (Quatar being an outlier).

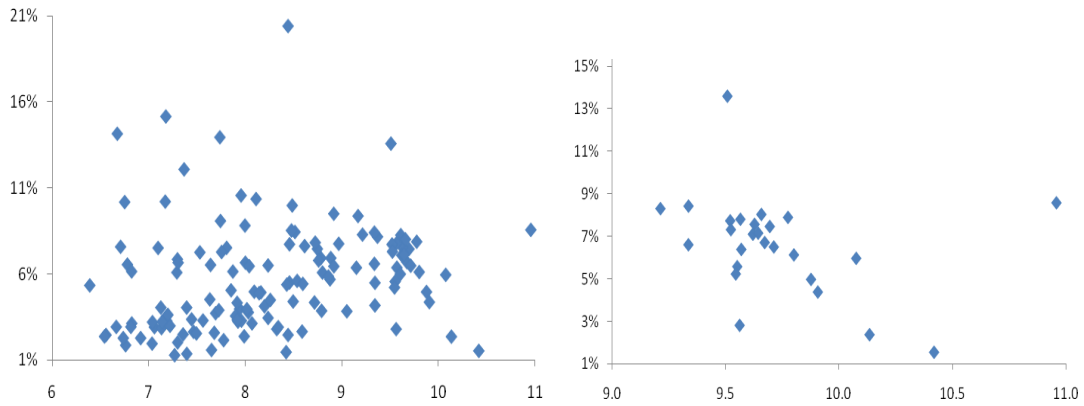


Figure 1: *Const. shares and GDP per capita,1970* ***Figure 2:*** *Only advanced countries, 1970*

Several regressions, none of which was satisfactory were executed. The ”best” one is the following:

$$\ln C = -1.689 + 0.1580 \ln Y - 0.0511 \ln N \qquad (2)$$
$$(-9.642) \quad (3.648) \qquad (-2.380)$$
$$\text{Adj } R^2 = 0.112; \ F[2,136] \text{ (prob)} = 9.69 \ (.0001)$$

The coefficient of determination is very small, even for cross section analysis and most of the variability of construction share is left unexplained. However, all the variables are statistically significant, according to t values (shown in brackets) and F test, but surprisingly population has a negative effect. As put forward by Branson et al. (1998), the quadratic term have been verified in the following way:

$$\ln C = -1.484 + 0.0213 (\ln Y)^2 - 0.0073 (\ln N)^2 \qquad (3)$$
$$(-16.489) \quad (3.573) \qquad (-2.399)$$
$$\text{Adj } R^2 = 0.1089; \ F[2, 136] \text{ (prob)} = 9.43 \ (.0001)$$

Elasticities seem to be not linear. The shape is not the one advocated by Bon (1992) but quite the opposite. Only the negative relationship with population is lessened. These signs do not change if the share of urban population and/or population density is added. The results are not presented, as estimates are not significant at 5% confidence. Finally, dummies are used to differentiate Less Developed Countries , Lower Medium Countries, Upper Medium Countries and advanced ones, but, as expected, the model performance is poor. Hence GDP per capita is enough to identify stages of development. Population, in addition, was replaced with value added to assess economic size, but the negative relationship persisted.
The equivalent analysis for the year 2005 was then addressed. The considered sample is larger with 176 records, but no clear pattern is recognizable in the scatter plots of Figure 3 and 4, even in the subsample of advanced countries is considered.

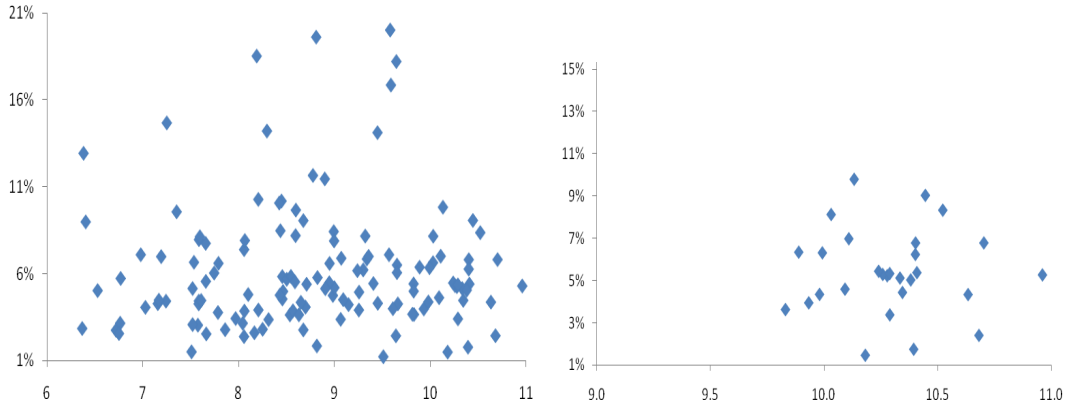


Figure 3:*Const. shares and GDP per capita,2005* ***Fig 4:*** *Only advanced countries,2005*

According to the same regressions that were presented earlier, the outcome is surprising:

$$\ln C = \underset{(-7.353)}{-2.727} + \underset{(0.965)}{0.0335} \ln Y \; \underset{(-3.029)}{-.0607} \; \ln N \qquad (4)$$

$$\text{Adj } R^2 = 0.06; \; F[2,173] \text{ (prob)} = 5.52 \; (.0048)$$

The coefficient of determination is smaller, but GDP per capita is no longer an explicative variable, as shown by the t and F tests. The estimated quadratic form is:

$$\ln C = \underset{(-14.61)}{-2.872} + \underset{(0.977)}{0.002} (\ln Y)^2 - \underset{(-2.542)}{0.003} (\ln N)^2 \qquad (5)$$

$$\text{Adj } R^2 = 0.033; \; F[2, 173] \text{ (prob)} = 4.03 \; (.0195)$$

Thus, it is doubtful that development can explain construction share. However GDP per capita can be included with another specification that has at least the same (weak) power than the 1970 data. Moreover we tried several specifications using variables discussed in the previous section. Unfortunately just a few proved satisfactory. Actually value added appears to be a better measure of economic size and only population density is statistically significant:

$$\ln C = \underset{(-6.511)}{-2.634} + \underset{(2.641)}{0.1064} \ln Y \; \underset{(-3.435)}{-0.0652} \; \ln VA + \underset{(2.342)}{0.0673} \ln \text{PopDensity} \qquad (6)$$

$$\text{Adj } R^2 = 0.103; \; F[3,173] \text{ (prob)} = 6.61 \; (.0002)$$

This equation performs much better than the “standard” model seen above. Hence this very exploratory analysis appears to show that non classical variables, such as population density, i.e. people per sq. km of land area, and market size, measured by valued added, should be considered to explain the behavior of the construction sector in the year 2005, while total and urban population are not significant.

CONCLUSIONS

Even if the interest in structural analysis has considerably decreased in the last decade due to new endogenous growth models, classical structural analysis is the core of development theory. Patterns of economic development are indeed a key issue during transition from a low income, rural economy towards an industrialized urban one with a large income per capita. Accumulation of physical capital has always been at the core of these analyses, but construction often has been neglected as a driver of sustained growth. Maddison's remarkable book on long run performance by 16 advanced capitalistic countries since 1820 (1991) should be considered. This author states "there are three main kinds of physical capital: non-residential, residential, and inventories. The first is the biggest and has the greatest influence on growth; the second is substantial, but much more limited in its impact" [Maddison 1991, p. 65]. Moreover Maddison presents interesting data about gross residential capital stock per head and as a ratio to GDP in leading economies from 1950 to 1987 (table 3.11 and 3.12) but he does not provide any attention at all to the remarkable data of Germany and Japan. The field of construction economics filled this gap. Turin postulated a causal relationship between construction and economic growth, while Strassman argued that building activities can even replace manufacturing after the initial stage of development. Since these fundamental contributions there has been a significant debate about the role of construction in a given economy. It has been argued that building technology is shifting towards the service sector. Bon has argued that construction per se is less dynamic than other major economic industries, when abundant physical capital is already in place (Bon, 1992). Little statistical analysis has been put forward in this regard. In this paper this old debate has been revised by providing same explorative regressions that link construction value added share to GDP per capita. The contribution of this paper is the introduction of new variables, such as total value added and population density, that should help the understanding of these relationships. Our outcome is still tentative, as explanatory power is quite weak. Additional longitudinal analysis is needed, but this very preliminary analysis shows that the worldwide construction role in the Seventies appears to be very different from the current one and, therefore, new variables should be used for analyzing this changing role.

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MULTI-CRITERIA BID EVALUATION OF PUBLIC PROJECTS

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Abstract
Local and national Governments must deliver the public facilities that citizens need and, at the same time, select private firms that are able to build these facilities according to the best possible compromise between available resources (money, time...) and the quality of the required work/service. Consequently, multi-criteria evaluation schemes, such as the Most Economically Advantageous Tender (MEAT) scheme, are often used by tendering committees in public projects. The used procedure has to meet the requirements of full transparency and to assure competitiveness among bidders. Many MEAT award related models have been proposed in the specialized literature. This paper presents a classification of these models. Their strength and weakness are illustrated. The assessment of some of these models builds upon their application to an example of public procurement. The presented analysis can be used by Governments and public firms in the selection of the tendering mechanism that best meets their requirements, needs and expectations in bid evaluation.

Keywords: public tender, Most Economically Advantageous Tender, supplier selection, bid evaluation

INTRODUCTION

One of the main tasks of local and national Governments is to deliver the public facilities that communities need. This activity involve many challenges, such as gaps in the required financing, need for facilities that meet different qualitative requirements fully, need for their timely delivery, the large number of involved stakeholders and so on.
Consequently Public Procurement has received increasing attention in the specialized literature. This activity has a significant economic relevance. In 2003 the European Public Procurement accounted for more than €1500 billion, equal to about 16% of the EU Gross Domestic Product (Lewis, 2007). In order to implement efficient investment policies, Governments have to encourage competitiveness among candidate suppliers (Malmberg, 2003). In this way, it is possible to build more environmentally friendly public facilities at lower prices and with better quality.

The implementation of efficient Public Procurement procedures is challenged by bid rigging, i.e., the collusion among bidders or between a bidder and a corrupt public officer (Tanaka and Hayashi, 2011). The awarding committee (usually a commission of experts selected by the public authority) must follow prescribed procedures and maintain transparency in public tenders in order to prevent these situations (Panayiotou et al. 2004). Definitively, any given Government aims at obtaining the best possible public goods or services and avoiding collusion: specific laws exist in this regard. In order to meet this goal, a public client must find private firms that can build the required facilities according to the best possible compromise between available resources (money, time...) and the quality of the required work (e.g., in terms of post delivery service, technical features, etc.). Consequently multi-criteria evaluation schemes often are used by tendering committees in this kind of public works.
The European Union Public Procurement Directive 2004/18/EC imposes the use of the Linear Weighting technique (when possible) in the public tenders to be awarded according to the MEAT criterion. This practice is limited by the lack of an optimal choice of weights to be assigned to the evaluation criteria. Moreover, when MEAT is used, public officers can favour a given bidder by assigning a high weight to a criterion that only that competitor is expected to meet fully. Consequently this method is characterized by some subjective choices which make corrupt behaviours possible. In the last few years many models, related to the multi-criteria evaluation of bids, have been proposed in the specialized literature.

Some of these models have been developed for the specific purpose of public construction projects, while others, although aimed at a more general application, can be also applied to evaluating construction bids. Some of these methods address the optimal choice of the weights for the linear weighting. Others are based on the qualitative comparison between alternatives. Another set of methods is based on the estimation of the utility coming from each bid. Lastly, another approach aims at determining the social costs of completion time and the quality of the final work. These costs are added to the submitted bid price.
A classification of several published bidding mechanisms for public projects is proposed in this paper. Their strengths and weaknesses are illustrated. The analysis aims at informing Governments and public agencies the type of mechanism that best meets their requirements, needs and expectations in bid evaluation.
The paper is structured as following. The next section describes the multi-criteria bid evaluation, as proposed by the European directive, and it presents a classification of the considered models, while the following section presents an application of these models to an example of public procurement practice. A final section concludes the paper.

THE MULTICRITERIA SELECTION IN PUBLIC PROCUREMENT

Background

In most countries, public procurement is ruled by specific legislative requirements. In the European Union, this matter is regulated by the 2004/18/EC Directive (European Parliament and Council, 2004), also known as Public Procurement Directive. This law sets the application of one of the two following award criteria: the Lowest Price (LP) or the Most Economically Advantageous Tender (MEAT). The LP criterion is typically used in conjunction with pre-qualification requirements (Lorentziadis, 2010). In this case, money saving is one the main goals of the tender, because the features of the supplied product, service or work are standardized and price is the only element that differentiate offers (Piga and Zanza, 2005). Differently, when the contract is awarded on the basis of the MEAT criterion, various (quantitative and qualitative) factors are considered simultaneously. In this

last case, scores for different factors are synthesized into an overall score by using of the linear weighting method (European Parliament and Directive 2004/18). In this regard, the committee has to assign a weight to each criterion before the submission of the offers. These weights are to be specified in the request for proposals (Lorentziadis, 2010). The literature on supplier selection suggests many methods for weights determination (for an overview see De Boer, 1998), but the Public Procurement directive does not impose any specific procedure in this regard. Consequently, weights could be set on the basis of subjective judgments that, of course, create consistency and validity problems in the evaluation process (Lorentziadis, 2010 and Borcherding et al., 1991). In fact, there is no absolutely optimal choice of weights (Dulmin and Mininno, 2007). In addition, when this awarding scheme is used, public officers can give an unfair advantage to a given bidder by assigning a high weight to a criterion that only she can meet fully (Søreide, 2002).

Literature review

In order to overcome these limits, several studies have proposed the adoption of vendor rating methods that are used in the private sector. These instruments can be a valid alternative to the simple linear weighting of performance values that is based on the weights allocated by public officers.

The methods can be classified in five categories:

- *Linear Weighting-based methods*. These use specific algorithms to find weights to be used for scoring each bid
- *Comparison-based methods*. Each bid is compared to all others in a quantitative or qualitative manner. With this procedure, a final score is assigned to each offer through techniques such the Analytic Hierarchy Process (AHP)
- *Cost-Benefit Analysis*. The cost and benefits of each offer are estimated. The weighted sum of these indicators determines the final score.
- *Utility-based methods*. Specific utility curves, as a function of different criteria, are defined to estimate the overall utility of each bid.
- *Costing-based methods*. The cost consequences of non price related performance are determined and summed to the bid cost. The resulting overall cost is the indicator used for award.

Table 1 shows examples of the models that characterize the above illustrated categories.

Table 1:*Methods for multi-criteria bids evaluation.*

Type	**Authors**	**Techniques**
Linear Weighting-based	Lorentziadis (2010)	Linear Programming that defines the weights used for Linear Weighting evaluation
Comparison-based	Costantino et al. (2011)	Fuzzy Analytic Hierarchy Process
	Padhi and Mohapatra (2009a)	Analytic Hierarchy Process + Simple Multi-Attribute Ranking Technique
	Padhi and Mohapatra (2009b)	Fuzzy Analytic Hierarchy Process + Simple Multi-Attribute Ranking Technique
	Sipahi and Esen (2010)	Analytic Hierarchy Process
Cost-Benefit Analysis	Bana e Costa et al. (2007)	Weighted sum of cost and benefit scores determined with the MACBETH method
	Topcu (2004)	AHP-based pre-qualification and weighted normalized sum of pre-qualification score and price

Utility-based	Hatush and Skitmore (1998)	Utility functions for a set of six criteria
	Holt et al. (1993, 1995)	Bidder pre-qualification and weighted sum of utility and cost scores
	Lambropoulos (2007)	Cost-utility and time-utility curves
Costing-based	Ellis and Herbsman (1991)	Sum of bid price and Road User Cost during the construction
	Herbsman and Ellis (1992)	Sum of bid and Road User Cost during the construction with quality cost

Linear Weighting-based methods

Lorentziadis (2010) proposes linear programming for evaluating criteria weights by suggesting the choice of the average of the least or most favourable set of weights for all candidate suppliers. All weights range according to the limits established by the public client. Suppliers can be assigned differing degrees of importance provided that the related criteria are known in advance when the request of proposal is announced.

Even if there is no direct definition of weights by public officers, this model is still subject to discretionary choices about weights range and degrees of importance of candidate suppliers.

Comparison-based methods

Many approaches use performance indices as inputs to the Analytic Hierarchy Process (AHP) for defining the best offer among alternative bids (Sipahi and Esen, 2010). AHP determines a ranking of evaluation criteria through their pair-wise comparison first, and then uses this rating to define the ranking of bids. The pair-wise comparison of all alternatives is performed according to their degree of satisfaction of each criterion. This method sometimes is employed in conjunction with the Simple Multi-Attribute Ranking Technique (SMART) (Padhi and Mohapatra, 2009a). Other techniques use fuzzyfied input data (Padhi and Mohapatra, 2009b). Costantino et al. (2011), for example, determined the best offer in a public tender through a Fuzzy Analytic Hierarchyic Process (FAHP) that was based on pair-wise comparison of alternatives according to different factors and on fuzzyfication according to specific membership functions.

These methods allow the peer evaluation of all bids, however qualitative comparisons could still be made in a discretionary way. At the same time, membership functions in fuzzyfied models cannot be chosen in a univocal way.

Cost-Benefit Analysis

Many authors have argued about the need for differentiating cost and benefit criteria in the evaluation of bids. For instance, Topcu (2004) proposes a model according to which, after the pre-qualification of contractors with weights determined by AHP, each bidder receives a score that results from the weighted sum of the normalized overall pre-qualification score (estimated benefits) and bid price. A similar, but more complex, approach is proposed by Bana e Costa et al. (2007). Cost and benefits are evaluated in different ways. Cost is considered with the use of an adequate coefficient, while benefit is determined by a set of qualitative sub-factors. The shift to a quantitative scale and the definition of a set of weights for the sub-factors is obtained through a pair-wise comparison that is based on the MACBETH method (Bana e Costa and Vansnick., 1994). In this case the trade-off between cost and benefit scores is obtained by a weighted sum (where the weights are selected by decision makers).

These analyses allow the differentiation between the required price and offered benefits of each bid, but do not take into account other non-monetary requirements for completing a

project, such as completion time. Moreover, discretionary choices can still affect these models.

Utility based methods

Other authors have focused on evaluating the utility of the overall bids. Holt et al. (1993, 1995), for instance, defined a three-stage evaluation procedure for construction related tenders. After a prequalification phase on the basis of non-subjective criteria, all bids are assigned a score according to the utility resulting from pre-defined project criteria and, successively, a second score is assigned to each offered price. A weighted sum of these two indicators determines the final ranking. Differently, Hatush and Skitmore (1998) use six evaluation criteria (bid value and a set of attributes related to a given bidding company, such as financial strength, technical ability, management capability, health and safety records, and reputation). For each of these attributes, a score is determined. The corresponding utility is given by a curve that is developed after bid opening and reflects all offers. The bidder with the highest overall utility is awarded the contract. A similar method has been proposed by Lambropoulos (2007), with two fundamental differences: the considered criteria are cost and delivery time discounts and the utility curves are defined before the request for proposals and known a priori by all bidders. The main drawback of the utility function is its difficult estimation.

Costing based methods

In the last twenty years, the MEAT award scheme has been also adopted in the United States, namely in the construction sector. Ellis and Herbsman (1991) have proposed bid price and completion time as the basis for awarding highway projects. In the initial formulation of the method, the bid price of each competitor is summed to the cost value of each day of incompletion of the project. For each proposal a factor, known as the Road User Cost per day, is estimated. This includes the client's contract administrative costs and the cost to road users for the unavailability of the road (or lane) during construction. The Road User Cost per day is then multiplied by the completion time (in days) proposed by the bidder and the result is added to the bid price. The contractor with the lowest total bid is awarded the project. The same authors (Herbsman and Ellis, 1992) extended their model by considering also the quality of the work (e.g., in terms of roughness index of provided road asphalt). The analysis of 101 highway projects (that had been awarded with the MEAT method) has showed substantial benefits in terms of time savings in comparison with similar projects awarded with the Lowest Price method (Herbsman, 1995).

The cost estimate of completion time or quality allows the quantification of comparable performance indicators and, at the same time, the use of true values in selecting the best bid. The limit of this method is the difficult estimate of the User Cost.

The literature review shows that the above outlined methods have some limits, notwithstanding their benefits, particularly in the case of highway projects. Most of them are based on some subjective selection criteria, such as the interval between weights or membership functions (to be chosen by public officers). Other methods require the subjective estimation of the bid (i.e., in the pair-wise comparison). The qualitative scores, as defined by a given evaluation committee, can still favour a corrupt bidder (Lengwiler and Wolfstetter, 2006). Consequently, this type of arrangement can undermine the transparency of the process. The distinction between the cost and benefit of each bid, furthermore, does not take into account that any given project requires other resources (e.g., time and maintenance services), in addition to money.

Lastly, some of these methods do not respect the EU legislation, because the awarding conditions are not known before the bid opening (Lambropoulos, 2007).
Consequently there is no absolutely a best method when the bid award according to multiple criteria is considered. A public client should select the method which best fits his expectations and established procurement procedures.

THE APPLICATION OF SELECTED MODELS TO PROCUREMENT PRACTICE

In order to verify how different methods can affect the awarding outcome of a public project, three of the outlined models are applied to a case of procurement practice, namely the renovation of a facility at the Politecnico of Bari, Italy (Costantino et al., 2011). In this public project the target price of the auction $\overline{d}_1$ was € 148500 plus VAT and the maximum project duration $\overline{d}_2$ was 35 weeks. The winning bid was selected according to the MEAT criterion.
The number of bidding suppliers was m=45. Each bid (see Table 2) was evaluated according to n=4 criteria, as specified in the request for proposals. The considered criteria were: 1) Price c_1 (with the corresponding performance value d_{i1} measured in € for the i-th supplier and i=1,…,m); 2) Reduction of project completion time c_2 (with d_{i2} measured in weeks and i=1,…,m); 3) Duration of post delivery free maintenance c_3 (with d_{i3} measured in months and i=1,…,m); 4) Quality of enhancement plans c_4 (with d_{i4} and i=1,…,m to be evaluated according to a 0-10 scale that reflect the quality of changes proposed for the design plans and/or material and component substitution). The criteria used for the award were of quantitative (c_1, c_2, c_3) and qualitative (c_4) nature.
The bids of Table 2, are evaluated according to three different ways: the fuzzy AHP (FAHP) (Costantino et al., 2011), a utility based method and a costing-based method.

Table 2: *Bids, related decision criteria, and ranking*

Vendor	**Price**	**Reduction of execution time**	**Post-delivery maintenance**	**Enhancement plans**
s_i	d_{i1} **[€]**	d_{i2} **[weeks]**	d_{i3} **[months]**	d_{i4}
s_1	110238.11	8.00	48.00	8.00
s_2	110963.63	4.00	9.00	9.00
s_3	109514.93	20.00	29.00	1.00
s_4	110484.45	8.00	15.00	9.00
s_5	110681.87	13.00	22.00	6.00
s_6	111092.92	4.00	29.00	1.00
s_7	112930.37	15.00	50.00	3.00
s_8	112783.38	7.00	6.00	5.00
s_9	**131714.23**	16.00	108.00	**10.00**
s_{10}	109920.87	17.00	113.00	**10.00**
s_{11}	110821.52	19.00	59.00	2.00
s_{12}	109775.89	11.00	59.00	**10.00**
s_{13}	108511.70	2.00	41.00	**10.00**
s_{14}	111457.61	6.00	108.00	5.00
s_{15}	111127.97	23.00	44.00	8.00
s_{16}	108990.13	4.00	13.00	1.00
s_{17}	115299.67	21.00	94.00	4.00

s_{18}	111242.01	13.00	47.00	9.00
s_{19}	112036.06	**25.00**	29.00	8.00
s_{20}	111461.96	2.00	48.00	**10.00**
s_{21}	111009.58	11.00	12.00	7.00
s_{22}	110504.87	3.00	16.00	**0.00**
s_{23}	110247.06	24.00	113.00	8.00
s_{24}	110438.76	**0.00**	**120.00**	9.00
s_{25}	112457.83	19.00	69.00	7.00
s_{26}	108469.71	20.00	7.00	8.00
s_{27}	110667.84	22.00	28.00	7.00
s_{28}	111660.57	2.00	42.00	4.00
s_{29}	110500.76	10.00	99.00	7.00
s_{30}	110918.29	6.00	**0.00**	2.00
s_{31}	115520.49	20.00	5.00	7.00
s_{32}	119535.68	11.00	20.00	**0.00**
s_{33}	110183.27	23.00	78.00	3.00
s_{34}	109839.68	5.00	88.00	**0.00**
s_{35}	110583.74	7.00	78.00	1.00
s_{36}	110186.17	4.00	54.00	8.00
s_{37}	125075.21	3.00	66.00	7.00
s_{38}	111151.44	22.00	36.00	3.00
s_{39}	109224.97	14.00	89.00	**10.00**
s_{40}	110556.28	14.00	23.00	**0.00**
s_{41}	110575.67	4.00	82.00	4.00
s_{42}	**107967.74**	21.00	22.00	4.00
s_{43}	111367.66	16.00	44.00	8.00
s_{44}	116276.03	9.00	75.00	8.00
s_{45}	118868.15	13.00	94.00	2.00

As far as the FAHP is concerned, the criteria for weights and membership function can be found in Costantino et al. (2011). This method takes into account all the four decision criteria proposed in the tender.

Lambropoulos's model (2007), as an example of the utility-based method, is used in this application. The inputs to this model are the cost and time discounts proposed by each bidder. Because the required duration of the free maintenance period is not specified in the request for proposal, the application cannot consider this performance value. This is also true for the quality of enhancement plans, which cannot be determined on the basis of a purely quantitative scale. Consequently, the offer that maximizes the overall utility function (1) is to be selected

$$U(s_i) = KU(\lambda_{ci}) + XU(\lambda_{ti}) \quad (1)$$

where $U(s_i)$ is the overall utility of the offer of bidder s_i; $U(\lambda_{ci})$ □ [0,1000] is the utility of the price discount by s_i; $U(\lambda_{ti})$ □ [0,1000] is the utility of the time reduction offered by s_i; K and X are the weights of $U(\lambda_{ci})$ and $U(\lambda_{ti})$. The utility functions $U(\lambda_{ci})$ and $U(\lambda_{ti})$ used in this application are expressed by (2) and (3)

$$U(\lambda_{ci}) = \begin{cases} 3000\lambda_{ci} & \text{for } 0 \le \lambda_{ci} \le 0.2 \\ 400 + 1000\lambda_{ci} & \text{for } 0.2 \le \lambda_{ci} \le 0.4 \\ 667 + 333 * \lambda_{ci} & \text{for } 0.4 \le \lambda_{ci} \le 1 \end{cases} \quad (2)$$

$$U(\lambda_{ti}) = \begin{cases} 200\lambda_{ti} & \text{for } 0 \le \lambda_{ti} \le 0.2 \\ -167 + 1333\lambda_{ti} & \text{for } 0.2 \le \lambda_{ti} \le 0.8 \\ 500 + 500 * \lambda_{ti} & \text{for } 0.8 \le \lambda_{ti} \le 1 \end{cases} \quad (3)$$

The parameters λ_{ci} and λ_{ti} are determined according to (4) and (5) respectively.

$$\lambda_{ci} = \frac{\overline{d}_1 - d_{i1}}{\overline{d}_1} \quad (4)$$

$$\lambda_{ci} = d_{i2} \quad (5)$$

The values of the weights used for the two utility functions are respectively $K = 0.55$ and $X = 0.45$.

As far as the costing based method is concerned, the following evaluation approach is proposed. The user benefits that result from the time reduction (*tub*) and the free maintenance (*mub*) are subtracted from the bid price. Thus the total bid cost b_i (6) is obtained through

$$b_i = d_{i1} - tub \cdot d_{i2} - mub \cdot d_{i3} \quad (6)$$

In this case, the time reduction benefit has been assumed to be equal to *tub* = 800 €/day, while the free maintenance is equal to *mub* = 50 €/week.

Table 3 shows the scores of all offers according to the three considered methods.

Table 3: *Bid scores according to the three considered methods*

Vendor s_i	**Overall performance**		
	FAHP	**Utility-based**	**Costing-based**
s_1	0.4243	423.85	101438.11
s_2	0	369.31	107313.63
s_3	0	632.25	92064.93
s_4	0	422.94	103334.45
s_5	0	507.92	99181.87
s_6	0	368.83	106442.92
s_7	0.4714	533.88	98430.37
s_8	0	397.28	106883.38
s_9	0	385.79	113514.23
s_{10}	0.8069	579.31	90670.87
s_{11}	0.4472	610.26	92671.52
s_{12}	0.6835	476.99	98025.89
s_{13}	0.2593	373.25	104861.7
s_{14}	0.5657	372.62	101257.61
s_{15}	0.3300	677.70	90527.97

s_{16}	0	376.62	105140.13
s_{17}	0.3973	627.96	93799.67
s_{18}	0.4007	505.85	98492.01
s_{19}	0	**708.62**	90586.06
s_{20}	0.3266	362.32	107461.96
s_{21}	0	472.42	101609.58
s_{22}	0	368.44	107304.87
s_{23}	0.400	698.11	85397.06
s_{24}	0	360.97	104438.76
s_{25}	0.5922	604.20	93807.83
s_{26}	0	636.12	92119.71
s_{27}	0	662.26	91667.84
s_{28}	0.2828	361.59	107960.57
s_{29}	0.7303	457.17	97550.76
s_{30}	0	374.62	106118.29
s_{31}	0	610.00	99270.49
s_{32}	0	435.40	109735.68
s_{33}	0.5477	681.20	87883.27
s_{34}	0	376.04	101439.68
s_{35}	0.3162	405.43	101083.74
s_{36}	0.4619	372.19	104286.17
s_{37}	0.0413	267.99	**119375.21**
s_{38}	0.1414	660.47	91751.44
s_{39}	**0.8641**	530.46	93574.97
s_{40}	0	525.53	98206.28
s_{41}	0.4619	370.75	103275.67
s_{42}	0	655.12	90067.74
s_{43}	0.3300	556.81	96367.66
s_{44}	0.3408	418.63	105326.03
s_{45}	0.2152	477.10	103768.15

The data of Table 3 shows different results depending on the type of awarding method. According to FAHP, the utility-based and costing based method the winning bid would be s_{39}, s_{19} and s_{37} respectively. Table 4 shows that each method determines very different rankings of the offers.

Table 4: *Top 10 bids according to the three considered methods*

Rank #	FAHP	Utility-based	Costing-based
1	s_{39}	s_{19}	s_{37}
2	s_{10}	s_{23}	s_{9}
3	s_{29}	s_{33}	s_{32}
4	s_{12}	s_{15}	s_{28}
5	s_{25}	s_{27}	s_{20}
6	s_{14}	s_{38}	s_{2}
7	s_{33}	s_{42}	s_{22}
8	s_{7}	s_{26}	s_{8}
9	s_{36}	s_{3}	s_{6}
10	s_{41}	s_{17}	s_{30}

Moreover, the variability in the final rankings of bids is not determined by the choice of the awarding method only, but also by the parameters used in the evaluation. The same method can lead to very different results by changing its parameters. Thus there is the possibility that a given competitor is favoured over the others. This problem has been addressed in specialized literature (e.g., Telgen and Schotanus, 2010).
Consequently, the selection of an awarding method by local and national Government or governmental agencies should take into account two factors: the availability of useful information for setting the evaluation parameters and the possibility of corrupt behaviour.

CONCLUSIONS

The delivery of public projects is one of the main tasks of local and national Governments (or governmental agencies). These facilities must meet a set of economic, technical and environmental requirements. In this regard, the Most Economically Advantageous Tender is increasingly used as the award method of public projects. The literature review has shown that many models can be applied to the MEAT tenders. This paper has addressed and discussed some of these models. Five types of awarding mechanisms have been outlined. All of them require the setting of some selection parameters and sometimes they are based on the subjective evaluation of offers.
Three of these methods have been applied to evaluating the bids for the renovation of a facility at the Politecnico of Bari, Italy. The data show different outcomes depending on the considered method. The correct evaluation of bids depends on a method that is characterized by fair air and precise parameters and minimizes the possibility of anticompetitive behaviour.
Future research should address the development of an awarding method that is based on objective evaluation and without the need for selecting parameters for ranking.

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EU FUNDED PROJECTS – BEST TOOLS FOR CONSTRUCTION SPECIALISTS EDUCATION

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Abstract
Paper presents first findings, assumptions and initial results of the two innovative projects for construction industry: Leonardo da Vinci Projects (TRAIN.CON, 2010-2012) – "Augmented Reality Applied to Machinery Maintenance from Construction Sector" and Norwegian Instrument Project (NORW, 2009-2011) - "Distance Learning within Management in Construction".

Keywords: augmented reality, distance learning, management, machines operators.

INTRODUCTION

Author is the member of research teams for two EU funded projects connected with education of construction personnel in Europe: MAIN.CON project (No: 2010-1-ES1-LEO05-20930), titled: "Augmented Reality Applied to Machinery Maintenance from Construction Sector", related to the creation of innovative system facilitating construction machinery maintenance, with use of the augmented reality basis. NORW project (No: FSS/2008/X/D5/W/0005/U/0013), titled: "Distance learning within management in construction", is the part of the Development of Polish Universities Program, donated by Norway, Iceland and Lichtenstein within the Norwegian Financial Instrument project. NORW project is related to development of modern, blended learning types of studies for Polish and Norwegian construction managers. Logos of the Norwegian Financial Instrument and Leonardo da Vinci programs are presented in fig. 1.



Figure 1: *Logos of FSS and Leonardo da Vinci projects.*

ASSUMPTIONS FOR THE MAIN.CON PROJECT

Introduction

The effectiveness of construction processes implementation today depends on the production capacity of sets of construction machines and equipment. An equipment contains a mechanism or a set of mechanisms aimed at processing of energy or conducting of works, while a machine is a device containing an engine of any type. Nowadays, mechanization of

various construction processes requires application of leading machines, complemented by machines parts, to establish the mechanized construction work lines. The term 'mechanization' encompasses the production-related operation of machines performing tasks related to particular technology. Production-related operation pertains to performance by machines of mechanical works under varying conditions at the building site. The activities of the technical service for any machine include the planned preventive measures, aimed at preventing the excessive use and damages of machines and repairs, restoring the original technical conditions of machines.
Generally speaking, mechanization and automation are forms of technological progress. Significant features of mechanization and automation include recognition of any organizational relations, which take place within the technological operation sequences (storage, transport, production and assembly, operation and maintenance) and using them in the common production process, using the increasingly mechanized lines of machines.
Mechanization is a process related to the development of machines. Progress in the field of mechanization of construction trade depended on technological progress with regard to construction machines. At present, in association with the quick development of industrial automation devices, it is becoming increasingly dependent on the progress of IT science and computer techniques. Regardless of technical progress, the development of the basic theory of mechanization in construction trade was observed relatively recently. In the fifties of the 20th century, the first principles of mechanization of construction works were formulated in Poland, and in the sixties - the principles of complex mechanization.
The gradual automation of processes on the construction sites will depend on the changes in the way of thinking about the building techniques. While the main problem in mechanization of processes is the technology and the technical works equipment (a properly selected set of machines), for automation and then robotics of processes, the problem lies in control (management) of the entire processes or great systems, using the appropriate automatic devices or computer software. Augmented reality can be a vital part of construction technology development

Basis for the project

MAIN.CON project partners are as follows: Labour Foundation for the Construction Sector, Spain (the Promoter), Polish British Construction Partnership, Poland, BZB, Germany, Centro Edile Andrea Palladio, Italy and Ente Scuola per la Formazione delle Maestranze Edili, Italy. The aim of the Leonardo da Vinci MAIN.COM project is to design and apply a training system in basic machinery maintenance using a new technology called augmented reality. This system will improve the basic skills of machinery operators related with a safe maintenance of their machines and not only with their operation. Main assumptions for the project are presented at fig. 2.

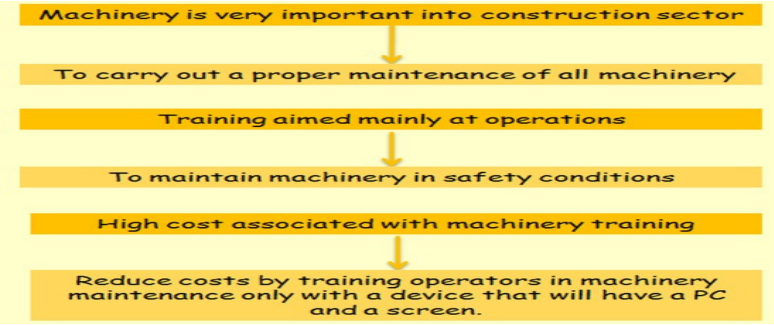


Figure 2: *Main goals of the MAIN.CON project [2].*

The Augmented Reality (AR) is the term to define a direct or indirect view of the physical environment in the real world, which elements combine with virtual elements in order to create a mixed reality in real time. So, it consists in a group of devices which add virtual information to real information. This is the main difference with virtual reality, because it doesn´t replace physical reality, but superimposes virtual data on real world. This project is going to be focused in excavation works for two reasons. Firstly, because of intensive work, which emphasizes the necessity of preventive maintenance. Secondly, because of the enormous quantity of self-employers and SMEs, who own, for example a digging machines and are working for others companies. This project is going to be based upon the outcomes obtained in the project "Training system for mechanical digger operators", in which one of the most important developments was maintenance training. Furthermore, it included an experimental system based on personal digital assistants (PDA) of which function was to support the learning through the use of checklists. The system pretends to enhance the training of operators in the field of maintenance, through the use of Augmented Reality. To reach this aim, the project will provide a system which will allow to select maintenance operations by means of a interface easy to use by the operator. One of the first attempt for use of augmented reality was conducted by car producer – BMW, for easy maintenance of cars. Fig. 3 presents screenshot from BMW movie showing general maintenance of the car engine – replacement of the cooler duct.



Figure 3: *BMW system of cars maintenance with use of augmented reality screenshot [4].*

Classification of chosen construction machines

Every machine consists of three basic elements: undercarriage, bodywork and working equipment. The type of each of these elements serves as a basis for classification of machines. The MAIN.CON project will base on the standard ISO/TR 12603, which provides the European classification of construction machines according to their use within the framework of individual work groups. For example - group 100 will be the subject of MAIN.CON project. This group consist of earth-moving machines and equipment: (for preliminary earthworks and wide excavations: 110 - bulldozers: wheel, caterpillar, 120 - loaders; wheel, caterpillar, 130 - digger-loaders; wheel, caterpillar; 140 - diggers; hydraulic, drag line excavators, bucket wheel diggers, bucket chain excavators; demolition equipment; transport of soil: 150 - articulated dump trucks, tipper trucks; for earthworks finishing: 160 - scrapers, 170 - graders; narrow and pit excavations: 180 - ditch diggers, 190 - pipe-laying machines) [1].

The process of machine operation is an entire set of organizational and technical tasks, which are aimed at performance of production tasks using machines in accordance with their technical parameters, as well as maintenance of the technical capacity of machines enabling them to perform work.
In the operation process, the following two (A and B) states of machines are recognized:
A). Production-related operation of machines – it is a state of capacity of machines to perform mechanical works (in relation to rented machines, the applicable term is – the state of production-related use of machines). In the state of production-related operation of machines, two significant sub-states can be identified: the sub-state of machines waiting for implementation of tasks and the sub-state of production-related tasks implementation by machines (performance of mechanical work). The basic tasks performed during the production-related operation of machines include:

- formal and legal activities associated with driving machines on public roads,
- transport of machines to construction sites (conditions, securing of transport),
- preparation of machines for work (location of machine, connecting of the power supply),
- performance of tasks and mechanical work of machines (position-related limitations, occupational health and safety),
- disassembly of machines and transport to another work site or to the place of storage.

The time of waiting for task performance is an inevitable time of production-related operation of machines and it amounts to 5 to 15% of their production time. The structure of activities performed in the state of production-related operation of machines and auxiliary equipment is presented in table 1.

Table 1: *The structure of construction machines maintenance activities [1].*

The structure of activities performed in the state of waiting and performance of production tasks for machines and sets of auxiliary equipment (boarding, scaffolds, templates, etc.)					
Transport arrangements	■			■	
Transport of the machine to the construction site	⇨				
Assembly and setting for operation		●			
Period of the machine works			▬		
Disassembly and transport of machine				⇨	
Maintenance and repairs after completion of works			*Random events (breakdowns)*		●

B). Technical maintenance status of machines - is the status of prevention of breakdowns, repairs or renovation of machines and control of their ability to perform production tasks. The basic tasks performed in the technical maintenance status of machines are as follows:

- washing of working elements of machines and lubricating of those components, which are most sensitive to damages after the end of each working shift,
- periodical inspections, technical and transport servicing of machines and auxiliary equipment after the end of the cycle of works or all works on the building site, as well as the planned repairs and renovations of machines and auxiliary equipment.

The typical features of the process of construction machines operation include:

- frequent changes of the place of operation and the associated frequent transfer of machines between construction sites or places of operation on the site,
- a wide scope of changeability of the conditions of operation due to external conditions (weather, terrain) or technological conditions of works,
- a relatively high frequency of technical maintenance due to sensitivity of drives and auxiliary systems of machines to work overloads.

Depending on the intensity of operation, the production capacity and efficiency of machines lowers as a result of wear of the structure elements and the process of ageing of machines. Restoration (regeneration) of the original technical capacity of machines, that is, their full ability to perform tasks, depends on a number of organizational and technical activities, belonging to the appropriate system of technical maintenance of machines.

System of maintenance and repair of machines

Machines, which have the status of technical maintenance, are either reparable or irreparable. Irreparable machines include those, which are technically unfit or which are reparable from the technical perspective, but their repair is not profitable. The issue of technical maintenance of machines is associated with the concept of repair capacity of machines.

Repair capacity of a machine – is the component of the concept of reliability and it is the adaptation ability based on prevention, identification and elimination of damages (inspections and repairs of the machine), which may arise during operation of the machine or as a result of ageing of the materials and the structure.

The basis for planned operation of machines and technical devices is a schedule of technical maintenance and repairs of machines and devices. The system provides for obligatory technical maintenance and major (general) repairs after the machine performs a specific number of hours of work.

Periodical technical maintenance includes the planned preventive measures, preventing the early damage of the machine. The following types of maintenance can be identified:

- everyday technical maintenance – a set of maintenance tasks: washing, lubrication and inspection of some mechanisms (components of the hydraulic system, bolts, flat runners etc.), which are performed every day, usually after the end of each working shift. Lubrication of the machine mechanisms is based on addition or replacement of lubricant in the lubrication points within specified time intervals. Everyday maintenance is considered to be one of the most significant tasks, decisive for maintenance of the machine in the proper technical condition and for reliability of its work.
- periodical technical maintenance – a set of maintenance tasks: control of the condition of the machine and replacement of some parts or small sub-assemblies, performed prior to each summer or winter season or prior to transfer of the machine to the new construction site. Periodical inspections, apart from the ordinary maintenance tasks, such as replacement of oil, include checking of the main mechanisms of the machine (the gear, clutches, breaks, bearings, hydraulic systems etc.) and determining of the medium-level repair date.
- transport-related technical maintenance – a set of special tasks performed in order to prepare and secure the machine during transport. The transport maintenance may include a partial disassembly and safeguarding of the machine for the transport period.

Planned and preventive repairs are technical tasks, aimed at restoring of the original technical condition of the machine. The following types of repairs can be identified:

- medium-level repair – is a set of maintenance and repair tasks performed after a specific number of hours of work of the machine (e.g. about 2.5 thousand hours for a loader); it includes elimination of defects or replacement of sub-assemblies of the hydraulic and

electric system, mechanisms of work tools, etc. The most significant inspection tasks include: measurement of clearances in the machine driving mechanisms and work tools (gear wheels, bearings, bolts etc.), inspection of rubber seals of pumps, cylinders and hydraulic pipes, checking of wear of electric sub-assemblies and parts, etc.

- major repair – a set of renovation tasks performed after a large number of working hours of the machine (e.g. about 5 thousand hours for a loader); it includes verification of all parts and sub-assemblies, repair or replacement of the main sub-assemblies of the machine. The most significant tasks include: replacement of seals and flexible pipes, hydraulic pumps and manipulators, main electrical sub-assemblies, disassembly and repair of the main machine assemblies, the engine, the gearbox, the driving mechanisms and work tools, replacement of parts and sub-assemblies.
- breakdown repair – it includes the full scope of repairs resulting from damage.

Initial results of the project

MAIN.CON project consist of several general work packages (WP), leading to the achievement of project goals:

- WP I - analysis of construction earthworks machinery. In this work package Partners will carry out a Focus Group in each partners' country in which they will analyze and select the most appropriate machine for its implementation under Augmented Reality (AR). First meetings with construction personnel in Poland showed that the most used machinery for earthworks are medium size diggers.
- WP II - definition and establishment of a map of basic skills in machinery maintenance. This work package consist of: analysis of machinery operators, definition of key functions and main functions, definition of the elements of the operators' skills, identification of performance evidences, definition of the implementation criteria, identification of knowledge evidences, establishment the different levels of the skills. Fig. 4 shows possible connections between real world and artificial reality.

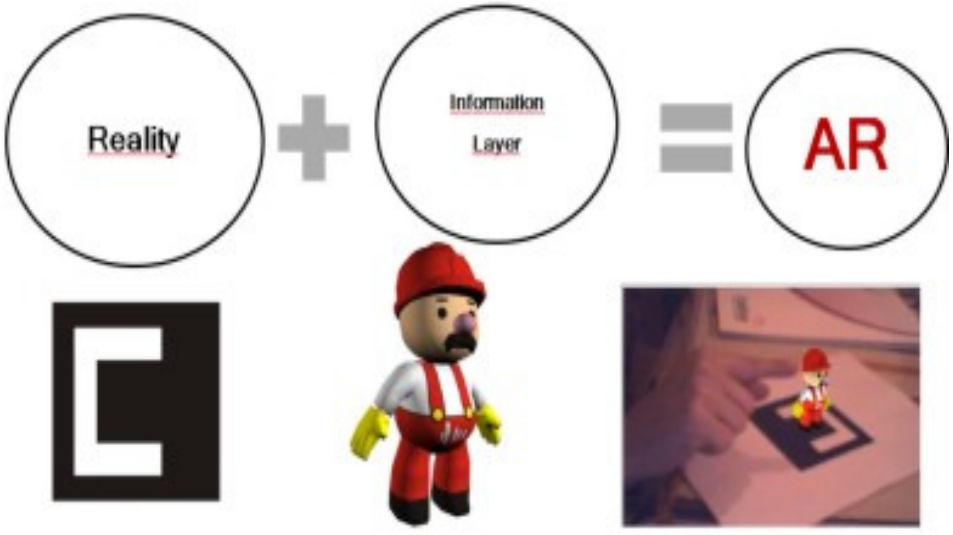


Figure 4: *Ramon (in Poland – Roman) - animated PDA - character facilitating operators training created in the MAIN.CON project [2].*

- WP III - development of the software and hardware based on Augmented Reality for maintenance training. This work package consist of: development of the contents, make graphic design, building the graphics under Augmented Reality rules, design of the training system, design of assessment system, make the needed devices to carry the hardware. Fig. 5 shows possible elements of the future training system.

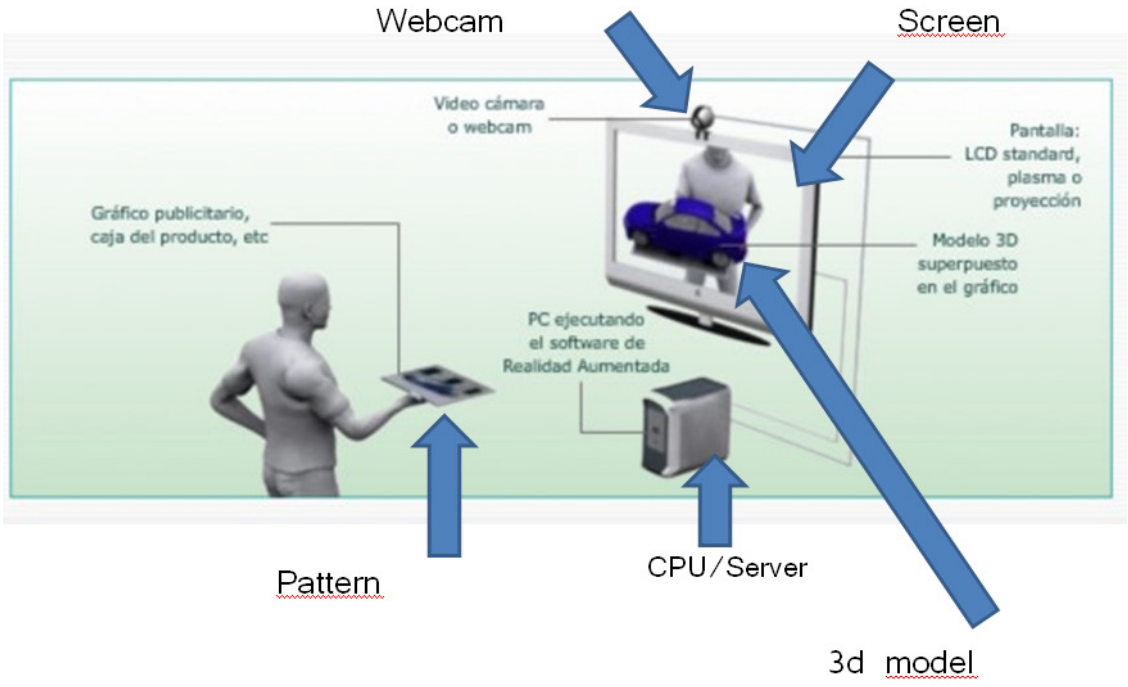


Figure 5: *Augmented Reality of the MAIN.CON project [2].*

All products of the project will be tested and evaluated. Full, usable version of the Augmented Reality system for machines operators should be ready at the end of the year 2012.

Initial results of the survey held in Poland

The survey was made among Polish operators of the construction machinery, to find what excavators are the most useful / popular in the country and what kind of maintenance operations could be run at the building site by themselves.

Focus Groups in Poland took place on 19.02.2011, during weekly meeting of excavators operators course, organized by "LEKTOR" – Centre for Continuous Education of Drivers and Machine Operators, ul 1-go Maja 7, 05-250 Radzymin, Poland. Each focus group was composed by 10 to 15 experts in the field of machinery maintenance. The duration of the focus group was around 2 hours. The focus group was managed by a moderator who follow the following steps (as agreed with Partners and Promoter of the Main-Con project):

Step 1: Overview about the project.
Step 2: Explanation about the aims of the focus group.
Step 3: Asking opened questions included in the questionnaire. Recording and moderation of the debate.
Step 4: Provide the questionnaire with closed questions to the experts.
Step 5: Collect the questionnaires and closure.

Results shows that operators can perform chosen maintenance operations on site. Summary of the results are shown in table 2.

Table 2: *Results of the survey in Poland (*first five most popular answers – yes)

CONTROLS:	YES	NO
Oil leakage from hydraulic system	39	2
Proper running of bucket	38	0
Proper running of indicator lights and instrumentation	36	2
Condition of hoses and metal pipes	35	3
Abnormal noise of axles	35	3
Oil leakage from transmission and reductors	35	2
Tires wear and tear	35	5
INSPECTION REGISTRATIONS:	YES	NO
Cleaning of electrical poles and battery terminals	24	12
Cleaning of the filter element of engine vent	23	11
Cleaning of plug and filter fuel tank	14	19
Empty sediments from fuel tank	10	24
Empty sediments from reservoirs	10	24
FILTERS AND LUBRICANTS:	YES	NO
Check of hydraulic oil level	38	1
Check coolant level	36	2
Inspection and cleaning of cabin air filters	25	11
Inspection and cleaning of secondary air filter	20	14
Replacement of air primary filter	19	16
Cleaning of air pre-filter and check of turbine pre-filter	19	16
LUBRICATION:	YES	NO
Greasing of loader unit	37	3
Backhoe greasing	36	3
Greasing of oscillator of front axle	25	9
Greasing of rear axle support	23	11
Supports and cross pieces of drive shaft	22	13
SAFETY:	YES	NO
Proper running of lighting devices	37	1
Proper running of parking brake	37	1
Proper running of auxiliary brake	36	2
Proper running of the wiper	34	1
Proper working of rear-view mirrors	33	3

The following (few chosen as the example) questions were asked during debate:

1. Which heavy machine is the most used for carrying out the excavation?

Caterpillar or wheeled excavator are the most useful machines – 8 answers; 6 persons are convinced that JCB excavator are the most popular machines (medium size, for example JCB JS130W); one person mentioned VOLVO excavators; all agreed that backhoes are the most useful (both on wheels or caterpillars).

2. Which are the typical works for maintenance and services that can be made on the machine by the operator?

Lubrication (10 persons fully agree); checking the oils and fluids (5 persons fully agree); technical check of tires; checking the wires and electrical equipment; minor reviews before and after the work (battery, cables, tires); checking the state of the petrol tank and other tanks.

3. Which operations are done daily? All agreed:

Checking the hydraulic ducts; lubrication; checking the possible leakage; checking the blades; checking the tires and wheel clamping; exchange the filters.

4. Which operations are done monthly?

Overall clearing; checking and changing the tires; technical review; checking the wires / hydraulic; checking and cleaning / exchange the filters; conservation of electric wires; checking the lubricates / exchange.

5. Which of the listed operations are particularly uneasy to fulfill?

Checking the levels of lubricates and exchange of lubricates and filters; checking and changing the tires; exchange of wires / hydraulic ducts; conservation of electric wires.

6. Do you think that "Augmented Reality" could be useful for training operators on maintenance works?

All courses are important for better professionalism; 16 answers YES (one – very useful); 3 answers NO; 10 answers – NOT SURE.

Focus Groups show interest of machinery operators in finals results of the project - Augmented Reality distance learning courses and didactic materials - which will be the final results of the project.

FINDINGS OF THE FSS NORWEGIAN PROJECT

Introduction

The NORW project is related to development of studies in English for construction managers in Poland and Norway (English as a language of instruction for the lectures and workshops). The project will develop some new courses, modules and curriculum as well as modify the existing ones.

New curriculums were created in cooperation with sector of small and medium - sized enterprises. The project will create two first courses organized in the blended learning mode of teaching (face to face mixed with e-learning):

- "Economy and Financial Management in Construction" and
- "Construction Management".

Need for the courses was confirmed during numerous research works and projects and contacts with Polish, Norwegian and other European construction companies. Operational goals of the project are: increasing the attractiveness of teaching at Universities and increasing the professionalism of construction managers running the European funded projects in construction infrastructure (roads, bridges, airports, water and waste water treatment plants, sewage networks, etc.). Detailed goal of the project is creation of the didactical internet platform for teaching elements of management in construction together with didactical materials and methodology, both in English and Polish. Partners of the project are: Department of Construction Engineering and Management, Civil Engineering Faculty of Warsaw University of Technology (the Promoter), Poland, Polish British Construction Partnership, Poland, Norwegian University of Science and Technology (NTNU) in Trondheim and SINTEF in Oslo (Norway). Results of the project – distance learning courses – will be used in Poland and Norway for postgraduate study and then transferred to other EU countries.

For the distance learning courses, created in the NORW project, the It's Learning platform located at NTNU will be used. General website of the platform is shown at the figure 6.

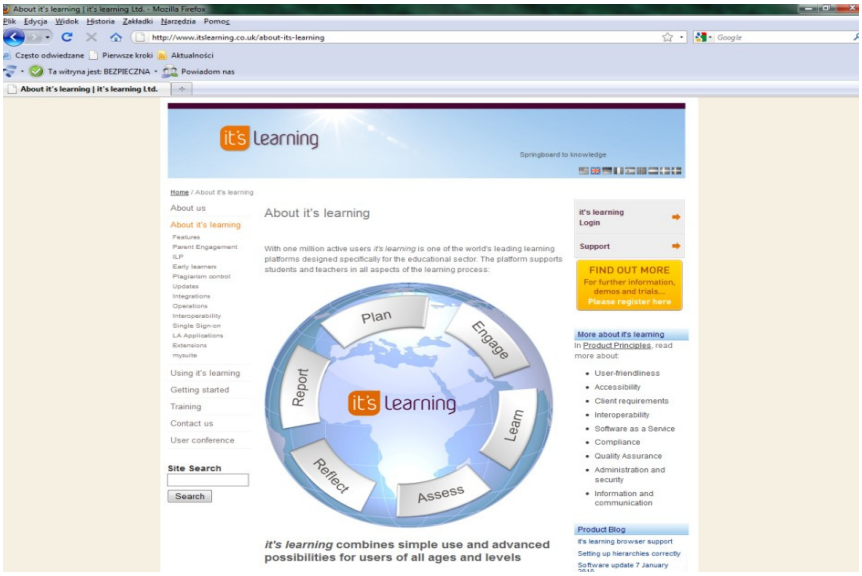


Figure 6: *Main It's Learning website screenshot [5].*

Main content – related assumptions of the NORW project's courses

Economy and Financial Management in Construction Course

The process of decision making is not an individual but iteration process, conducted from general to detailed approach in three stages of preparatory procedure:

- opportunity study,
- pre-feasibility study,
- feasibility study.

All three stages employ, to a larger or smaller extent, methods and analyses which were presented in the first manual converted into distance learning mode of study. The manual "Economy and Financial Management in Construction" consist of the following elements [6]:

- the basic method is the method of determining the present net value (NPV). It is based on discounting cash flows from the future periods to the present period. Discount rate has to be usually at least equal to the percentage rate of the capitals in banks increased by appropriate percentage rates connected with inflation and applicable risk. Percentage rate where the NPV value is equal to zero is called the boundary internal rate of return (IRR). Obviously while making investment decisions various scenarios should be taken into account (optimistic, neutral, pessimistic) in order to gain attitude towards the project's behavior in various economic situations. In these scenarios it should be specified which of the factors for analysis of cash flows have the biggest influence on the final result of the NPV value.
- capital asset pricing method (CAPM) - determining discount rates, trends concerning rates of return from other projects and the will to bear risk by potential investors should be taken into account. All such research may be conducted including the strategy of games and the risk, which means establishment of a large group of operation research methods and probability-static methods.
- the unique application of the Fuzzy Theory for the analysis of NPV method value is emphasized.

- financing methods of investment projects and methods of organization structure selection for management of investments, especially covering the structures useful for launching projects in the public private partnership (PPP) are also analyzed.
- the basic principles of Value Management Method are presented. The Value and Risk Management method (V-RM) may also analyze risks and related probability of achieving the expected advantages.

For all the issues presented above – set of over hundred different exercises were created. Example of such an exercise from NTNU It's Learning platform is shown on fig. 7.

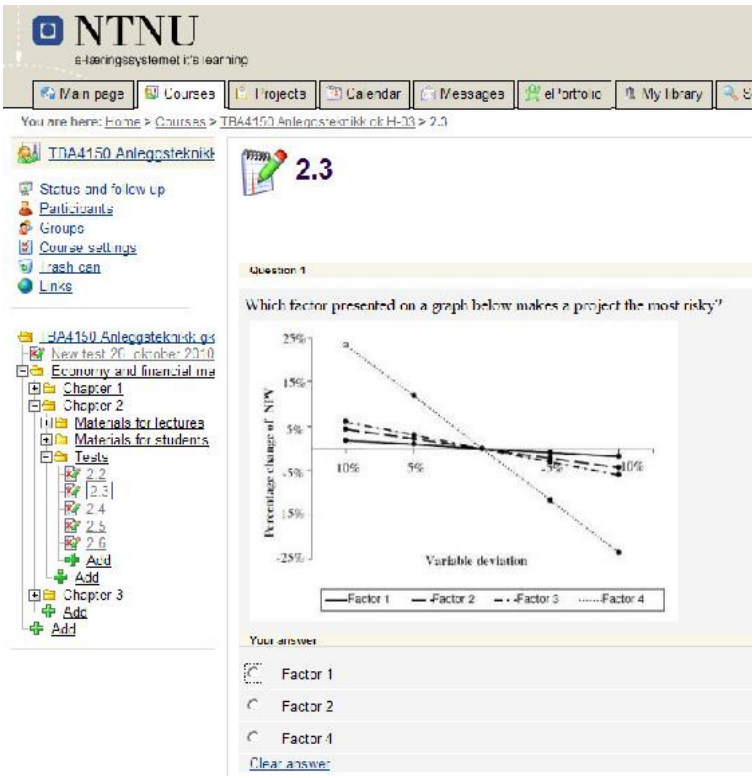
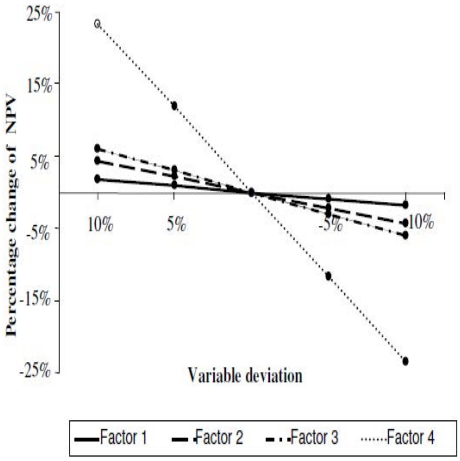


Figure 7: *Example of the "financial" exercise on It's Learning NORW Platform – screenshot from the prepared course.*

Example of the exercise "sensitivity analysis" is presented below.

> "SENSITIVITY ANALYSIS - Introduction - Sensitivity analysis is an analytical method indicating how NPV and IRR change together with modification of a single variable and other factors remaining unchanged. The starting point for this analysis is the basic presented during lectures. Then a few or more than ten variants of calculations are conducted. Each time the same variable is changed by the same percentage below and over the expected value, for example –10%, –5%, +5%, +10%. The other factors remain unchanged. Therefore it is possible to answer the question what would happen to a given project if the variable assumed in the analysis was different. Thanks to the sensitivity analysis by single changes new NPV values are obtained. Then charts picturing dependence of NPV on the changed factors are prepared, which enables obtaining sensitivity curves. Inclination of the curves shows how a given project is sensitive for the course of a given variable. The

bigger is the NPV curve inclination, the more a given project is sensitive to the analyzed factor. A project with a bigger curve inclination is considered more risky. After presenting all sensitivity curves on one chart it is possible to assess which data is the most sensitive and should be estimated in the most detailed and probable way at the stage of budgeting the investment. Try to answer the question below:
Which factor presented on a graph below makes a project the most risky?



a) Factor 1,
b) Factor 2,
c) Factor 4.

Figure 8: *Exercise on the sensitivity analysis [3].*

Solution
Factor 4 has a bigger curve inclination, therefore it makes a project the most risky. Answer c) is correct."

Construction Management Course
The manual "Construction Management" consist of the following elements [7]:

- chapter 2 introduces the construction industry in general. The chapter also gives data on construction in the European Union and presents the construction company, including some of their traditional organisational hierarchies, and the link between the firm and the construction site.
- chapters 3 and 4 examine the contractual documents and the different agents that appear in the construction phase. Documents of the design project and tendering documentation are analysed. Chapter 4 introduces other interesting issues such as communications, decision making and negotiation.
- chapter 5 analyses information flow, documentation and record keeping. It develops mainly the daily logs, the reports, the diary and the meetings.
- next chapters explain basic issues related to the execution of works, such as: machinery and equipment (6), productivity and performance (7), site setup and planning (8) and technology and quality (9). Chapter 6 takes into consideration the selection of machinery, the calculation of its cost and, finally, the machinery maintenance. Chapter 7 presents the study of works, techniques of work measurement, equipment performance and productivity assessment; two fresh concepts are also introduced: value engineering and

benchmarking. Chapter 8 considers constrains of the site and the equipment, storage of materials, temporary facilities, jobsite offices and jobsite security. Finally, chapter 9 summarises construction processes and procedures in building and civil works, and it explores the temporary works, innovation and quality management at the construction site.

- chapter 10 is focused on health and safety in the construction site. Taking into account the European Union directives, the general principles of prevention and the involved agents and their duties are explained. Site specific safety plans and incidents during the execution of works are also considered.
- chapter 11 shows the environmental management at the construction site; the issue of sustainability is also explained. Chapter 12 analyses supply chain management in construction, introducing the issue of lean construction.
- chapter 13 describes resources management, investigating the scope of activities, the assignment of resources to activities, their sequence, duration and monitoring. It develops the bar and network diagrams, cost of resources and cost control.
- chapter 14 considers changes and claims during the construction phase.
- chapter 15 focuses on progress payment procedures.
- chapter 16 describes the closeout process of the construction works and also the construction contract. It analyses the testing and commissioning procedures, handover and occupation. It introduces the operation and maintenance manual and the as-built documents.

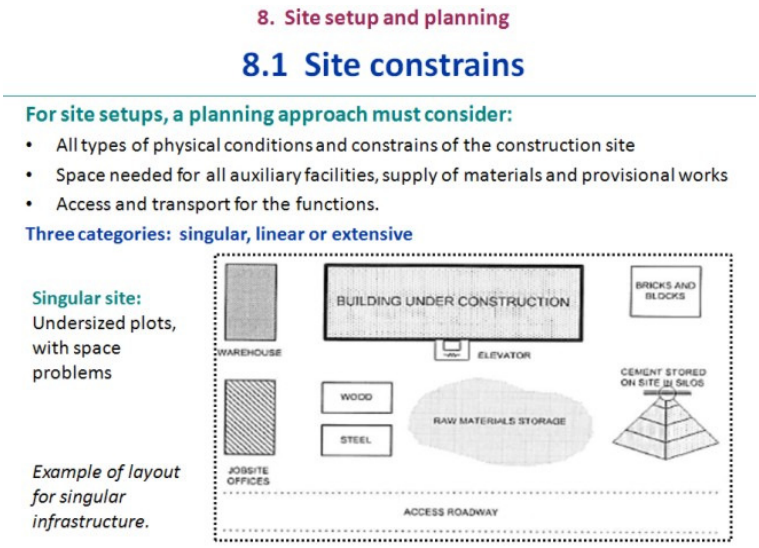


Figure 9: *Example of the exercise on It's Learning NORW Platform – Construction Management Course.*

For all the chapters presented above, as for the previous course - set of different exercises were created, for example - the exercises connected with design of different building site layouts for different types and sizes of the construction project. Example of the exercise is presented on figure 9 (exercises for Chapter 8: "Site setup and planning", subchapter 8.1: "Site constraints").

SUMMARY

Results of both projects presented above should significantly improve education system of construction industry personnel. NORW project will allow to take a part in the postgraduate

study in construction project management for those engineers, who are very busy at infrastructure construction project, having no time to gain their knowledge via stationary, face to face courses. E-learning will allow them distance learning mode of study – from home or from the site office. Results of the MAIN.CON project will improve daily work of construction machines operators. Transport works (including earth moved with excavation preparation) in construction are important element of building process, for example for 1 m2 of apartment there is a need for transport of 1800 – 2400 kg of materials and elements. (depends on the technology and materials). [1]. Better maintenance of the construction machinery will significantly improve work capacity. Training provide with augmented reality system will decrease costs of construction machinery maintenance courses for operators.

ACKNOWLEDGEMENTS

Author would like to express his sincere thanks to Warsaw University of Technology, Civil Engineering Faculty, Poland, Norwegian University of Science and Technology and SINTEF from Norway for help in preparation of FSS project and to promoter of MAIN.CON project: Fundacion Laboral de la Construction, Spain.

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THE TIME-COST ANALYSIS OF THE CONSTRUCTION PROJECT, TAKING INTO ACCOUNT RISK BASED ON EXPERT KNOWLEDGE USING FUZZY SETS

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Abstract
The analysis proposed is aimed at a detailed risk review for a given project at the stage of value engineering of the integrated value and risk management. On the basis of the cost estimate and the time schedule established, for individual groups of works, the cost or time deviations for each task are specified. Expert knowledge is used for this purpose. In order to transform the input information, it is necessary to introduce fuzzy modeling, which includes fuzzification, inference and defuzzification processes. The procedure proposed allows for automatic determination of optimistic and pessimistic project scenarios with regard to both time and cost, using simple math operators like the arithmetic average and the center of mass. In this way, we obtain the quantified risks associated with time and cost of the project, which allows for comparison of several technologies for implementation of the same project and selection of the most optimum variant.

Keywords: risk, analysis, project management, construction, fuzzy sets

INTRODUCTION

A key stage of every construction project is its implementation, or the moment of creation of the facility. This is associated with selection of the contractor, technology of performance of works, the implementation cycle. All of these aspects influence to a specific extent the two key project parameters, which are the cost and deadline of implementation.

In the article, we present the method of introducing the risk associated with a given investment at the implementation stage, using the experience and knowledge of independent experts. We used the fuzzy set theory as a tool. Fuzzy set can be presented as a set of pairs, which assigns to each element in space a degree of membership: from non-membership, through partial membership, to full membership [1]. Thus, we can see that apart from the alternative "membership – non-membership", typical for a conventional set, there are cases of partial membership here. The fuzzy set theory is a theory of classes, in which going from membership to non-membership is not incremental, like in a conventional set, but graded.

In order to transform the input information, we used fuzzy modeling, which includes fuzzification - presentation of input data (information) in form of fuzzy sets, inference- transforming several input functions into a resulting function and defuzzification- obtaining of an acute value, which reflects a given fuzzy set.

This approach towards the investment project implementation allows the investor or the general contractor to obtain knowledge on the potential changes in the time and cost of implementation.

DESCRIPTION OF THE METHOD

The example used involved the following project. The facility under concern is an apartment building, and the estimated construction cost is PLN 28 346 000. The entire project consists of seventeen groups of works, such as preparatory works, earthworks etc. Specific costs, determined by the author of the cost estimate, are associated with each group of works. These have been presented in table 1.

No.	Name	Costs
	APARTMENT BUILDING	28 346 000
1	Preparatory, background works	450 000
2	Earthworks	1 640 000
3	Raw state – underground level	2 250 000
4	Raw state – above ground part	5 300 000
5	Brickworks – external walls	950 000
6	Brickworks – internal walls	825 000
7	Roof insulation	1 320 000
8	Windows	3 120 000
9	External plaster + heat insulation	1 950 000
10	Wall lining – clinker brick	823 000
11	Interior finishing works	4 220 000
12	Passenger elevators	758 000
13	Power supply and low current installations	1 800 000
14	Sanitary installations	1 350 000
15	Building service lines	260 000
16	External works	1 150 000
17	Preparation of the facility for final acceptance	180 000

Table 1: *A tabular breakdown of costs for individual groups of works.*

The groups of works presented in table 1 constitute the time schedule of the project planned. Presented below is the Gantt chart for the project examined. The schedule below presents the planned time of implementation of individual tasks, defining the correlations between them. Apart from the sixteen groups of works, presented in table 1, the schedule includes some control points and activities that do not generate costs directly. For the needs of the method presented, we focused on analysis of deviations, associated with seventeen groups of works specified in table 1. Nevertheless, the total time of implementation of the investment is a result of twenty three tasks included in the schedule.

No.	Task name	Cz. trw.
1	APARTMENT BUILDING	488 d
2	Takeover of site	0 d
3	Preparatory, background works	35 d
4	Earthworks	104 d
5	Raw state - underground level	74 d
6	Raw state - above ground	118 d
7	Brickworks - external walls	140 d
8	Brickworks - internal walls	130 d
9	Roof insulation	77 d
10	Windows	118 d
11	External plaster + heat insulation	120 d
12	Elevation wall lining	101 d
13	Deadline for residential changes	0 d
14	Finishing interior works	253 d
15	Passenger elevators	93 d
16	Power supply and low current installations	323 d
17	Sanitary installations	366 d
18	Building service lines	140 d
19	External works	114 d
20	Preparation for final acceptance	26 d
21	End of works, filing of application for a certificate of occupancy	1 d
22	Acceptance by the Acceptance Commission	12 d
23	Obtaining of the binding permission for occupancy	1 d

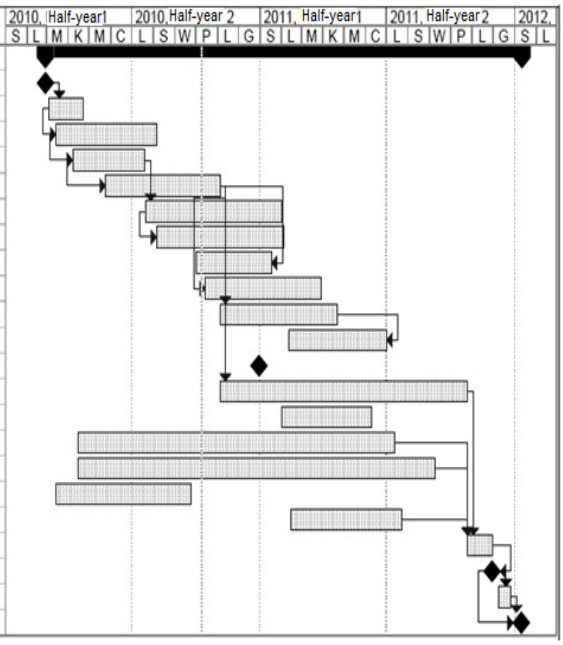


Figure 1: *Gantt chart for the project planned.*

During implementation of the project, there are various deviations from the cost or time planned. The objective of this article is to present a method of determining these prior to commencement of the project. It was assumed that information in this regard would be presented by Experts in form of 3 answers to the following questions:

What is the most probable cost/time value for task „x" and its probability (level of membership)?
What is the minimum cost/time value for task „x" and its probability (level of membership)?
What is the maximum cost/time value for task „x" and its probability (level of membership)?

For the needs of analysis, it was assumed that knowledge on deviations was obtained from 3 independent experts, using the issues associated with fuzzy modeling. At the same time, it was assumed that the probability of occurrence of deviation would be expressed as the so-called membership level. In fuzzy modeling (inference), three stages of the operating block can be distinguished: fuzzification, inference – creation of the resulting membership function, defuzzification – sharpening of the fuzzy set. The diagram has been presented in figure 2.

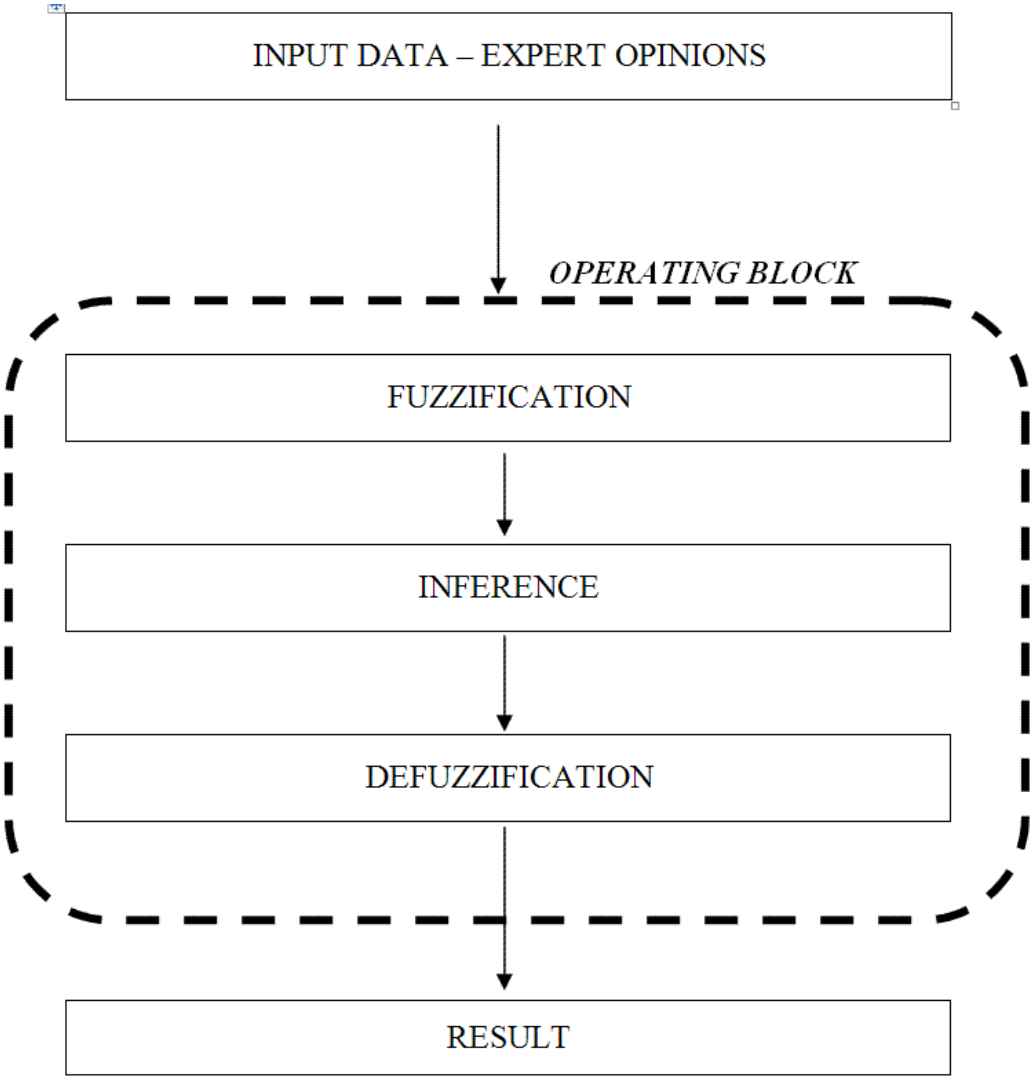


Figure 2: *A fuzzy model diagram.*

The input model data consists of answers to three questions from three experts. The first stage of the operating block is fuzzification. It is based on presentation of input data (information) in form of fuzzy sets. For the needs of this study, it was assumed that the input function of membership of the fuzzy set has the form of a linear piecewise function. The space of sets corresponding with one task of the investment has been presented below:

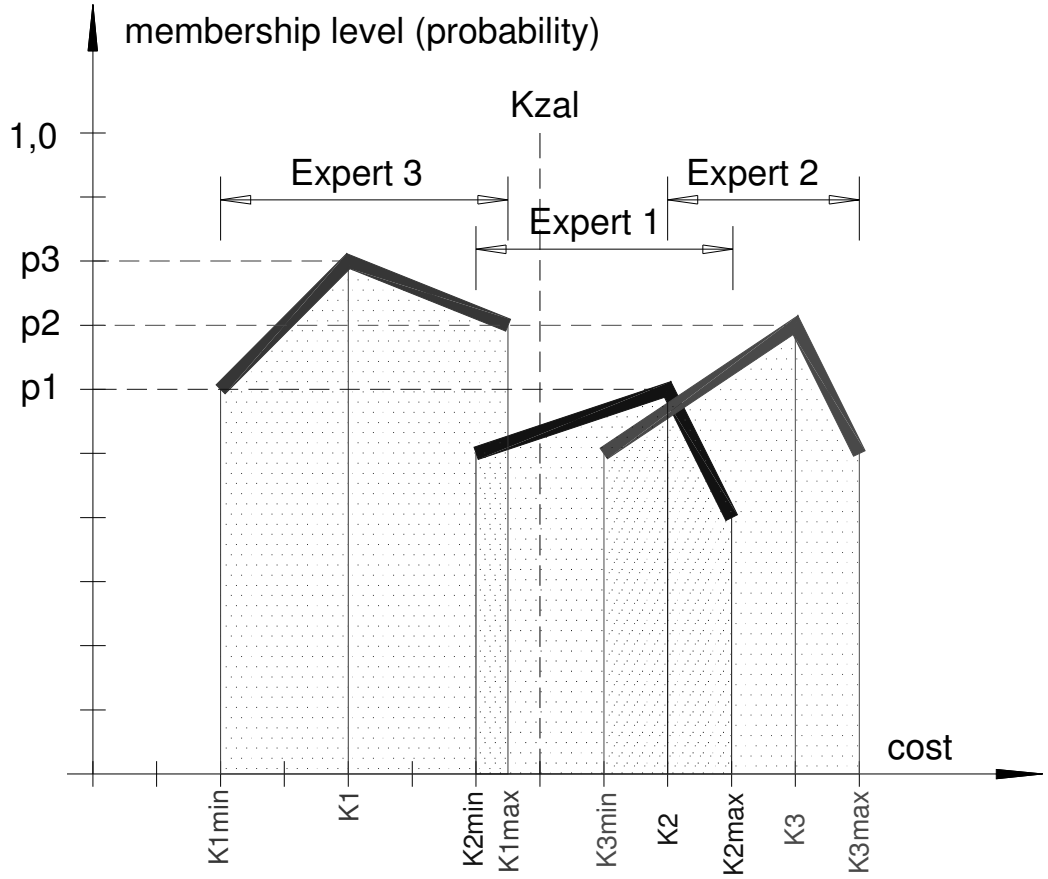


Figure 3: *Representation of input information (expert opinions) in form of fuzzy sets*

Each of the three experts has presented the most probable cost (K1, K2, K3) and its probability (p1, p2, p3). Apart from this, the experts gave answers concerning the extreme values, that is (K1min, K2min, K3min, K1max, K2max, K3max) and the corresponding probability values (p1min, p2min, p3min, p1max, p2max, p3max). As it has been mentioned, the probability of emergence of a specific cost was expressed by the membership level. The chart also shows the Kzal, or the assumed cost. Analogically, the fuzzification process was conducted for the time of implementation of each group of works. This representation of expert knowledge presents three fuzzy sets, in which the central point is the most probable value, and the extreme values are, accordingly, the acceptable minimum and maximum values. Figure 3 depicts the fuzzy representation of input information for only one task (group of works), e.g. the preparatory/ background works. In table 2, input data on cost deviations for all investment tasks can be found.

No.	Kzal	Kemin1	pemin1	Ke1	pe1	Kemax1	pemax1
1	450 000	315 000	0,65	562 500	0,90	585 000	0,85
2	1 640 000	1 230 000	0,65	1 476 000	0,70	1 558 000	0,60
3	2 250 000	1 462 500	0,60	1 800 000	0,90	1 912 500	0,90
4	5 300 000	3 445 000	0,60	5 565 000	0,95	6 095 000	0,70
5	950 000	1 045 000	0,90	1 092 500	0,95	1 140 000	0,90
6	825 000	618 750	0,65	825 000	0,70	948 750	0,65
7	1 320 000	792 000	0,80	1 056 000	0,90	1 188 000	0,60
8	3 120 000	2 964 000	0,75	3 432 000	0,75	3 744 000	0,65
9	1 950 000	1 755 000	0,75	2 145 000	0,80	2 242 500	0,60
10	823 000	658 400	0,65	1 028 750	0,75	1 069 900	0,65
11	4 220 000	3 798 000	0,60	4 642 000	0,75	5 064 000	0,75
12	758 000	492 700	0,75	795 900	0,85	871 700	0,70
13	1 800 000	1 440 000	0,80	1 620 000	0,85	2 070 000	0,60
14	1 350 000	1 080 000	0,70	1 147 500	0,70	1 417 500	0,65
15	260 000	182 000	0,65	208 000	0,80	260 000	0,80
16	1 150 000	977 500	0,65	1 380 000	0,80	1 495 000	0,70
17	180 000	117 000	0,65	144 000	0,85	171 000	0,75

No.	Kzal	Kemin2	pemin2	Ke2	pe2	Kemax2	pemax2
1	450 000	270 000	0,70	495 000	0,80	517 500	0,75
2	1 640 000	1 394 000	0,60	2 050 000	0,80	2 132 000	0,70
3	2 250 000	1 462 500	0,70	1 687 500	0,85	2 025 000	0,60
4	5 300 000	3 975 000	0,70	4 505 000	0,90	5 565 000	0,90
5	950 000	1 092 500	0,65	1 187 500	0,85	1 235 000	0,75
6	825 000	536 250	0,90	948 750	0,95	990 000	0,80
7	1 320 000	1 254 000	0,75	1 584 000	0,95	1 650 000	0,75
8	3 120 000	2 184 000	0,85	3 120 000	0,90	3 588 000	0,80

9	1 950 000	1 267 500	0,95	2 145 000	0,95	2 340 000	0,95
10	823 000	534 950	0,60	699 550	0,85	781 850	0,60
11	4 220 000	3 587 000	0,70	4 220 000	0,90	4 642 000	0,70
12	758 000	871 700	0,60	947 500	0,80	985 400	0,60
13	1 800 000	1 440 000	0,65	1 530 000	0,85	1 710 000	0,65
14	1 350 000	1 080 000	0,70	1 147 500	0,70	1 417 500	0,65
15	260 000	182 000	0,65	208 000	0,80	260 000	0,80
16	1 150 000	977 500	0,65	1 380 000	0,80	1 495 000	0,70
17	180 000	117 000	0,65	144 000	0,85	171 000	0,75

No.	Kzal	Kemin3	pemin3	Ke3	pe3	Kemax3	pemax3
1	450 000	292 500	0,75	315 000	0,85	450 000	0,75
2	1 640 000	1 312 000	0,75	1 804 000	0,75	1 886 000	0,70
3	2 250 000	1 800 000	0,70	2 137 500	0,80	2 250 000	0,75
4	5 300 000	3 710 000	0,70	3 975 000	0,85	5 035 000	0,60
5	950 000	855 000	0,65	997 500	0,90	1 045 000	0,70
6	825 000	866 250	0,75	948 750	0,75	1 031 250	0,60
7	1 320 000	924 000	0,60	990 000	0,80	1 188 000	0,65
8	3 120 000	2 028 000	0,75	2 184 000	0,75	2 340 000	0,75
9	1 950 000	2 047 500	0,60	2 145 000	0,90	2 340 000	0,80
10	823 000	699 550	0,80	864 150	0,90	946 450	0,85
11	4 220 000	2 743 000	0,60	3 587 000	0,80	4 009 000	0,75
12	758 000	568 500	0,65	606 400	0,90	758 000	0,85
13	1 800 000	1 440 000	0,75	1 530 000	0,75	1 890 000	0,70
14	1 350 000	945 000	0,70	1 755 000	0,90	1 822 500	0,60
15	260 000	169 000	0,75	221 000	0,75	286 000	0,70
16	1 150 000	1 035 000	0,75	1 380 000	0,80	1 437 500	0,60
17	180 000	153 000	0,60	171 000	0,80	189 000	0,70

Table 2: *A breakdown of input cost data for all investment tasks.*

In the fuzzy sets theory, Figure 3 simply presents 3 fuzzy sets. This is input information. For further use of the knowledge of 3 experts, information presented by them was consolidated to one set representing the cost (time) deviations for a given task. In other words, the so-called resulting membership function was presented. The process transforming several input functions into a resulting function in fuzzy modeling is known as inference. There are many operators used to determine the resulting membership function. In this article, we used the arithmetic average operator. The value of the resulting membership function is equal to the average level of membership of each input set, which can be recorded according to following formula:

$$f_{wynik}(k) = \frac{\sum_{i=1}^{n} f_i(k)}{n},$$

where:

$f_{wynik}(k)$ – the resulting membership function (function determining the probability of occurrence of events),

k – function argument – cost or time

n – number of experts (number of fuzzy sets), n=3,

i=1, 2, …, n.

Upon the assumptions made, the formula can be recorded as follows:

$$f_{wynik}(k) = \frac{f_{EKS1}(k) + f_{EKS2}(k) + f_{EKS3}(k)}{3},$$

where:

$f_{EKS1}(k)$ – membership function determined on the basis of data from expert 1,

$f_{EKS2}(k)$ – membership function determined on the basis of data from expert 2,

$f_{EKS3}(k)$ – membership function determined on the basis of data from expert 3.

Using the MS-Excel spreadsheet, the resulting function was established for each investment task, presenting the potential risk information.

Figures 4 and 5 below present the operation of inference, using as an example the first group of works in the project or „Preparatory, background works”

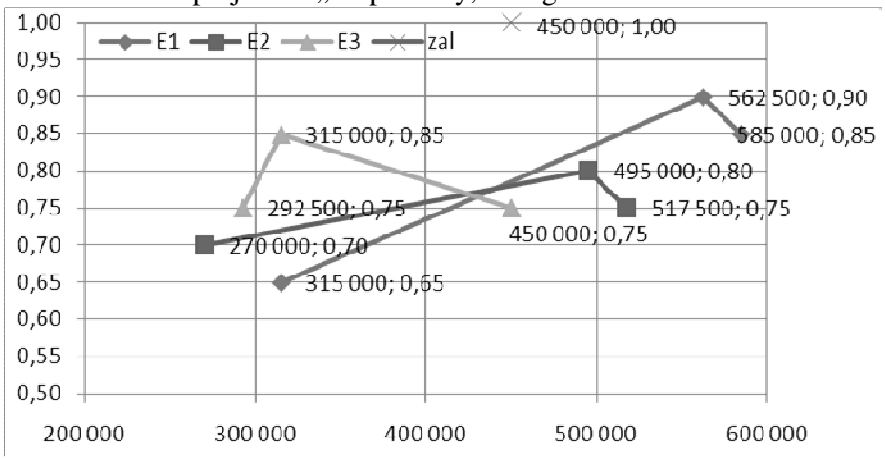


Figure 4: *Input functions – opinions of three Experts concerning risk for the task „Preparatory, background works”.*

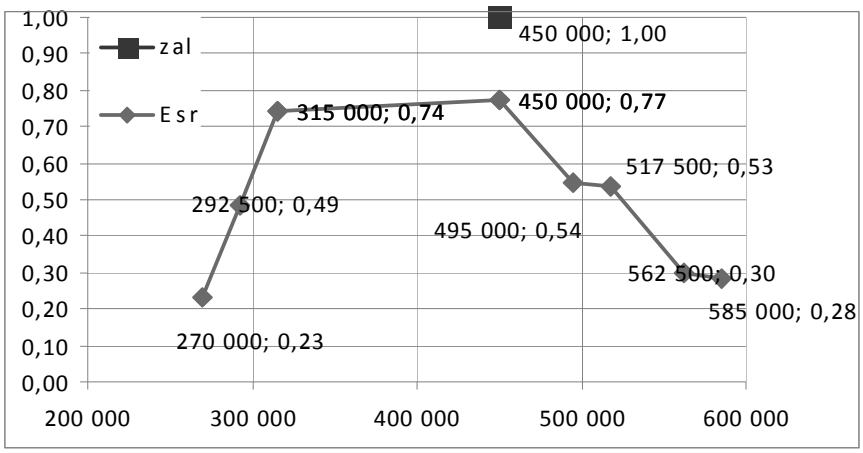


Figure 5: *Resulting risk function for task „Preparatory, background works".*

The defuzzification process leads to obtaining of an acute value, which reflects a given fuzzy set. Having the resulting function of the expert opinion, we established two points, dividing the set of results into the optimistic and pessimistic part. These points were established using the center of mass method. The acute value was calculated on the basis of following formula:

$$k_{wyn} = \frac{\int k \cdot u_{wyn}(k)dk}{\int u_{wyn}(k)dk},$$

where:

k_{wyn} – the acute costs value (input value),

$u_{wyn}(k)$ – the resulting membership function,

k – the cost (argument) of the membership function.

In the presented case, the resulting membership function is in form of a broken line. The center of mass of the broken line, e.g. ABCD, was determined by replacing each line section with a material point, placed in the middle of the section, of the mass equal to the section length [2]. The coordinates of the center of mass of the broken ABCD were determined on the basis of following formulas. According to Figure 6 symbols d_1, d_2, d_3 represent lengths of sections AB, BC, CD, and $S_1(k_1,u_1)$, $S_2(k_2,u_2)$, $S_3(k_3,u_3)$ are centers of these sections.

$$k_0 = \frac{d_1k_1 + d_2k_2 + d_1k_3}{d_1 + d_2 + d_3},$$

$$u_0 = \frac{d_1u_1 + d_2u_2 + d_1u_3}{d_1 + d_2 + d_3}.$$

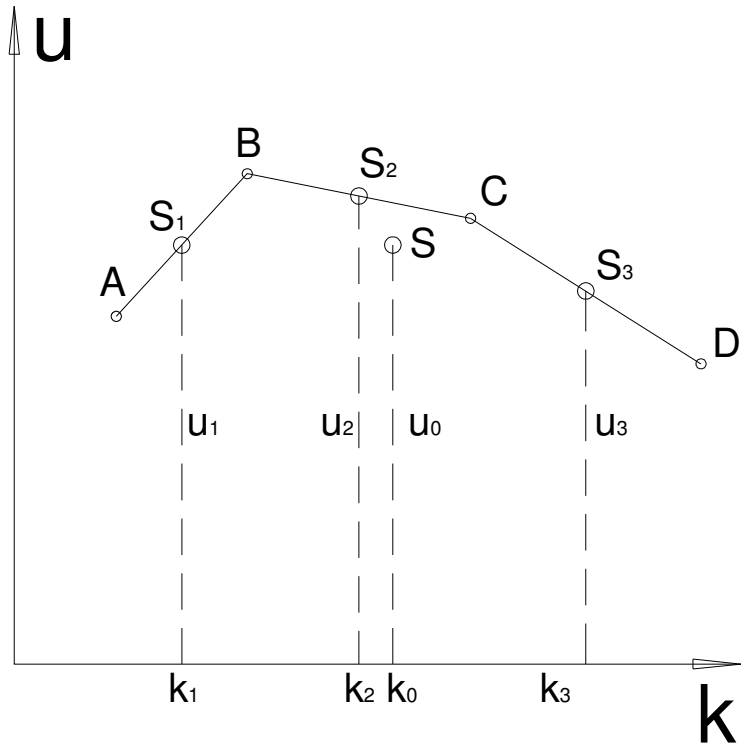


Figure 6: *Graphic representation of determination of the center of mass of a broken line.*

On the basis of the above formulas and using the Excel spreadsheet, for each group of works, optimistic and pessimistic centers of mass were established. For the first group of costs, the "Preparatory, background works", were presented in Figure 7.

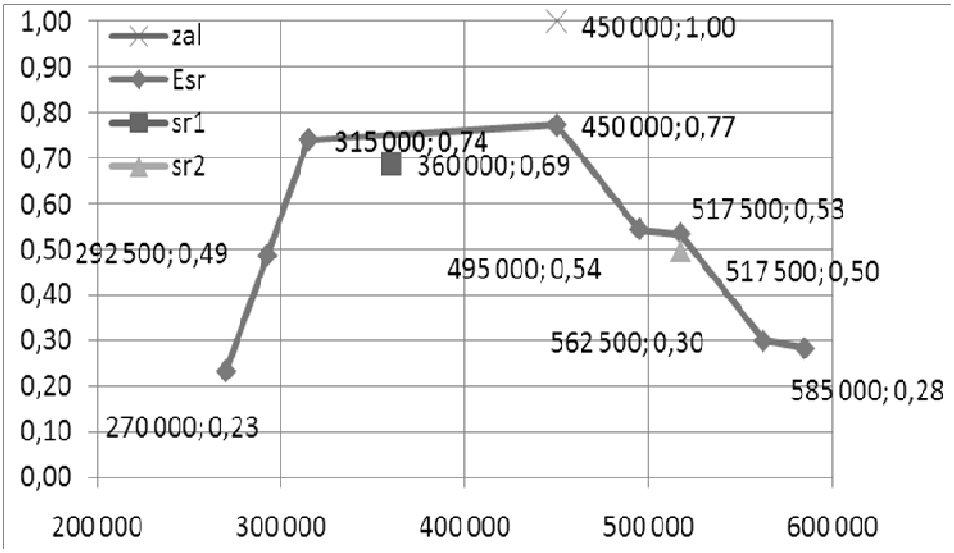


Figure 7: *Graphic representation of establishing of the center of mass for the first group of costs of „Preparatory, background works".*

The same operations, that is, fuzzification, inference, defuzzification were conducted for all groups of investment costs. The results obtained were presented in table 3 for cost values and in table 4 for time values.

No.	Name	Est cost	Opt cost	popt	Pes cost	ppes
	APARTMENT BUILDING	28 346 000	22 648 750	0,53	31 438 350	0,46
1	Preparatory, background works	450 000	360 000	0,69	517 500	0,50
2	Earthworks	1 640 000	1 394 000	0,57	1 886 000	0,41
3	Raw state – underground level	2 250 000	1 631 250	0,53	2 081 250	0,40
4	Raw state – above ground part	5 300 000	3 975 000	0,60	5 565 000	0,54
5	Brickworks –external walls	950 000	950 000	0,30	1 163 750	0,41
6	Brickworks – internal walls	825 000	701 250	0,52	1 419 000	0,29
7	Roof insulation	1 320 000	990 000	0,45	1 419 000	0,29
8	Windows	3 120 000	2 496 000	0,52	3 432 000	0,47
9	External plaster, heat insulation	1 950 000	1 706 250	0,54	2 242 500	0,75
10	Wall lining – clinker brick	823 000	658 400	0,52	946 450	0,43
11	Interior finishing works	4 220 000	3 376 000	0,45	4 642 000	0,44
12	Passenger elevators	758 000	625 350	0,50	890 650	0,33
13	Power supply and low current installations	1 800 000	1 485 000	0,77	1 845 000	0,42
14	Sanitary installations	1 350 000	1 012 500	0,55	1 586 250	0,48
15	Building service lines	260 000	195 000	0,67	286 000	0,51
16	External works	1 150 000	948 750	0,47	1 322 500	0,48
17	Preparation of the facility for final acceptance	180 000	144 000	0,37	193 500	0,46

Table 3: *A breakdown of pessimistic and optimistic cost values with probability.*

No.	Name	Time	Opt t	popt	Pes t	ppes
	APARTMENT BUILDING	488	415	0,48	539	0,47
1	Preparatory, background works	35	29	0,57	39	0,48
2	Earthworks	104	96	0,65	130	0,54
3	Raw state – underground level	74	59	0,75	83	0,53
4	Raw state – above ground part	118	86	0,47	124	0,23
5	Brickworks –external walls	140	115	0,27	161	0,46
6	Brickworks – internal walls	130	104	0,48	75	0,51
7	Roof insulation	77	58	0,44	75	0,51
8	Windows	118	91	0,52	127	0,48
9	External plaster + heat insulation	120	81	0,67	117	0,56
10	Wall lining – clinker brick	101	83	0,58	116	0,43
11	Interior finishing works	253	215	0,63	291	0,62
12	Passenger elevators	93	70	0,54	102	0,34
13	Power supply and low current installations	323	234	0,46	323	0,38
14	Sanitary installations	366	302	0,29	421	0,48
15	Building service lines	140	119	0,50	158	0,52
16	External works	114	97	0,51	120	0,39
17	Preparation of the facility for final acceptance	26	23	0,50	33	0,48

Table 4: *A breakdown of pessimistic and optimistic time values with probability.*

In the analysis presented, the measure of risk applied was the ratio of the value of deviation to its probability. Thanks to the above analysis of each investment task, it is possible to establish the summarized deviations associated with the entire project. Figures 8 and 9 present the resulting estimated, pessimistic and optimistic values of cost and time. They were based on aggregation of individual values for investment tasks, using the MS-Project software to create 3 scenarios of the task implementation: optimistic, estimated and pessimistic. The resulting probability of summarized values has been established as a weighted average.

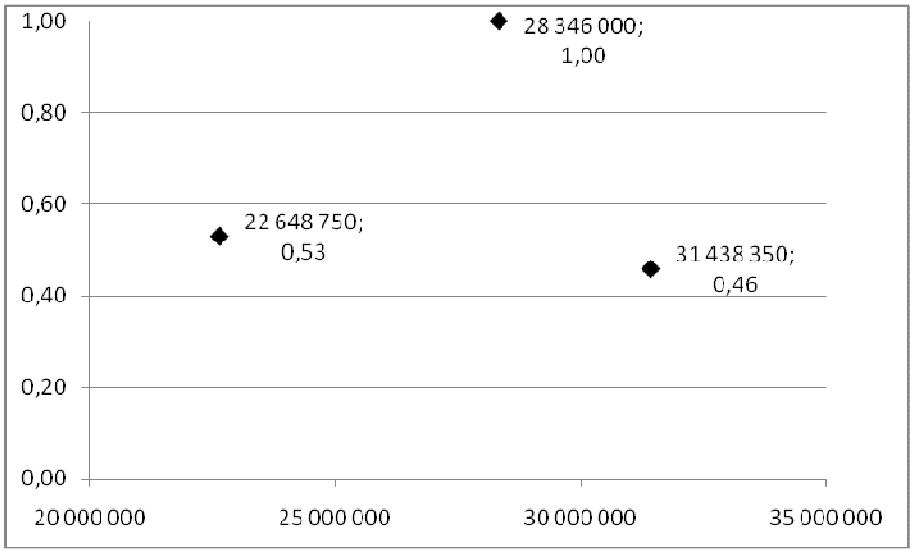


Figure 8: *Graphic representation of risk for the investment cost*

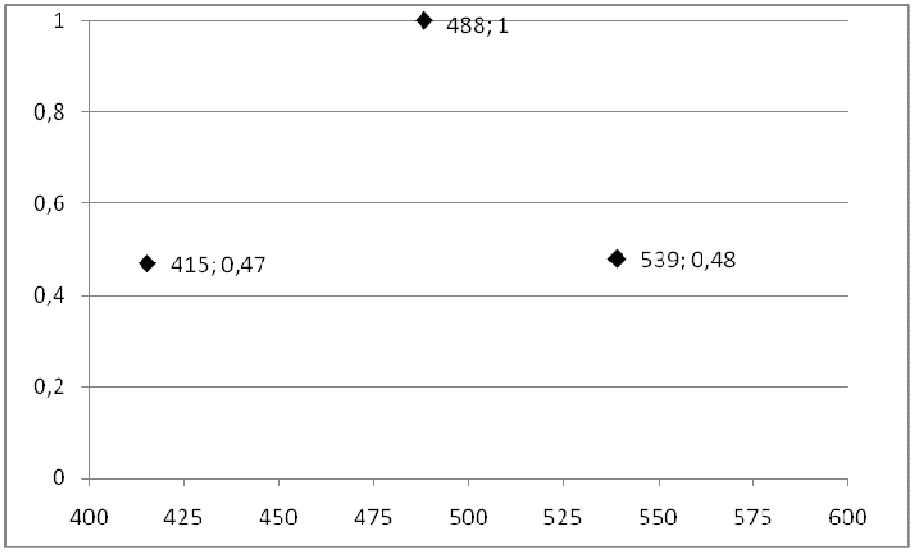


Figure 9: *Graphic representation of risk for the investment time.*

Thanks to this representation of the cost and time of implementation, the general project risk, as function of probability and deviation value was determined on the basis of following formulas:

$$R_k^{pes} = \frac{\left(K_{pes} - K_{zal}\right)/K_{zal}}{1 - p_{pes}} = \frac{\left(31438000 - 28346000\right)/28346000}{1 - 0{,}46} = 0{,}202$$

$$R_k^{opt} = \frac{\left(K_{zal} - K_{opt}\right)/K_{zal}}{1 - p_{opt}} = \frac{\left(28346000 - 22648750\right)/28346000}{1 - 0{,}53} = 0{,}428$$

On the basis of the same formulas and according to figure 9 it is possible to determine risk values for the investment time.

CONCLUSIONS

The method presented provides the general contractor or the investor with knowledge on the potential deviations, cost and time associated risks. This method uses expert knowledge associated with individual stages of works, which are very diversified. Expert knowledge has been used separately for each stage, at the same time obtaining the risk associated with the entire project.

On the basis of quantification of risk, investor or contractor obtain the possibility of responding quickly to unexpected scenarios. Thanks to this analysis, commencing the investment, they are aware of the potential threats associated with a failure to meet the deadline or exceeding of the budget planned. Moreover it is possible to compare several possible projects on the basis of cost and time deviation and its probabilities.

The analysis proposed makes it possible to control the project further during its implementation. It is possible to use the data obtained to control the project e.g. using the

earned value method [3]. Thanks to time and cost analysis, at the level of individual tasks, it was possible to determine cash flows in the time function for different variants.

In this way, at any time during the project life cycle, the investor or the general contractor is able to determine whether the threshold values of the earned value method indicators have not been exceeded. At the same time, at the stage preceding decision-making, the investor is able to determine the possible risk (variance) of the assumed implementation cost or time.

Having the knowledge on the time and cost variances so far, the general contractor will find it easier to plan the financing of the project, without exposing the project to additional problems, associated with delayed payments.

THE PROCEDURE ALGORITHM – A BLOCK DIAGRAM

Presented below are the general rules of the procedure in form of a block diagram.

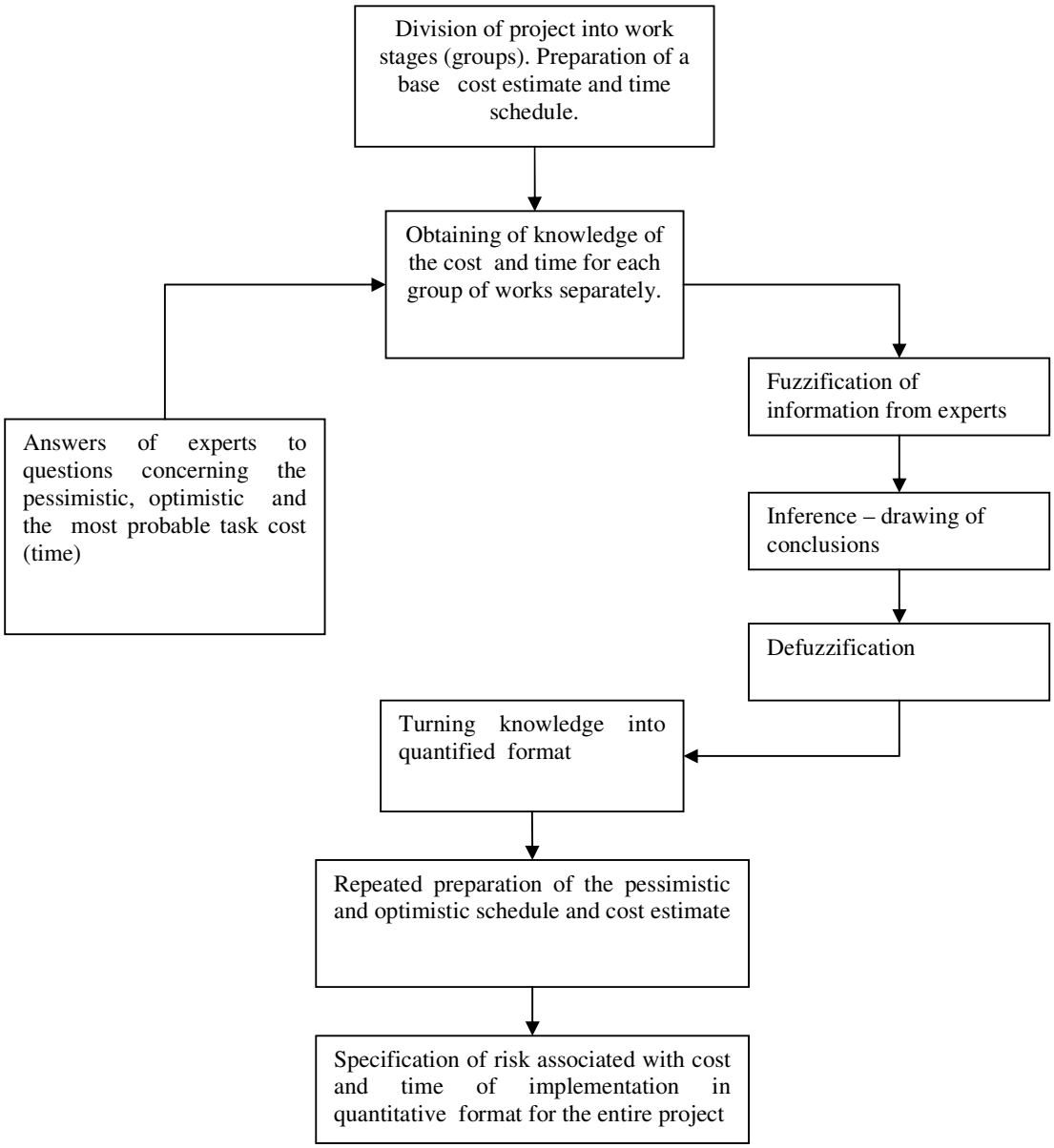


Figure 9: *A block diagram of time-cost analysis of the project planned, taking into account the risk, on the basis of expert knowledge, using fuzzy sets.*

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CONSTRUCTION PROJECT SCHEDULING WITH IMPRECISELY DEFINED CONSTRAINTS

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Abstract
This paper regards to the scheduling of a construction project under ill-defined constraints of time and resources for the execution of works. Fuzzy numbers are used for modelling the imprecision of constraints. Two methods of the measurement of fuzzy constraints satisfaction are presented. The first method uses the possibility measures based strictly on the assumptions of the fuzzy sets theory. The second method uses the measure based upon the concept of the α-cuts of a fuzzy number and the probability theory. The numerical examples are given for the comparison of both methods. The results confirm that the use of the probabilistic measure provides the neutralization of the assessment of the fuzzy constraints meeting and improves the construction schedule.

Keywords: construction schedule, imprecision, possibility measure, probability measure.

INTRODUCTION

The planning data used in the scheduling of construction projects are often imprecisely defined with regard to the required project completion time and the availability of renewable resources (key personnel and construction equipment) required for the project execution. This is caused by the various circumstances, e.g.:

- the uniqueness of the any given construction project makes it difficult or even impossible to use the statistical methods for the assessment of the project makespan;
- the acquisition of contracts in the tendering procedure does not allow for the precise planning of the owned renewable resources distribution to the individual projects;
- conditions of contract provide for a time interval between the completion time preferred by the client (due-to date) and the completion time required by the client under the penalty of the contract termination of contractor's fault (deadline); the existence of such a time interval allows the contractor for the flexible planning of the sufficient time for the completion of the works.

As a result, the planning data for the planner are often defined imprecisely [3], with the use of a natural language, e.g.: "*about two weeks*", "*about two to three weeks*," "*a little over two weeks*", "*about fifteen to twenty workers*" and alike [14]. In the literature dealing with the problems of project scheduling on the basis of imprecisely defined planning data, there is a common approach to use the fuzzy sets theory for modelling the imprecision of project data, in conjunction with the various schedule optimization methods, as for example the branch-and-bound method, e.g. [16], priority heuristics, e.g. [4], [15], [18] and metaheuristic methods, e.g. [5], [11], [15], [18]. However, the most of the literature under

consideration take into account only the imprecision of durations of works and the imprecision of time available for the execution of works. The availability of any renewable resource is treated as well-known, which in the case of a real construction project rarely holds true. The assessment of the fulfilment of imprecisely defined time constraints is done with the use of possibility measure for the comparison of two fuzzy numbers or the real number and the fuzzy number, one representing the planned project makespan and the other representing the project makespan limit. The comparison is done with the Hurwicz criterion, e.g. [8], [17], [18] and the result is highly affected by the specific risk attitude of the assessor. In result, two or more persons may express different opinions about the degree of meeting the fuzzy limit of the project makespan.

In this paper, the principles of the fuzzy modelling of imprecisely defined planning constraints and the principles of the assessment of the fuzzy constraints satisfaction are presented. The problem of the neutralisation of the assessment of meeting the fuzzy time and resource constraints is resolved with the use of the α-cuts of a fuzzy number and the probability theory. The paper also presents a numerical example showing the advantages of the use of probability measure for the optimization of the construction schedule with regard to the imprecisely defined time and resource constraints.

THE MODELING OF THE PROJECT CONSTRAINTS USING FUZZY SETS

To model the imprecision of the availability of the *k*-th resource, a planner can use a trapezoidal fuzzy number $\tilde{R}_k$ in the form of the ordered four $\tilde{R}_k = (r_k^{(1)},\ r_k^{(2)},\ r_k^{(3)},\ r_k^{(4)})$, where real numbers $r_k^{(i)}$ (i = 1, …, 4) should satisfy the condition: $0 \le r_k^{(1)} \le r_k^{(2)} \le r_k^{(3)} \le r_k^{(4)}$. Fig. 1 shows an example of a trapezoidal fuzzy number modelling imprecisely defined resource constraints, expressed as "*from about* $r_k^{(2)}$ *to about* $r_k^{(3)}$, *but not less than* $r_k^{(1)}$ *and not more than* $r_k^{(4)}$".

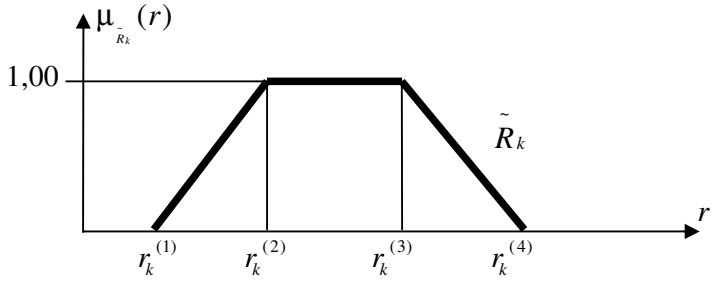


Figure 1: *An example of using a trapezoidal fuzzy number for modelling the imprecisely defined availability of the renewable resource constraints. Source: Own*

In the more specific case, a planner is able to narrow the area of imprecision and to express his opinion about resource constraints as "*about* $r_k^{(2)}$, *but not less than* $r_k^{(1)}$ *and not more than* $r_k^{(3)}$". To express this imprecision mathematically, a planner can use a triangular

fuzzy number $\tilde{R}_k$ in the form of the ordered three $\tilde{R}_k = (r_k^{(1)},\ r_k^{(2)},\ r_k^{(3)})$ or a trapezoidal fuzzy number $\tilde{R}_k$ in the form of the ordered four $\tilde{R}_k = (r_k^{(1)},\ r_k^{(2)},\ r_k^{(2)},\ r_k^{(3)})$.

Similarly, to model the imprecision of the project makespan limitation one can use a trapezoidal fuzzy number $\tilde{T}_d = (t_d^{(1)},\ t_d^{(2)},\ t_d^{(3)},\ t_d^{(4)})$, where real numbers $t_d^{(i)}$ (i=1, …, 4) satisfy the condition: $0 \le t_d^{(1)} \le t_d^{(2)} \le t_d^{(3)} \le t_d^{(4)}$. One can determine the components of this ordered four, assuming for example:

- as the real number $t_d^{(1)}$: the shortest feasible project makespan, determined as the result of the network model analysis without the renewable resource availability constraints;
- as the real number $t_d^{(2)}$: the lower limit of the project makespan, evaluated by the scheduler as having the greatest chance under the given circumstances;
- as the real number $t_d^{(3)}$: the upper limit of the project makespan, evaluated by the planner as having the greatest chance under the given circumstances;
- as the real number $t_d^{(4)}$: the project completion time required by the client.

ASSESSMENT OF THE PROJECT FUZZY CONSTRAINTS SATISFACTION

Application of the possibility measures

If the maximum consumption of the *k*-th renewable resource must not exceed the imprecisely defined resource availability limitation, the schedule must satisfy the following relation:

$$r_k^{\max} \le \tilde{R}_k \qquad (1)$$

The satisfaction of the relation (1) means that the maximum consumption of the *k*-th renewable resource, expressed by the real number $r_k^{\max}$, should not exceed the limit, which is the unknown (yet) output of the fuzzy number $\tilde{R}_k$.
Similarly, if the works must be completed within the imprecisely prescribed time period, the schedule must satisfy the following relation:

$$t \le \tilde{T}_d . \qquad (2)$$

The satisfaction of the relation (2) means that the planned project makespan expressed by the real number *t*, will not be longer than the time limit, which is the unknown (yet) output of the fuzzy number $\tilde{T}_d$.

Using the theory of possibility [1], one should assess the degree of fulfilment of the relation $r_k^{\max} \le \tilde{R}_k$ and evaluate of the veracity of the statement: "*the real number* $r_k^{\max}$ *will not be greater than the unknown* (*yet*) *output of the fuzzy number* $\tilde{R}_k$" using the necessity measure $\mathrm{N}(r_k^{\max} \le \tilde{R}_k)$ and the possibility measure $\Pi(r_k^{\max} \le \tilde{R}_k)$. The necessity measure is used to assess how much the occurrence of the relation $r_k^{\max} \le \tilde{R}_k$ is obvious throughout the

state of the knowledge of the planner of the circumstances which are limiting the availability of the *k*-th renewable resource. The possibility measure is used to assess how much the occurrence of the relation $r_k^{\max} \le \tilde{R}_k$ remains in compliance with the state of knowledge of the planner of the circumstances which are limiting the availability of the *k*-th renewable resource. According to [1] and [8], the appropriate formulas are as follows:

$$\Pi(r_k^{\max} \le \tilde{R}_k) = \sup_{r \ge r_k^{\max}} \mu_{\tilde{R}_k}(r), \tag{3}$$

$$\Pi(r_k^{\max} \ge \tilde{R}_k) = \sup_{r \le r_k^{\max}} \mu_{\tilde{R}_k}(r), \tag{4}$$

$$\mathrm{N}(r_k^{\max} \le \tilde{R}_k) = 1 - \Pi(r_k^{\max} \ge \tilde{R}_k), \tag{5}$$

where $\mu_{\tilde{R}_k}(r)$ is the membership coefficient of the fuzzy set $\tilde{R}_k$.

It should be noted that the possibility measure $\Pi(r_k^{\max} \le \tilde{R}_k)$ does not have the property of complementarity, i.e. $\Pi(r_k^{\max} \le \tilde{R}_k)$ does not have to be equal to $1 - \Pi(r_k^{\max} \ge \tilde{R}_k)$.

Using the necessity measure and the possibility measure for assessing the credibility of the statements given above, one should consider the cases shown in Fig. 2.

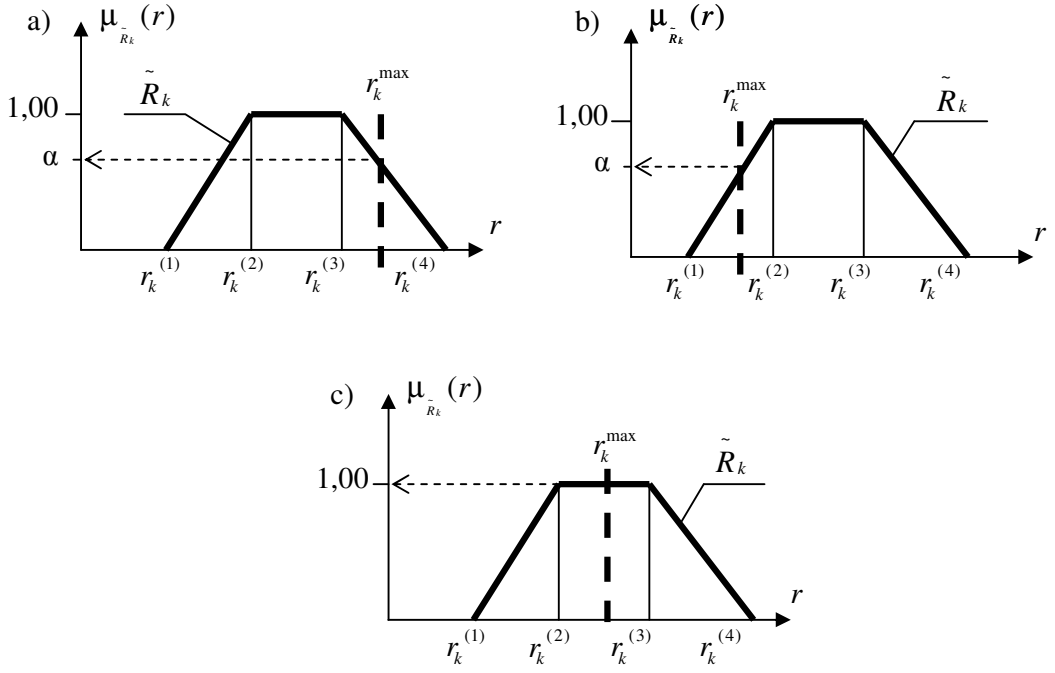


Figure 2: *The alternative schemes of relations between the fuzzy number* $\tilde{R}_k$ *and the real number* $r_k^{\max}$. *Source: Own*

On the basis of the formulas (3), (4) and (5), one can conclude that:

1) For the case shown in Fig. 2a: $\Pi(r_k^{\max} \le \tilde{R}_k) = \alpha$, $N(r_k^{\max} \le \tilde{R}_k) = 0$; the evaluated statement may be true to a degree of α, but the obvious truth of this statement is zero;

2) For the case shown in Fig. 2b: $\Pi(r_k^{\max} \le \tilde{R}_k) = 1$, $N(r_k^{\max} \le \tilde{R}_k) = 1 - \alpha$; the evaluated statement is possibly true, but the obvious truth of this statement is $1 - \alpha$,

3) For the case shown in Fig. 2c: $\Pi(r_k^{\max} \le \tilde{R}_k) = 1$, $N(r_k^{\max} \le \tilde{R}_k) = 0$; the evaluated statement is possibly true, but the obvious truth of this statement is zero.

The meaning of the assessment presented above may be sometimes difficult to understand for the planner. Therefore, for the assessment of the degree of fulfilment of the relation $r_k^{\max} \le \tilde{R}_k$, there is a sought after the synthetic measure (marked here as ST), having – in line with the intuition of the planner – the property of complementarity:

$$\mathrm{ST}(r_k^{\max} \le \tilde{R}_k) = 1 - \mathrm{ST}(r_k^{\max} \ge \tilde{R}_k). \tag{6}$$

Using the approach shown in [4], [17] and [18], one can implement the Hurwicz criterion for the assessment of the degree of domination of the fuzzy number $\tilde{R}_k$ over the real number $r_k^{\max}$:

$$\mathrm{ST}(r_k^{\max} \le \tilde{R}_k) = \beta\,\Pi(r_k^{\max} \le \tilde{R}_k) + (1-\beta)\,N(r_k^{\max} \le \tilde{R}_k), \tag{7}$$

where $\beta \in (0.0;\ 1.0)$ is the *coefficient of optimism*, which characterizes the risk attitude of the planner. For example, assuming the neutral risk attitude of the planner ($\beta = 0.5$), one can obtain:

$$\mathrm{ST}(r_k^{\max} \le \tilde{R}_k) = \begin{cases} 1{,}0 & for\ r_k^{\max} \le r_k^{(1)}, \\ 0{,}5 + 0{,}5(1-\alpha) & for\ r_k^{(1)} \le r_k^{\max} \le r_k^{(2)}, \\ 0{,}5 & for\ r_k^{(2)} \le r_k^{\max} \le r_k^{(3)}, \\ 0{,}5\alpha & for\ r_k^{(3)} \le r_k^{\max} \le r_k^{(4)}, \\ 0{,}0 & for\ r_k^{\max} \ge r_k^{(4)}. \end{cases} \tag{8}$$

In a similar way one can assess the degree of fulfilment of the relation $t \le \tilde{T}_d$.

As can be seen from the formula (7), the result of the assessment of the degree of fulfilment of the relations $r_k^{\max} \le \tilde{R}_k$ and $t \le \tilde{T}_d$ strongly depends on the value of coefficient β, which characterizes the risk attitude of the planner.

Application of the probabilistic measure

It should be noted, after [2], that the necessity measure and the possibility measure determinate the lower bound and the upper bound of the probability:

$$N(r_k^{\max} \le \tilde{R}_k) \le P(r_k^{\max} \le \tilde{R}_k) \le \Pi(r_k^{\max} \le \tilde{R}_k), \tag{9}$$

$$N(t \le \tilde{T}_d) \le P(t \le \tilde{T}_d) \le \Pi(t \le \tilde{T}_d). \tag{10}$$

This arises the question whether it is feasible to neutralize the assessment of the fulfilment of relations $r_k^{\max} \le \tilde{R}_k$ and $t \le \tilde{T}_d$, through the direct use of the probabilistic measure. The resulting problem can be described as follows:

– there are two numbers given: (1) a real number *m*, representing the maximum consumption of some renewable resource or the planned project makespan, and (2) a fuzzy number $\tilde{N}$, modelling the limit of resource availability or the limit of the project makespan;

– assess the probability $\mathrm{P}(m \le \tilde{N})$ that a real number *m*, resulting from the construction project schedule, will be not greater than the unknown (yet) output of a fuzzy number $\tilde{N}$.

The idea of the assessment of the probability $\mathrm{P}(m \le \tilde{N})$ presented below is based upon the use of the α-cuts of a fuzzy number $\tilde{N}$ for a finite number of levels of certainty of the imprecise estimation of the given constraint. For the any given α-cut of a fuzzy number $\tilde{N}$, an interval number $\overline{N}_{\alpha_i} = [n^{\mathrm{l}}_{\alpha_i}, n^{\mathrm{u}}_{\alpha_i}]$ is obtained. Symbol *i* is an index of a sequent α-cut. An example of an interval $\overline{N}_{\alpha_i}$ is shown in Fig. 6.3.

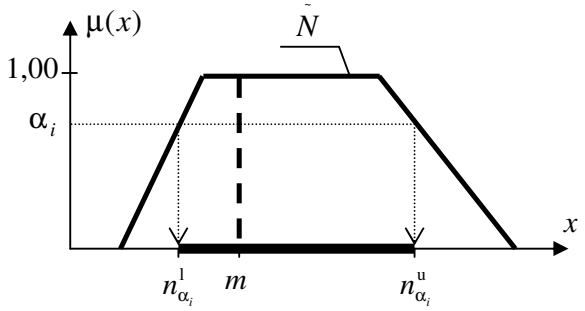


Figure 3: *An example of an interval* $\overline{N}_{\alpha_i}$ *. Source: Own.*

On the basis of Fig. 3 one can conclude that if $n^{\mathrm{l}}_{\alpha_i} < m < n^{\mathrm{u}}_{\alpha_i}$, then an interval $\overline{N}_{\alpha_i}$ is divided further into subintervals $[n^{\mathrm{l}}_{\alpha_i}, m]$ and $[m, n^{\mathrm{u}}_{\alpha_i}]$. The probability that a real number *m* will be not greater than the unknown (yet) output of an interval number $\overline{N}_{\alpha_i}$ can be determined geometrically as:

$$\mathrm{P}(m \le \overline{N}_{\alpha_i}) = \frac{n^{\mathrm{u}}_{\alpha_i} - m}{n^{\mathrm{u}}_{\alpha_i} - n^{\mathrm{l}}_{\alpha_i}}. \tag{11}$$

If $m \le n^{\mathrm{l}}_{\alpha_i}$ then $\mathrm{P}(m \le \overline{N}_{\alpha_i}) = 1$ and if $m \ge n^{\mathrm{u}}_{\alpha_i}$ then $\mathrm{P}(m \le \overline{N}_{\alpha_i}) = 0$. The aggregation of probabilities $\mathrm{P}(m \le \overline{N}_{\alpha_i})$ for the finite number of α-cuts of a number $\tilde{N}$, leads to the following formula:

$$\mathrm{P}(m \le \tilde{N}) = \frac{\sum_i \alpha_i \, \mathrm{P}(m \le \overline{N}_{\alpha_i})}{\sum_i \alpha_i}, \tag{12}$$

where $i = 1,\ldots, I$ is an index of sequent α-cut of a number $\tilde{N}$.

SCHEDULE OPTIMIZATION PROBLEMS FORMULATION

In this paper, an *activity–on–node* network model with *finish–to–start* relations between activities is adopted to represent the construction project. The start date of the project is set to zero. Only the imprecision of the schedule constraints is considered. Therefore, the formula for calculating the scheduled project makespan can be expressed as:

$$t = \max\{s_i + d_i\}, \quad i = 1, \quad 2,...,n,$$

where s_i is the start date of activity i, d_i is the duration of activity i, and n is the total number of activities.

The following two alternative optimization problems can be formulated, based upon the two alternative measures of the compliance with the fuzzy limit of the project makespan:

– find the start dates of activities so as to maximize the degree of compliance with the fuzzy limit of the project makespan:

$$\max \mathrm{ST} : \mathrm{ST} = \mathrm{ST}(t \le \tilde{T}_d), \tag{13}$$

– find the start dates of activities so as to maximize the probability of compliance with the fuzzy limit of the project makespan:

$$\max \mathrm{P} : \mathrm{P} = \mathrm{P}(t \le \tilde{T}_d), \tag{14}$$

where t is the real number, representing the planned project makespan, and $\tilde{T}_d$ is the fuzzy number, modelling the imprecisely specified constraint for the project makespan.

Taking into account the relations of type *finish–to–start* between the activities, the solution of the problem (14) or of the problem (15) must fulfil the following condition:

$$s_j \ge s_i + d_i \big| i \in \{Prec(j)\}, \tag{15}$$

where $Prec(j)$ is the set of predecessors of an activity j in the project network model.

The solution of the problem (14) or of the problem (15) must also take into account the fuzzy constraints of the renewable resources availability. The maximum consumption of the k-th resource can be determined as:

$$r_k^{\max} = \max\{\sum_{p \in \{A(\tau)\}} r_{kp\tau}\}, \tag{16}$$

where $\{A(\tau)\}$ is the set of operations executed in a time period τ, $\tau = 1,...,t$, $r_{kp\tau}$ is the consumption of the k-th renewable resource for the execution of an activity p in a time period τ, and t is the planned project makespan. According to the two alternative measures of the compliance with the fuzzy resource constraints, the planner should assess the required degree ST_{kr} of compliance with the fuzzy constraint of k-th resource availability or the required probability P_{kr} of compliance with the fuzzy constraint of k-th resource availability. This leads to the following conditions:

– for the solutions of the problem (14): the condition of meeting the required degree of compliance (ST_{kr}) with the fuzzy limit of availability of the k–th renewable resource:

$$\mathrm{ST}(r_k^{\max} < \tilde{R}_k) \ge \mathrm{ST}_{kr}, \tag{17}$$

– for the solutions of the problem (15): the condition of meeting the required probability of compliance (P_{kr}) with the fuzzy limit of availability of the *k*–th renewable resource:

$$P(r_k^{\max} < \tilde{R}_k) \geq P_{kr}. \tag{18}$$

SCHEDULE OPTIMIZATION PROBLEMS SOLVING

Despite the specific measure adopted for the assessment of the fuzzy constraints satisfaction, optimization problems presented above are the resource – constrained project scheduling problems, which belong to the class of NP-hard problems [4]. For solving such problems, the use of heuristic or metaheuristic methods is well justified. Their detailed description is omitted here. The surveys appropriate for the construction project scheduling has been done by the others, e.g. [6], [7], [9] – [13], [16]. In this paper, the considered schedule optimization problems were translated into numerical optimization problems solved with the use of Genetic Algorithm (GA). To preserve the required technological precedence relationships among activities in the project network model, the general idea was to use the GA technique to establish the additional resource relationships among some activities. Those additional relationships were based upon the selected priority rules. On the basis of the solution presented by the *m*-th chromosome, the start dates s_j of each activity were calculated using the following formula:

$$s_j(m) = \max_{i \in \{Prec(j)\}} \{s_i(m) + d_i\}. \tag{19}$$

The following fitness functions were used to assess the resulting construction schedule:

1) for the problem of maximization the degree of compliance with the fuzzy limit of the project makespan:

$$f(m) = ST(m) - \sum_{k=1}^{K} F_k, \tag{20}$$

2) for the problem of maximization the probability of compliance with the fuzzy limit of the project makespan:

$$f(m) = P(m) - \sum_{k=1}^{K} F_k, \tag{21}$$

where:

$f(m)$ – the value of fitness function for the solution presented by the *m*-th chromosome;

$ST(m)$ – the degree of compliance with the fuzzy limit of the project makespan, resulting from the schedule drawn upon the solution presented by the *m*-th chromosome:

$$ST(m) = ST(t(m) \leq \tilde{T}_d); \tag{22}$$

$P(m)$ – the probability of compliance with the fuzzy limit of the project makespan, resulting from the schedule drawn upon the solution presented by the *m*-th chromosome:

$$P(m) = P(t(m) \leq \tilde{T}_d); \tag{23}$$

$t(m)$ – the planned project makespan, resulting from the schedule drawn upon the solution presented by the *m*-th chromosome;

F_k – the penalty (large enough positive real number) for the failure to meet the required degree of compliance with the fuzzy limit of availability of the *k*-th renewable resource;

G_k – the penalty (large enough positive real number) for the failure to meet the required probability of compliance with the fuzzy limit of availability of the *k*-th renewable resource;

K – the number of types of renewable resources with limited availability.

NUMERICAL EXAMPLES

The scope of the exemplary construction project covers modernization of an existing housing estate. This includes the renovation of existing buildings A and B, the renovation of the existing estate road, car parking, and the construction of new buildings *C* and *D* with the ancillary facilities. The network of the project activities is shown in Fig.4. The network data are given in Table 1.

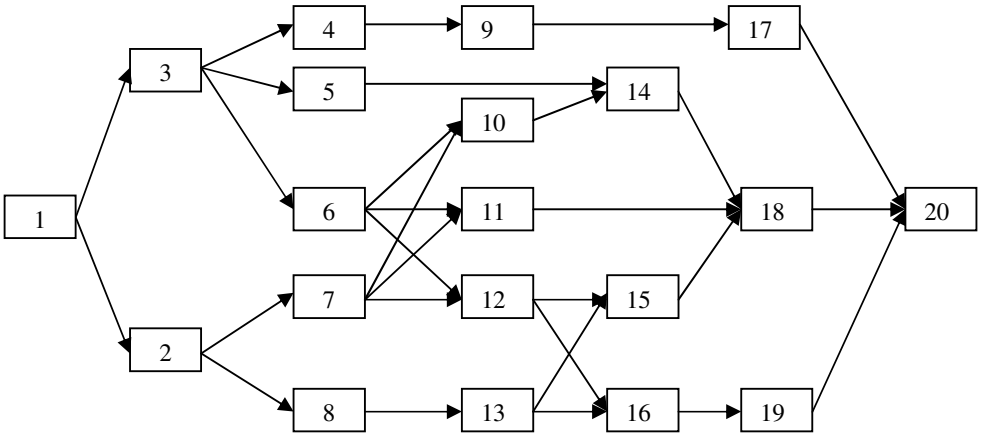


Figure 4: *An example of a construction project network model. Source: Own*

Neglecting the limit of workforce availability, the shortest feasible project makespan is t_s = 37 weeks, with the maximum employment of $r^{\max}$ = 49 workers per week. The contractor assumes that the number of available workers will be probably limited to 30 – 35 workers. In any case it will be not less than 25 and not more than 40 workers. The imprecisely specified limit of workforce availability can be modeled by the fuzzy trapezoidal number $\tilde{R}$ = (25, 30, 35, 40).

The client requires that the project has to be completed within a maximum period of 50 weeks from the date of commencement. On the basis of his past experience, the contractor assumes that he should be technically able to execute the works within about 40 – 42 weeks. Due to the commitments of the contractor to the other clients, the project makespan should not exceed 45 weeks, and the owner of this project will absolutely not accept the project makespan exceeding the period of 50 weeks. The imprecisely specified limit of time available for the execution of the works can be modeled by the trapezoidal fuzzy number $\tilde{T}_d$ = (37, 40, 45, 50).

Table 1. *Data for the project network model shown in Fig. 4. Source: Own*

Activity No	Description	Dura-tion (weeks)	Required number of workers	Earliest feasible	
				start date	finish date
1	Construction site preparation	4	8	0	4
2	Earthworks for buildings C and D	4	17	4	8
3	Renovation of foundations of building A	3	12	4	7
4	Renovation of an existing estate road	3	8	7	10
5	Renovation of the roof of building A	4	10	7	11
6	Renovation of internal services in building B	5	11	7	12
7	Foundation of building C	6	9	8	14
8	Foundation of building D	6	11	8	14
9	Renovation of the existing parking	3	6	10	13
10	Renovation of internal services in building A	6	9	14	20
11	Redecoration of building B	5	10	14	19
12	Superstructure of building C	4	12	14	18
13	Superstructure of building D	6	7	14	20
14	Redecoration of building A	4	9	20	24
15	Internal services in building C	5	10	20	25
16	Internal services in building D	5	11	20	25
17	Repair of auxiliary facilities	3	6	13	16
18	Finishing works in building C	7	6	25	32
19	Finishing works in building D	4	8	25	29
20	Construction site removal	5	9	32	37

In the first example, the planner is obliged to schedule the project to the highest degree of compliance with the imprecisely specified time limit for the execution of the works.

The planner is risk–neutral ($\beta = 0{,}5$). Moreover, the schedule should guarantee the degree of compliance with the fuzzy limit of workforce availability not less than $ST_{wr} = 0{,}50$.

The problem given above is described by the formula (13):

$$\max \mathrm{ST} : \mathrm{ST} = \mathrm{ST}(t \le \tilde{T}_d),$$

with the condition (15), concerning the *finish–to–start* relations among the activities in the project network model:

$$s_j \ge s_i + d_i \big| i \in \{Prec(j)\},$$

and with the condition (17), concerning the required degree of compliance with the fuzzy limit of workforce availability:

$$\mathrm{ST}(r^{\max} \le \tilde{R}) \ge 0{,}50.$$

The resulting construction schedule is presented in Fig. 5. The planned project makespan is $t = 44$ weeks and the degree of compliance with the fuzzy limit of time available for the execution of the works is $\mathrm{ST}(t \le \tilde{T}_d) = 0{,}50$. The maximum workforce employment is 35 workers per week and the resulting degree of compliance with the fuzzy limit of workforce availability is $\mathrm{ST}(r^{\max} \le \tilde{R}) = 0{,}50$. It should be noted that the resulting degree of compliance with the fuzzy limit of time available for the execution of the works is rated significantly higher by the more optimistic planner (see Fig. 7). It should be also noted, that the shortening of the planned project makespan to the level of 40 weeks does not change the resulting degree of compliance with the fuzzy limit of time available for the execution of the works (see Fig. 7). Similarly, the reduction of the maximum workforce employment to the level of 30 workers per week does not change the resulting degree of compliance with the fuzzy limit of workforce availability.

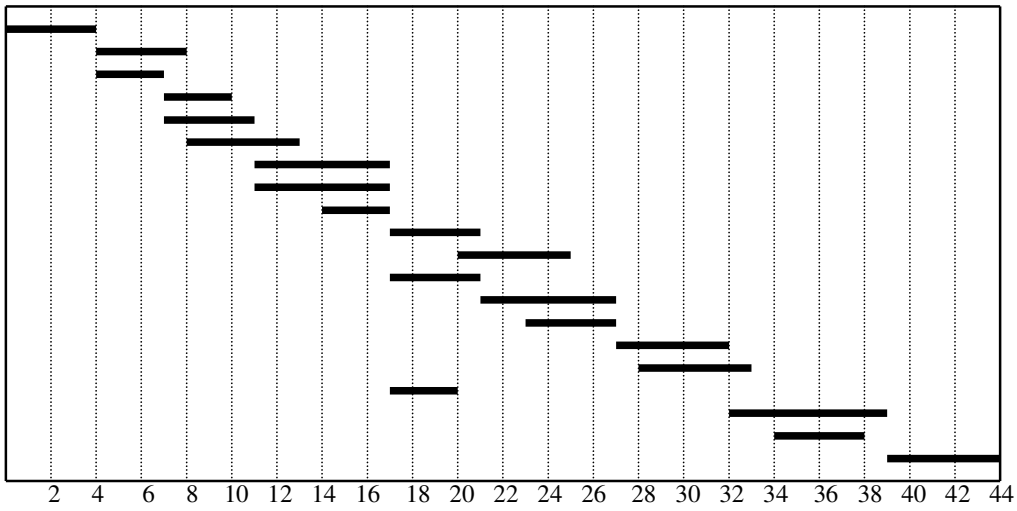


Figure 5: *Construction schedule ensuring the highest degree of compliance with the imprecisely specified time limit for the execution of the works. Source: Own*

In the second example, the planner is obliged to schedule the project to the highest probability of compliance with the imprecisely specified limit of time available for the

execution of the works. Moreover, the schedule should guarantee the probability of compliance with the fuzzy limit of workforce availability not less than P_{wr} = 0,50. This problem is described by the formula (14):

$$\max P : P = P(t \le \tilde{T}_d),$$

with the condition (15), concerning the *finish–to–start* relations among the activities in the project network model:

$$s_j \ge s_i + d_i \big| i \in \{Prec(j)\},$$

and with the condition (18), concerning the required probability of compliance with the fuzzy limit of workforce availability:

$$P(r^{\max} \le \tilde{R}) \ge 0{,}50.$$

The resulting construction schedule is presented in Fig. 6. The planned project makespan is t = 41 weeks and the probability of compliance with the fuzzy limit of time available for the execution of the works is $P(t \le \tilde{T}_d) = 0{,}70$. The maximum workforce employment is 32 workers per week and the resulting probability of compliance with the fuzzy limit of workforce availability is $P(r^{\max} \le \tilde{R}) = 0{,}56$. It should be noted that any shortening of the planned project makespan improves the probability of compliance with the fuzzy limit of time available for the execution of the works (Fig. 7), regardless the risk attitude of the planner. Similarly, any reduction of the maximum workforce employment improves the probability of compliance with the fuzzy limit of workforce availability.

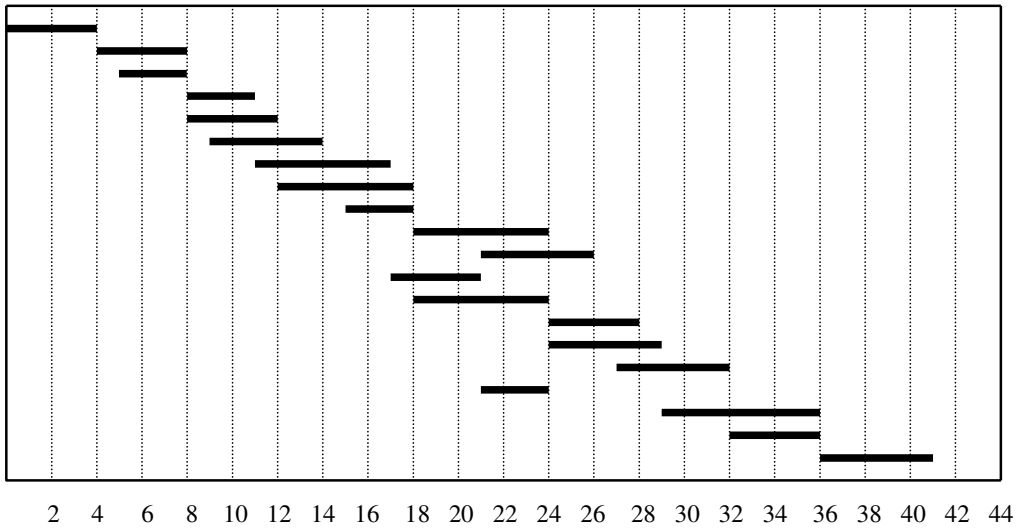


Figure 6: *Construction schedule ensuring the highest probability of compliance with the imprecisely specified time limit for the execution of the works. Source: Own*

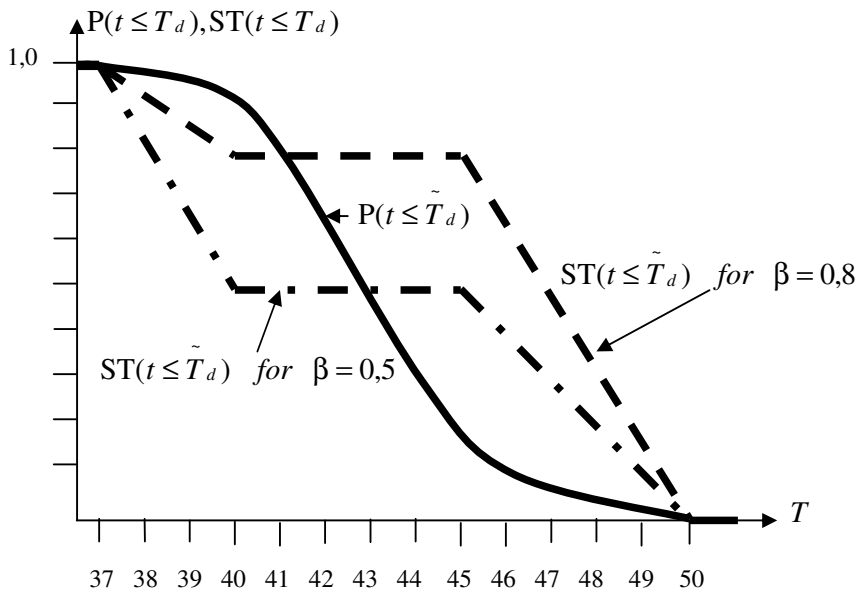


Figure 7: *Comparison of the functions* $ST(t \le \tilde{T}_d)$ *and* $P(t \le \tilde{T}_d)$. *Source: Own*

Suppose now that the workforce is divided into two main trades: construction workers (Trade I) for items 1 – 5, 7 – 9, 11 – 14, 17 – 20 and installers (Trade II) for items 6, 10, 15, 16.

The imprecisely specified limit of construction workers availability is "*about* 30", but not less than 28 and not more than 32 workers. This limit can be modelled by the fuzzy trapezoidal number $\tilde{R}_{\mathrm{I}}$ = (28, 30, 30, 32). Furthemore, the imprecisely specified limit of installers availability is "*about* 20", but not less than 18 and not more than 22 workers. This limit can be modelled by the fuzzy trapezoidal number $\tilde{R}_{\mathrm{II}}$ = (18, 20, 20, 22). The imprecisely specified limit of time available for the execution of the works remains as before: $\tilde{T}_d$ = (37, 40, 45, 50).

The planner is obliged to schedule the project to the highest probability of compliance with the imprecisely specified limit of time available for the execution of the works. Moreover, the schedule should guarantee the probability of compliance with the fuzzy limit of construction workers availability not less than $\mathrm{P}_{\mathrm{I}r} = 0{,}50$ and the probability of compliance with the fuzzy limit of installers availability not less than $\mathrm{P}_{\mathrm{II}r} = 0{,}50$. This problem is described by the formula (14):

$$\max \mathrm{P} : \mathrm{P} = \mathrm{P}(t \le \tilde{T}_d),$$

with the condition (15), concerning the *finish–to–start* relations among the activities in the project network model:

$$s_j \ge s_i + d_i \big| i \in \{Prec(j)\},$$

and with the conditions (18), concerning the required probability of compliance with the fuzzy limits of construction workers and installers availability:

$$\mathrm{P}(r_{\mathrm{I}}^{\max} \le \tilde{R}_{\mathrm{I}}) \ge 0{,}50,$$

$$P(r_{II}^{max} \leq \tilde{R}_{II}) \geq 0{,}50.$$

The resulting construction schedule is presented in Fig. 8.

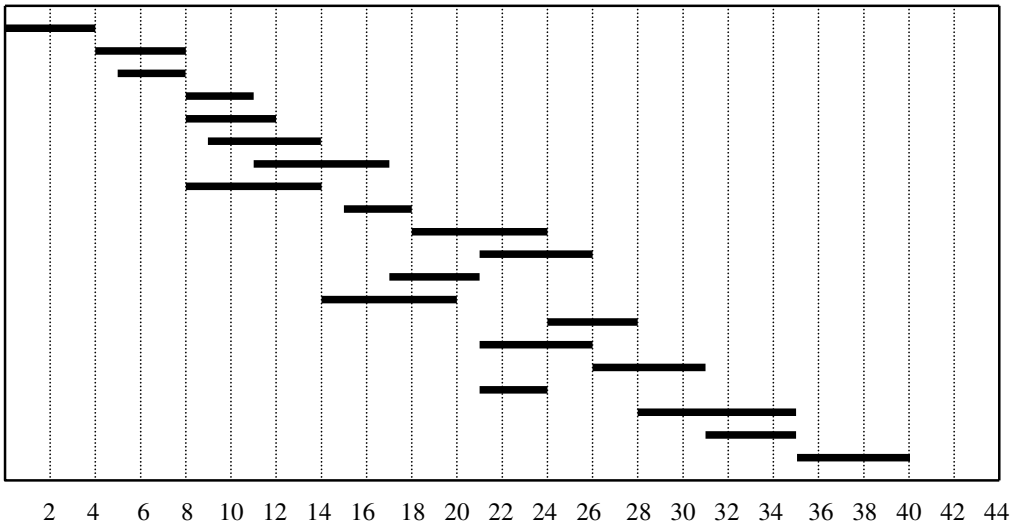


Figure 8: *Construction schedule ensuring the highest probability of compliance with the imprecisely specified time limit for the execution of the works in the case of two trades with limited availability. Source: Own*

In this case, the planned project makespan is t = 40 weeks and the probability of compliance with the fuzzy limit of time available for the execution of the works is $P(t \leq \tilde{T}_d) = 0{,}84$. The maximum employment of construction workers is 30 workers per week and the resulting probability of compliance with the fuzzy limit of workforce availability is $P(r_I^{max} \leq \tilde{R}_I) = 0{,}50$. The maximum employment of installers is 19 workers per week and the resulting probability of compliance with the fuzzy limit of workforce availability is $P(r_{II}^{max} \leq \tilde{R}_{II}) = 0{,}97$.

CONCLUSIONS

The theory of possibility allows for the modelling of imprecisely defined planning constrains by means of trapezoidal or triangular fuzzy numbers. If trapezoidal fuzzy numbers are used, some difficulties arise in determining the proper numerical value of coefficient β characterizing the risk attitude of the assessor. This may cause the different assessments of the degree of satisfaction of fuzzy planning constraints, formulated by planner and by the decision maker. In addition, the result of evaluation remains constant when the planned project makespan or the planned resource consumption takes the value from the core of the trapezoidal fuzzy number, modelling the given planning constraint. This adversely affects the optimality of solutions to scheduling problems with imprecisely defined constraints. If triangular fuzzy numbers are used, there still remain difficulties in the numerical

characteristics of the attitude towards risk. The approach presented in this paper combines the elements of the theory of possibility and the elements of theory of probability. The imprecision of project constraints is modelled by fuzzy numbers, while the level of satisfaction of fuzzy planning constraints is assessed by the use of probability measure. It has been demonstrated that the use of probability measure neutralize the assessment of compliance with the fuzzy constrains. Moreover, the results of the optimization of construction schedule are improved. The approach presented in this paper can be adopted when also the uncertainties of project activity durations are modelled by fuzzy numbers.

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STRATEGIES FOR THE COST-EFFECTIVE TECHNICAL MANAGEMENT OF HOUSING STOCKS

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Abstract

The paper presents an empirical study of investment activities on existing buildings and their dependencies on corporate strategic factors. The study is based on almost 3000 activities carried out from 2003 to 2007 on a typical characteristic housing stock in Germany. The stock is managed by a strategically positioned housing company.
First the state of the art in the research field is presented. The research concept is introduced. Using the methods of descriptive statistics key cost values of the investment activities are presented in accordance with the company's strategic factors. The cost values are compared with the investments of appropriate other German housing companies. In compliance with the obligations of the technical management, strategic recommendations are derived to control costs. The benefits of the strategic recommendations are evaluated with the identification of potential cost savings. The investment minimum of technical management is derived from the key cost values minus the cost saving potential. The minimum investment is discussed in comparison with the investment of other representative German housing companies. The strategic recommendations are incorporated in a concept for the selection of future activities.

Keywords: technical management, housing stock, strategies, existing buildings

INTRODUCTION

The investment activities on existing residential buildings are an important business sector in the German housing industry. As a research field, these residential buildings have been underestimated so far.

Since 2000, the volume of the investment on existing residential buildings is higher than the volume of the investment on new residential buildings (DIW Berlin, pp. 30-31). In 2007 the members of the Association of German Housing Companies (GdW) invested 77 % of their investments in the activities on existing residential buildings (GdW 2008, p. 154). These activities indicate construction work performed to maintain or modify the residential properties (residential building, outdoor areas) and their elements (Figure 1) (Kalusche 2007, pp.128-129).

By focusing on the existing residential buildings, the technical management of housing stock has become the most important task of the construction departments in German housing companies. The technical support of new construction plays only a minor role.

Basis for a rational and cost-effective technical management of the housing stock is the knowledge of the characteristics of the investment activities on existing buildings and their dependencies on corporate strategic factors. Rußig (2006, p. 20) notes, however, that in Germany as well as in other European countries there are only few reliable data concerning the performed technical investment activities and their dependencies.

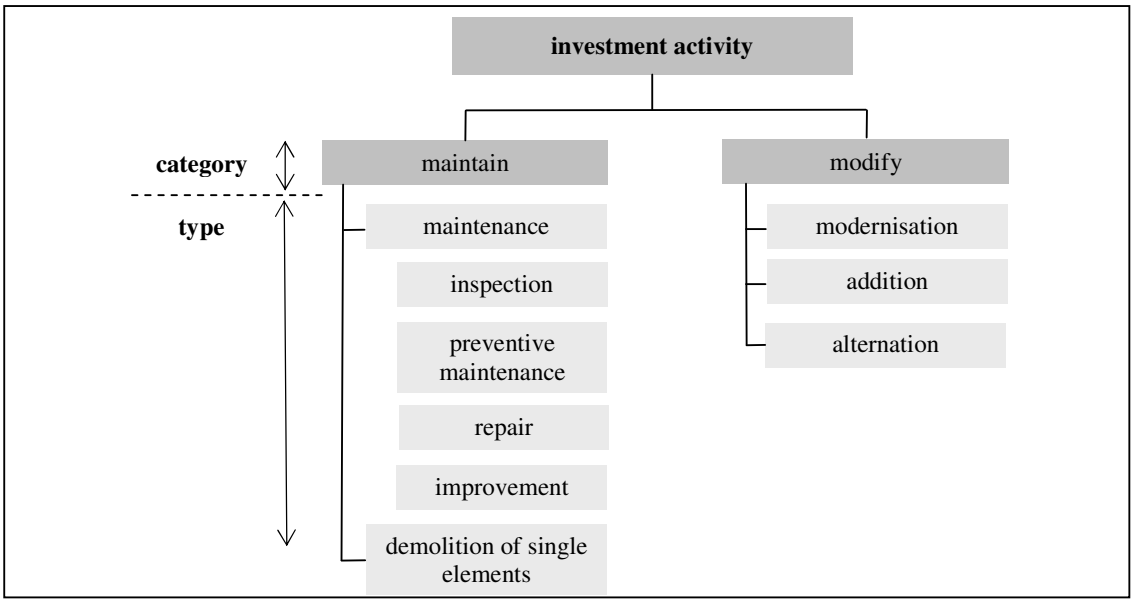


Figure 1: categories and types of investment activities

Lohse and Pfnür (2009, pp. 35, 50, 56-60, 101, 104) show in a survey that the implementation of strategic investment activities on existing residential buildings is one out of five key challenges for the German housing companies.

Currently, there are no scientific studies that use the experience from past activities (Figure 1) on existing residential buildings for a rational and systematic selection of future activities. Therefore the objective of the study is to develop strategies for the cost-effective technical management of housing stock.

STATE OF THE ART

The empirical study on investment activities on existing residential buildings is an emerging research field. First studies were conducted in the 1960s and 1970s by Mrosek (1972) and Zschirnt (1975). To date, there is quite a number of research projects available.

Still those projects show some deficits concerning their method or their content. The investigations have limited significance and are only qualitative. This results from the specific samples, the individual operationalizations, or the consideration of selected single criteria. The qualitative character is given for example in the research by the Statistisches

Bundesamt (2009), Klingenberger (2005), Aikivuori (1994) or Leather et al. (1998).

The novelty of the presented approach is characterized by a thorough multi-criteria analysis of the investment activities on a typical housing stock sample. The gained knowledge is used in order to systematically select appropriate future investment activities.

So far, the development of strategic recommendations is focused on the user-oriented management, the economic management and the damage (structural damage, personal injury) prevention and removing.

Up to now the recommended strategies for user-oriented management refer to user requirements in general and to some very specific requirements like accessibility, energy efficiency or sustainability. They refer to certain owner segments or to special age groups of the buildings. They are mostly based on case studies, expert interviews or surveys. Examples are found in Finkenbusch (2008) or Kirchhoff and Jacobs (2005).

The strategies for the economic management seek to find an economic alternative instead of the minimum investment level. They can be derived by cost-benefit analysis, by methods of investment analysis or by the adoption of entrepreneurial activities. The data are usually obtained by the analysis of case studies or surveys. The statistical analysis of in-company data is rare. The strategies are designed for specific user groups. Examples are found in Kirchhoff and Jacobs (2007), Veser et al (2007) or Kortmann (2008).

Strategies to prevent and repair damage (structural damage, personal injury) are developed component-based or process-related. They are mostly based on the analysis of case studies, expert interviews or the statistical analysis of damage cases (structural damages, accident reports, insurance claims). Examples are the investigations of Schrepfer and Gscheidle (2007), Rizkallah et al. (2003) and Schüler and Röbenack (1996).

The novelty of the presented approach is to meet the obligations of the technical management and to ensure an appropriate minimum investment level.

RESEARCH METHODOLOGY

The research is structured into the following steps:

- Sample selection
- Operationalization of the investment activities
- Data collection
- Data analysis

Sample selection

The study focuses on the analysis of investment activities carried out on a typical housing stock of one housing company. The in-depth study provides a thorough and detailed analysis of all its activities. The investigated period is from 2003 to 2007.

In the study 2939 investment activities have been investigated, which were managed by the technical department of the company. Therewith, about 90 % of all executed activities had been recorded.

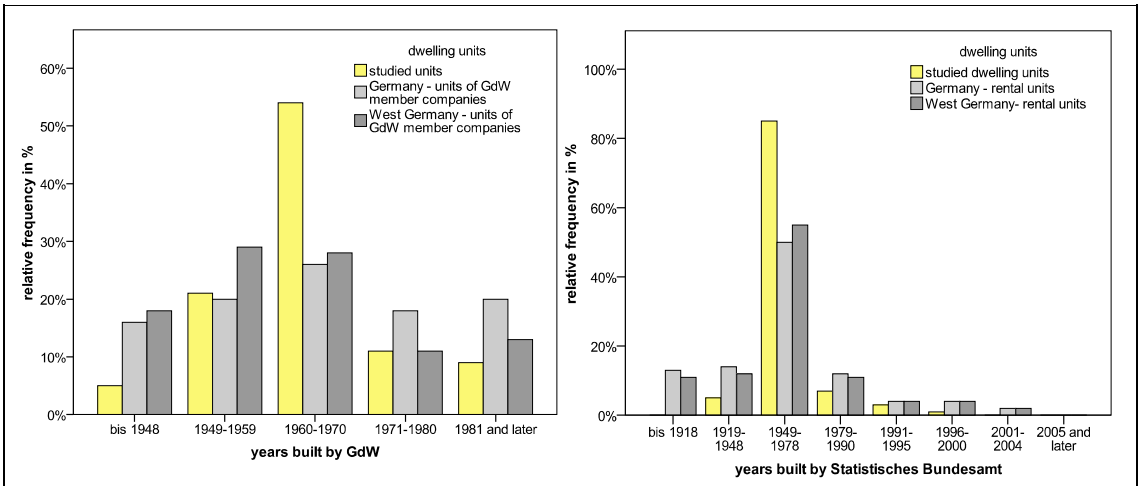
For the realization of these activities, according to DIN 276 (2008), preparation, planning and construction work are required. In this study, only the construction items are considered. According to VOB/A (2010), § 1, construction work is defined as work of any type to create, maintain, modify or remove a structure.

The housing stock includes 2164 dwellings with a total living space of 152.755 m². The dwellings are located in 251 multi-family houses of different age in major cities in West Germany.

The comparison of the dwellings of the research sample with the unit distribution within the member companies of the GdW shows that the years "1960 to 1970" are overrepresented in the sample (Figure 2). In all other regards, the examined housing stock shows the typical age distribution of the dwellings of the GdW member companies in West Germany. The typical West German age distribution is confirmed by the comparion of the studied units with the rental units recorded by Statistisches Bundesamt (Destatis) (GdW 2006, pp. 153-154; Statistisches Bundesamt 2008, pp. 12-13).

The analysed housing company is privately owned. Private owners manage 4.06 million dwellings. These are approximately 47 % of the 8.69 million professionally owned dwellings and about 10 % of all dwellings in Germany (BBR, 2006, p. 23; Veser et al., 2007, p. 26.).

The housing stock is managed by a housing company, which has adopted to changing market conditions by diversification (Kühne-Büning, pp. 123-124; Nordalm 2003, pp. 34-36). Since the late 1990s, the business segments management and marketing of existing housing stocks were supplemented with the segments purchase, sale and privatisation of existing housing stock as well as the management and marketing of purchased and privatized housing stock.



(Source: GdW 2006, p. 211; Statistisches Bundesamt 2008, pp. 12-13)

Figure 2: comparison of dwelling units

Operationalization of the investment activities

As part of the operationalization, the recorded investment activities have been classified by the following six features:

- Category

- Investment package
- Management concept
- Area
- Cause
- Cost (€)

The variables and their categories are defined on the basis of participant observation and by literature review. Their definitions and categories are described as follows:

Variable category of activities
According to Figure 1 the investments are classified in maintenance and modification activities. Maintenance activities secure the functional use of the objects. They lead to retain, restore or improve the required functions of the objects and their elements. Modification activities are usually associated with a distinct change in building design (DIN 276 2008, p. 3; Kalusche 2007, pp. 128-129; Zeitner 2006, p. 137).

Variable investment package
The investment activities fit into the three investment packages shown in Table 1.

Table 1: variable investment packages

no	package	explanation
1	**immediate measures**	day-to day activities carried out straight after the notification of dysfunction or failure
2	**planned actions**	predetermined activities carried out in accordance with a yearly prepared action plan
3	**complete renovations**	a bundle of activities carried out in the temporarily unoccupied or lately added units

Variable area
The technical management of the housing stocks is different for the dwelling and for the common areas. The definition of the area categories is chosen following the Condominium Act (WoEigG 2009).

The *dwelling area* includes the spaces and building structures that are privately owned property.

The *common area* includes the spaces and building structures that are common property.

Variable management concept
The investment activities can be derived from the strategic perspective on different management concepts. The concepts are focused on the three management approaches (Hegewald et al 2009, pp. 19-20):

- *Renting*: sustain the letting and liveability of the residential property
- *Privatisation*: sales design of the residential property (increasing the quality for the sake of marketing, meeting the requirements of future users)
- *Condominium*: sustain the use of the privately and individually owned residential property

The management concepts are applied in the dwelling and common areas. The application depends on the different ownership status as shown in Table 2.

To study the influence of the company's strategy on the entire property, the management concepts in the dwelling and common areas (e. g. renting + renting) are taken together.

Table 2: variable management concepts by area

area	management concept	owner status/responsibilities	explanation
dwelling area	renting	housing company is the only owner of the tenement (all dwellings and common area)	preparing the dwelling areas for renting
	privatisation	housing company owns unit in condominium	preparing the dwelling areas owned by the housing company for sale
	condominium	housing company owns unit in condominium	preparing the dwelling areas owned by the housing company for renting
common area	renting	housing company is the only owner of the tenement (all dwellings and common area)	preparing the common areas for renting
	privatisation	housing company changes the form of ownership from tenement to condominium	preparing the common areas for privatisation
	condominium	housing company manages the common property of the condominium	preparing the common areas for the condominium management in connection to the privatisation

Variable cause

The cause of an activity describes the event leading to that activity (Table 3).

Table 3: variable causes

	no	cause	explanation
material	1	maintaining functionality and usability	Functionality and usability are verified. Small changes in functionality and usability are removed.
	2	limited functionality and usability	Damages, limiting the functionality and usability are fixed.
	3	component failure	Failed components are retained in a functional and usable state.
immaterial	4	user demands	Functional, environmental and hygiene requirements are met. Architectural trends are realized.
	5	changed and new laws, standards and codes of practice	Legal or technical constraints or health issues are met (requirements of the Energy Conservation Act, health hazards due to asbestos).
	6	increase profitability, balance sheet aspects	Activities are carried out to increase the earning capacity of the housing stock.
materiell + immaterial	7	limited functionality and usability and user demands	Same as no 2 and no 4
	8	user demands and increase profitability, balance sheet aspects	Same as no 4 and no 6
(Source: Möschwitzer 2008, pp. 95-96)			

The causes can be divided into three groups:

- material cause (due to material wear)
- immaterial cause (due to non material wear)
- material/immaterial cause (due to material and non material wear)

Variable costs
The costs of the studied activities describe the expenses for the building work (Möller 2001, pp. 98-99) in accordance with DIN 276 (2008, p. 4). The costs of the activities are recorded as billed gross building work.

Data collection
The data have been collected in two steps: in the first step, secondary in-company data were collected. In the second step, the compiled data have been supplemented with additional variables by assignment and assessment.

Data analysis
Using the methods of descriptive statistics, key cost values (€ per m² of living space) of the investment activities are presented in accordance with the management concepts. The values are calculated for each investment package in the dwelling areas as well as for the common areas (Table 2).

The derived values of the housing company are used to calculate comparative figures (whole property = dwelling and common area) in total and by management concept. The values are used to compare the investment behaviour of the housing company with the investment of comparable other German housing companies.

The benefits of strategic recommendations are evaluated with the identification of potential cost savings (€ per m² of living space). The investment minimum of technical management (target key cost value) is calculated from the key cost value minus the cost saving potential per m².

The determined minimum investments are used to calculate the target comparison values. The target comparison values are used to compare the investments of the studied housing company with the investments of selected other German housing companies.

RESULTS

Key cost values

The investment activities lead to total costs of € 25,878,492.32 (Table 4). According to the definition of the different action packages in Table 1, the *complete renovations* (€ 4,639,083.53) represent the cost situation for the *dwelling areas*. The *planned actions* (€ 20,528,593.94) represent the cost situation for the *common areas*. The *recorded immediate measures* (*dwelling and common areas*) lead to relatively low costs (€ 710,814.85).

Table 4: costs of all studied activities (2003 to 2007)

area	cost							
	total		immediate measures		complete renovations		planned actions	
	total (€)	(%)	total (€)	(%)	total (€)	(%)	total (€)	(%)
dwelling area	4,960,333.77	100.0	321,250.25	6.5	4,639,083.53	93.5	0.00	0.0
common area	20,918,158.54	100.0	389,564.60	1.9	0.00	0.0	20,528,593.94	98.1
total cost	25,878,492.32	100.0	710,814.85	2.7	4,639,083.53	17.9	20,528,593,94	79,3

The key cost values in the *dwelling and common areas* vary depending on the management concept (Table 5, Table 6).

The highest key values occur, when the management concept *privatisation* is applied (Table 5, Table 6). Here it is more likely to invest in expensive maintenance and modification activities in order to increase the quality and to meet the requirements of future users (Hegewald 2009).

Table 5: key cost values of complete renovations by management concept (dwelling area) (2003 to 2007)

management concept	total costs (€)	costs (€/unit)	key cost value (€/m²of living space)
renting	1,321,739.27	8,418.72	133.84
privatisation	3,052,823.99	9,393.30	149.34
condominium	264,520.26	4,007.88	63.72

Table 6: key cost values of planned actions by management concept (common area) (2003 to 2007)

management concept	total costs (€)	key cost value (€/m² of living space)
renting	2,346,226.72	20.29
privatisation	18,046,603.08	176.23
condominium	135,764.14	1.33

The key cost values of the management concepts *renting* and *condominium* are significant lower than the values of the concept *privatisation*.

Within the *renting* management more cost-effective maintenance and modification investment activities are carried out. They are used to remove wear, adjust the property to the technical standards or fulfil tenants' requirements (Hegewald 2009).

In the *condominium* management especially cost-efficient maintenance investment activities are carried out. They focus on guaranteeing the habitability. The cost-intensive activities are or will be carried out only in connection with the *privatisation* strategy (Hegewald 2009).

Investments in comparison

The investment activities of the housing company (*dwelling* and *common area*) can be compared with the investment activities of the GdW member companies in West Germany and also with the investment activities of the member companies of the Association of North German Housing Companies (VNW) (Veser et al. 2007, pp. 61-62).

When comparing with those appropriate values from literature, the calculated key cost values are well above the benchmark (Figure 3). Overall, the analysed housing company is investing twice as much in its housing stock as the representative housing companies on average. The high level of investment is mainly due to the concept *privatisation*. The investment in *privatisation* is 2.3 times as high as the investment of the average GdW member company in West Germany.

This raises the question, which investment activities must be carried out on the existing housing stock and which not.

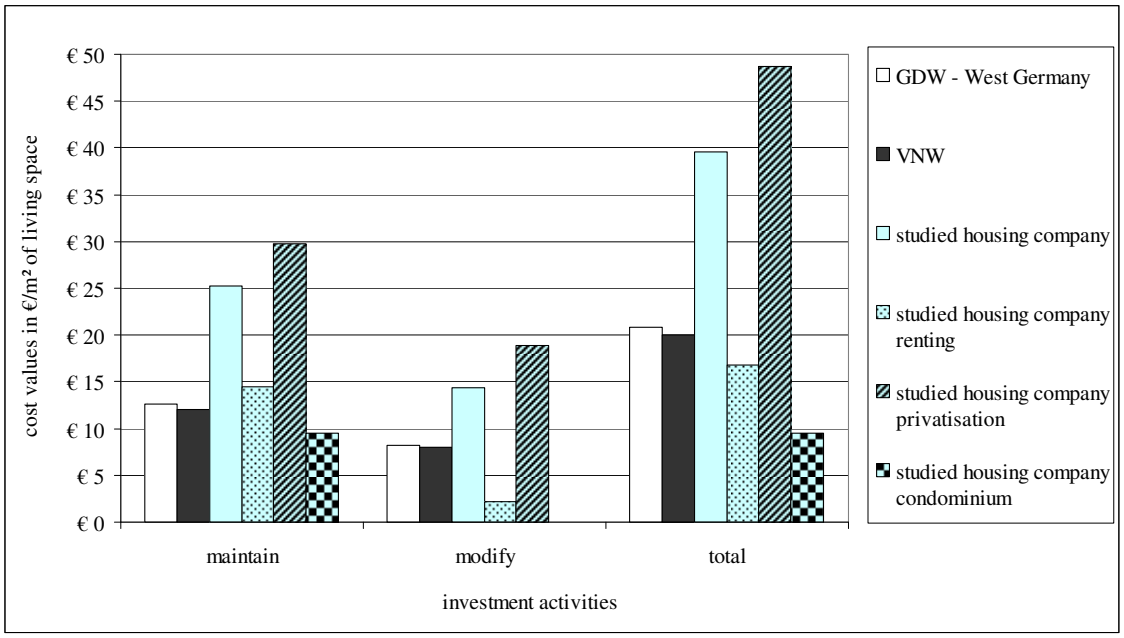


Figure 3: comparison of the investments (key cost values per year)

Duties of the technical management

With the investment activities the duties of the technical management have to be met. The duties are divided into the maintenance and adaptation requirements.

The maintenance requirements include the duty to obtain the housing stock in a functional and hazard-free condition. They can be derived from the law of tenancy, condominium law and the duty to implement safety precautions and to ensure upkeeping of the property.

The tenancy's maintenance requirements are defined in the Civil Code (Bürgerliches Gesetzbuch) (BGB, 2009). They result out of § 535 (1) Civil Code (BGB, 2009) (TÜV

Rheinland Group 2008, p.28). According to it it's the duty of the landlord to keep the tenant's property in a suitable, contractually fixed condition.

The committed maintenance investment activities of the law of tenancy include, as stated by Blank (2005, p. 397-399) and Palandt/Bassenge (2009, pp. 728-729):

- activities to prevent and remedy structural defects
- activities to maintain and restore the contractually fixed condition
- preventive maintenance
- improvements, that result from the maintenance and restoration of the contractually fixed condition

The maintenance requirements for property owners and their managers are derived from the Condominium Act (Wohnungseigentumsgesetz – WoEigG) (WoEigG 2009). They are described in §§ 14, 21 and 27.

The committed maintenance activities are, as written by Stürzer (2007, pp.65-66), the work done to conserve and restore the original condition or functionality of the residential property.

The duty to implement safety precautions and to ensure property upkeep results from § 823 (1) Civil Code (BGB, 2009) (Damm 2005, pp. 4, 6). It is the owner's duty to eliminate threats posed by the residential property or counteract them to prevent injury to others (Blankenstein 2008, p. 736).

Monitoring obligations arising from the implementation of safety precautions and property upkeep can be fulfilled by certain activities. These monitoring obligations and activities are derived e. g. from laws, regulations, or from the general state of the art (Damm 2005, p. 4). Detailed descriptions can be found in Damm (2005).

The adaptation requirements arise, when the protection of the existing use is restricted or has been repealed. They include the duty to adapt the residential property to changed or new legal regulations.

The protection of the existing use secures the residential property owner's right to use and maintain its property, even if it does no longer reflect the current applicable building regulations (Frankenstein 2006, p. 1081). The protection of the existing use is derived from article 14 (1) of the German Constitution (Grundgesetz) (Harlfinger 2006, p. 25).

On one hand, the protection of the existing use is limited or omitted by carrying out activities that implement a significant change in stocks or change in use, according to the wording of the building law (Harlfinger 2006, pp. 25-26). In these cases, an adjustment is required to meet the current building regulations. Maintenance activities are in general covered by the protection of the existing use. Möschwitzer (2007, pp. 21-26) describes this in detail.

On the other hand, the protection of the existing use is limited by the planning law, the building law (fire and safety measures) and others (energy measures (EnEV)). This requires an adjustment to meet the current legal regulations (Harlfinger 2006, p. 26-27).

Strategies

The investment activities are considered technically necessary, if they meet the maintenance and adaptation requirements of the management. Cost reduction potentials have those investment activities that reach beyond the responsibilities of technical management. These are named technically unnecessary investments.

The requirements for the technical management can be assessed with reference to the causes of the activities (Table 3). The assessment of the causes leads to the following strategies:

- Respond to those causes that are associated with the duties of technical management: the duties will be secured with the response to the three material causes, the material/immaterial cause and the immaterial cause "changed and new laws, standards and codes of practice".

- Do not respond to those causes that are not associated with the duties of the technical management: cost saving potential is evident in the response to the immaterial causes "user demands" and "user demands plus increase profitability, balance sheet aspects".

Cost saving potential

The cost saving potential is calculated for the two in Table 1 defined investment packages *complete renovations* and *planned actions* by cause (Table 7). The *immediate measures* are not considered, because they only meet maintenance requirements.

Table 7: cost saving potential of the investment packages by causes (2003 to 2007)

cause	complete renovations		planned actions	
	cost (€)	(%)	cost (€)	(%)
maintaining functionality and usability	26,547.38	0.6	613,556.54	3.0
limited functionality and usability	1,643,592.38	35.4	7,391,453.84	36.0
component failure	64,958.07	1.4	108,434.81	0.5
limited functionality and usability + user demands	2,660,269.38	57.3	2,289,717.63	11.2
changed and new laws, standards and codes of practice	118,421.42	2.6	1,498,623.50	7.3
user demands	*54,830.10*	*1.2*	*449,013.95*	*2.2*
user demands + increase profitability, balance sheet aspects	*70,464.80*	*1.5*	*8,177,793.68*	*39.8*
total	4,639,083.53	100.0	20,528,593.94	100.0
Cost saving potential is in grey and italics				

The cost shares of the technically unnecessary investments are typical for the management of the *common areas* (Table 7). In the management of the *dwelling areas*, the costs of those investments are low. Thus the cost saving potential focuses on the *planned actions*. 42 % of these total costs can be saved from a technical perspective, whereas only 2.7 % of the total costs of the *complete renovations* belong to the technically unnecessary investments.

In the management of the *common areas* the cost saving potential differs depending on the management concept (Table 8).

The cost shares of the technically unnecessary investments are typical for the management concepts *renting* (37.7 %) and *privatisation* (42.9 %) (Table 8). The response to those investments shows a cost saving potential up to 7.66 €/m²of living space for *renting*. For *privatisation* the cost saving potential is up to 75.60 €/m² of living space.

Within the management concept *condominium*, no technically unnecessary investments occur. Here no cost-reducing opportunities exist.

Table 8: cost saving potential of the planned actions by management concept (2003 to 2007)

cause	renting		privatisation		condominium	
	costs €/m² of living space (€)	(%)	costs €/m² of living space (€)	(%)	costs €/m² of living space (€)	(%)
maintaining functionality and usability	0.81 (93,404.78)	4.0	4.95 (506,532.84)	2.8	0.13 (13,618.92)	10.0
limited functionality and usability	7.59 (877,060.70)	37.4	62.57 (6,407,421.62)	35.5	1.04 (106,971.52)	78.8
component failure	0.45 (52,267.01)	2.2	0.40 (40,994.10)	0.2	0.15 (15,173.70)	11.2
limited functionality and usability + user demands	1.56 (180,000.90)	7.7	20.60 (2,109,716.73)	11.7	0.00	0.0
changed and new laws, standards and codes of practice	2.23 (257,885.93)	11.0	12.12 (1,240,737.57)	6.9	0.00	0.0
user demands	*0.15 (17,039.39)*	*0.7*	*4.22 (431,974.56)*	*2.4*	*0.00*	*0.0*
user demands + increase profitability, balance sheet aspects	*7.51 (868,568.01)*	*37.0*	*71.38 (7,309,225.66)*	*40.5*	*0.00*	*0.0*
total	20.29 (2,346,226.72)	100.0	176.23 (18,046,603.08)	100.0	1.33 (135,764.14)	100.0
Cost saving potential is in grey areas and in italics						

Minimum investment of the technical management

In the management of the *dwelling areas* only low cost saving potential is shown. The determined key cost values (Table 5) of the *complete renovations* are therefore equivalent to the minimum investment of the technical management.

In the management of *common areas*, the application of the strategic recommendations results in a significant cost reduction potential of 42 %. The minimum investment differs from the determined key cost values (Table 6).

The minimum investment is characterised by the values of the management concept *privatisation* (Figure 4). The target key cost value of the concept *privatisation* is 100.63 €/m² of living space. The target key cost value of the concept *renting* (12.63 €/m² of living space) is eight times lower than the value of the concept *privatisation*. The target key cost value of the concept *condominium* (1.33 €/m² of living space) is almost 10 times lower than the corresponding value of the concept r*enting*.

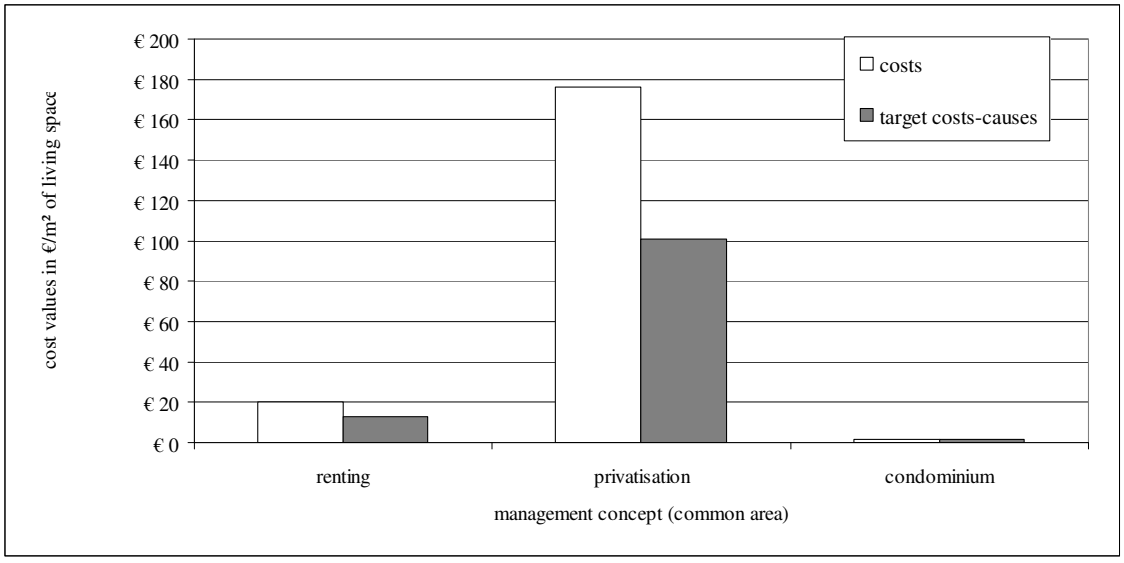


Figure 4: key and target key cost values of planned activities by management concept (2003 to 2007)

Minimum investment in comparison

The minimum investment (dwelling and common area) is higher than the representative member companies' average investment (Figure 5). The minimum investment is about 35 % higher than the average investment of the GdW member companies in West Germany. It is about 40 % above the average investment of the member companies of the VNW.

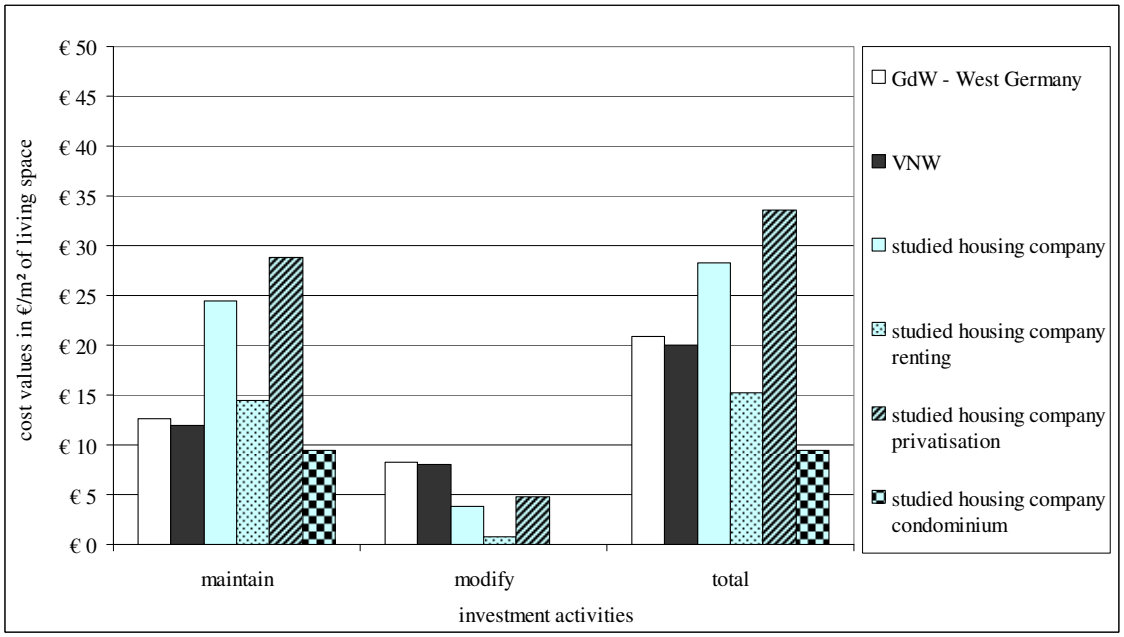


Figure 5: Comparison of the investments (target key cost values per year)

It might be supposed that the investment level of the representative companies could be too low for a long-term guaranteed housing stock quality. But Morgan Stanley mentions in Veser et al. (2007, p. 62) 16 to 20 €/m² of living space as sufficient for this purpose. The comparative values are 20.87 €/m² of living space (member companies of GdW) and 20.00 €/m² of living space (member companies of VNW).

Instead, it can be assumed that the studied housing company's proactive role, particularly in the context of *privatisation*, causes a considerably higher investment level. The technically necessary investment is performed more extensively as needed in order to avoid further investments. Therefore, the minimum investment in *privatisation* is 1.6 times higher than the investment of the GdW member companies on average.

The minimum investment of the concepts *renting* and *condominium* is lower than the average investment by the compared housing company members. Compared with the data from Morgan Stanley in Veser et al. (2007, p. 62) the investment in *renting* (15.22 €/m² of living space) is sufficiently high to ensure to keep the stock in a good quality. Even so, the investment in the concept *condominium* (9.46 €/m² of living space) is classified as adequate at the transition to an intensive phase of *privatisation*.

CONCLUSION – CONCEPT FOR THE RATIONAL SELECTION OF ACTIVITIES

To identify potential cost reductions by thorough analysis of the cost distribution is an important opportunity to derive a concept for the rational selection of the investment activities on housing stock. The analysis is able to answer the question, which investment activities have to be carried out and which not.

The derived concept refers to the investment activities classified as belonging to the *planned actions* (Table 1), whereas investment activities classified as belonging to the *immediate measures* and *complete renovations* are generally recommended to be carried out. They are realized in the context of the ordinary duties of the technical management.

The *planned actions* can be categorized into technically necessary and technically unnecessary investments. For the assessment of the recorded *planned actions* the causes and the resulting strategies can be used.

The technically necessary investments are generally recommended to be carried out. A temporary interruption of the technically unnecessary investments is possible without the risk of considerably damaging the stock values. But the general omission of the technically unnecessary investments is deemed critical for long-term user-oriented operation.

With the technically necessary investments all security and functional requirements are met, whereas the technically unnecessary investments customize the housing stock. They fulfil personal, social, aesthetic and efficiency demands (Preiser 1983).

To avoid possible vacancy, additional technically unnecessary investments might be appropriate to be carried out. Therefore, it is proposed that these unnecessary investments are evaluated by using a multi-criteria decision making model (AHP and cost-effectiveness analysis). With the help of the model, then the investment activities with the best cost-benefit ratios are candidates for implementation according to the available overall budget of the company.

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IMPLEMENTING GREEN DESIGN INITIATIVES IN THE UAE

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Abstract

The drive for more sustainable built environment in the United Arab Emirates (UAE) received a significant boost in the period 2006-2008 supported by new legislations from the government and increased interest from major stakeholder especially municipalities. The absence of locally developed frameworks for evaluating sustainable design of buildings has created opportunities for the introduction of foreign ones. LEED has become popular in industry and has even influenced the current attempts to develop a local framework. The paper will report the findings of a research that, first, evaluated the effectiveness of LEED framework in dealing with local issues. Secondly the paper will examine two case studies where LEED was used in only one of them while both cases aimed to ensure the project development is sustainable. The analysis shows that "responsible design" produced more effective solutions for sustainability.

Keywords: Sustainable development, LEED, UAE, Responsible design.

INTRODUCTION

The construction boom in the United Arab Emirates has created significant pressures and raised concerns about the impact of such boom on the environment and energy. This has prompted the local governments to issue directives and new regulations requiring all buildings in the major cities, such as Abu Dhabi and Dubai, to adhere to strict green standards prescribed worldwide

It is argued that global climate concerns can be largely alleviated by responsible design, may it be automotive, product, machinery or building design. Wann (1990) explains in his book *Biologic* that "environmental deterioration is a lack of relevant information [and that] poor design is responsible for many, if not most, of our environmental problems." It is not surprising that attention has focused on developing green building practices to substantially reduce or eliminate negative environmental impact of construction and operational practices. Reviewing design practices to that end may also contribute to reduce operational costs, enhance building marketability, increase worker productivity and reduce potential liability

resulting from indoor air quality problems. Thus green design can have environmental, economic and social elements that benefit all building stakeholders.

Building design is heavily influenced by its geographical location and where architecture varies vastly from place to place in response to its regional context. The focus of this study is on designing sustainably and responsibly for the arid regions of Dubai. The inculcation of green design strategy made mandatory by governmental regulations in Dubai and the appropriate way of introducing and infusing them, into the pre-existing system is perceived as a challenge.

There is an opportunity to extrude applicable techniques from already developed practices elsewhere and identify opportunities for application in this region, taking into consideration the local, cultural and ecological conditions International rating systems like LEED have been used widely in Dubai and is seen by many, especially foreign consultants, as a valid tool to initiate the green journey

This study main objective is to evaluate the effectiveness of current effort to design buildings that are seen to be more environmentally friendly. Two case studies will be examined where in one of them LEED framework was used while the second case study worked without a reference to a rating framework.

SUSTAINABILITY DECISION DRIVERS IN THE UAE

The unprecedented growth in the UAE construction industry in the late years coupled with its massive fossil fuel energy consumption has not escaped media attention. The LIVE PLANET report in 2006 revealed that UAE was responsible for the world's largest ecological footprint. World Wildlife Fund revealed that UAE was five times more unsustainable than any other country in the world.(Anon 2007, WSP 2009) It was observed that UAE had an Ecological Footprint of 11.9 hectares/person, while the global average is at 2.2 hectares/person and the sustainable average should be at 1.9 global hectares/person (Oehme, 2008).

In 2008, Dubai government released a directive proposing a regulation that requires all buildings in Dubai to adhere to strict green standards prescribed worldwide.(Sell 2007). Greening the future was the message delivered by the government of Dubai in its DM Circular 161 which underlines the fact that all buildings constructed in Dubai from the beginning of year 2009 shall conform to green standards.

The introduction of sustainability metrics should assist in turning the generic concept of green development into action. However, one must keep in mind that the fabric of the construction industry in Dubai is made up of a mix of small, medium and large sized local and foreign contractors, consultants and investors. The industry functioning under time and cost constraints largely depends on the cohesive symbiotic functioning of all of these diverse segments complementing each other to get the job done within desired project frameworks. Getting the message of the need for green development through, to these varied types of people involved, tagged with its high financial perception would be a matter of concern during actual implementation.

The difficulty also arises with the fact that LEED solutions were never designed to be used across multiple countries and often have features with a significant 'local' flavour. Hence the impact and effectiveness of the LEED system, which forms the basis of the proposed green regulations, needs to be critically analyzed as to whether these prescribed design

requirements suit the local context of Dubai. The next section will examine the applicability of LEED guidelines and their implementation in Dubai's construction projects.

EFFECTIVENESS OF LEED IN DEALING WITH LOCAL ISSUES

Climate responsive design has been the underlying principle while identifying green building design elements. By understanding climatic conditions that are specific to a project's location, design teams are able to develop climate responsive sustainable building designs. Positive climatic attributes are enhanced and unwanted impacts are eliminated through careful design consideration. The result is a building that utilizes less energy and provides high quality and a comfortable environment for the occupants. Broadly, the UAE is defined as having a tropical desert climate, with high humidity. It experiences two distinct seasons: a hot summer at 50ºC (120 ºF) (May to October), and a milder winter ranging from 10ºC (68 ºF) to 25ºC (77 ºF) (November to April). Wind speed is generally quite high, and its direction variable (Arup, 2004). This air movement can be enhanced through responsible design to create desirable comfort conditions.

Sustainability criteria defined in LEED are evaluated in the local context and each of these parameters is explained in below.

Environment and Planning criteria

The selection of an appropriate site has the biggest impact on a sustainable design. LEED stresses upon the utilization of previously developed land and brown fields for new developments and discourages new land development. Most of Dubai's land is undeveloped and only 20% of the emirate has been occupied so far (WSP, 2008). Hence it is not appropriate to restrict development to previously developed sites as against virgin land. However, preference should be given to developed sites as their infrastructural requirements will be limited leading to minimal environmental disruption. The availability of land in Dubai makes brown fields unattractive for development.

In Dubai, site selection is often based on the commercial viability of the location. Though connectivity is an important aspect it is not always a driving factor for site selection as most of the city commutes through privately owned vehicles. Besides care should be taken not to exploit the natural ecology by restricting developments along Creek area, land connecting to the mangroves which form habitat for migratory birds; along the beachside which are already over developed, desert zones with wildlife and such sensitive zones.

Building orientation in Dubai is in response to the adjacent development like roads or natural/manmade beaches to maximize commercial viability. The lack of natural landforms and expansive desert land has restricted the articulation of the building's architectural form. This is where the need for climate responsive design becomes critical and LEED pointers come in play. Accordingly landscaping should be planned to enhance the design and utilize natural resources to create comfort zones in design. Monotonous desert sprawls in the UAE are often landscaped mainly with turf grass lawns and high maintenance plants in discontinuous patches providing little relief from the building mass. The concept of a thoroughly thought building footprint has never been relevant. Much help can be sought by following the LEED principles. LEED credits for building orientation, planting hardwood trees, north facing windows, native vegetation, shadow profiling to mention a few could be most popularly used and are apt to be applied in Dubai.

LEED propagates minimal environmental disruption from a building footprint onto a site. Common issues faced in the region like heat island effects, reflected glare etc can be reduced by designing the building with underground parking hence reducing the building footprint. LEED suggests placing parking under cover like multistory, subterranean or shade structure or utilizing a parking deck. Parking facilities and roadways have negative impacts on the environment because impervious surfaces increase storm water run-off while contributing to urban heat island effects. Encouraging the use of mass transit reduces the demand for transportation thereby reducing the space needed for parking lots, which encroach on green space on the building site (USGBC, 2007).

Dubai also has the highest rate of car ownership in the world. LEED advocates various strategies to reduce the impact of vehicles, promote fuel efficient cars, car pooling and other alternative travel options. Alternative transportation are currently being reviewed and promoted by the government. One among them is the encouragement for the use of bicycles, as most new communities are being designed as being bicycle friendly. RTA has been instrumental in setting up Bicycle Network Master Plan that will be implemented in stages from 2008 (Noort, 2008) providing 1300 kms of cycling paths, as part of the 2015 strategic vision. To ensure the success of this strategy, it is important to provide amenities like bicycle storage and showering areas as support facilities as advised in LEED.

UAE has large urban sprawls of paved area under constant sunlight. In addition, hot air released from air conditioning units contributes to warming up of built spaces, leading to Heat islands (WSP,2008). The LEED point for Green roofs can be used efficiently here to reduce heat island effect by replacing heat absorbing surfaces with plants, shrubs etc for their insulating and aesthetic benefits. In the UAE this point can be altered to form Cool roofs wherein plant matter is substituted with photovoltaic panels or solar hot water collectors to utilize the enormous heat energy available.

Similarly photo pollution is a problem, arising from the reflection of excessive building lighting utilized commonly seen in this region. LEED suggests to classify projects as per lighting zones and to design accordingly. This should be adopted at design and a regional sensitivity to determine the type of environment the project falls under and then the design evaluated. Carefully designed exterior lighting solutions can reduce infrastructure costs and energy use.

Water efficiency

UAE has one of the highest water consumption levels in the world due to climatic conditions and high per capita income (Chaudhury, 2005) though the country has virtually no natural supply of fresh water. Per capita demand in the UAE has been estimated at 378 litres/day compared with the international benchmarks of 189 – 265 liters per day. LEED water efficiency credits aims at reducing potable water consumption and generated wastewater volumes which can be applied effectively to this region.

Desalination, an expensive and energy intensive process, provides much of the potable water. Considering the extensive amount of energy and infrastructure invested in providing potable water, the careful use of water should be enforced through policies and awareness should be brought about amongst the public about water conservation. LEED credits on high-efficiency fixtures, use of automatic fixture sensors, metering controls, occupant sensors, flow restrictors, reduced flow aerators on lavatory, low consumption fixtures for sink and shower, dual-flush water closet and ultra low flush urinals, dry fixtures such as composting toilet systems and non water using urinals, should be employed to cut down wastewater volumes.

In the arid region of UAE where fresh water is scarcely available LEED advocates the need for reusing recycled gray water for non potable activities, which is now actively taken up by the government. The Dubai Municipality (DM) has an established network to distribute treated sewage effluent (TSE) and has undertaken, in conjunction with Dubai Electricity Water Authority (DEWA), to provide TSE to any new district cooling plants and community landscaping if required (DM, 2009). Building design should incorporate gray and storm water for non-potable applications such as toilet and urinal flushing and custodial uses. Similarly all car washing facilities can recover and reuse their wastewater.

The high humidity in Dubai results in significant amounts of condensate being produced by air conditioning equipment. Rather than draining this water into the sewer system, condensate can be captured and used for irrigation and other various non-potable water applications on site. One of the largest condensate recovery systems in the world has been incorporated into the design of the Burj Dubai (WSP,2008).

In Dubai, large amount of potable water is consumed in irrigation practices. Plants which are better adapted to hot arid climate, better known as Xeroscapes, consume less water and should be incorporated in the design along with night time irrigation with the help of experts in the field. Design should minimize the amount of land covered with turf due to its high water requirement. A large number of golf courses proposed in the UAE, are with expanses of green water-consuming turf.

Energy efficiency

Dubai has the world's highest per capita energy consumption at 20,000kWh per year (Sinclair, 2008). Ventilation and air conditioning in Dubai's buildings has been shown to account for up to 60% of the total energy consumed in buildings (DM, 2009). The thermal performance of the building envelope is one of the main drivers in determining what the cooling load and resultant energy use will be. Hence it is important to consider the design of building envelope with primary significance. LEED, as well as DM, prescribes strict U values to adhere to, for Building thermal insulation.

The energy use of buildings are closely related to their size, use, the way they are operated, their construction characteristics, shape and of course the climate. The hot temperatures and humidity in UAE, necessitates that all buildings require air conditioning and mechanical ventilation to be installed. Mixed mode systems combining natural and mechanical ventilation should be encouraged as for five winter months of the year the weather is pleasant and air conditioning can be optional.

In Dubai's humid climate insulation plays an important part in reducing the heat exchange between the inside and the outside environment as well as the formation of condensation. Building envelope requirements should be based on UAE's climate zone 1A classification and must meet the minimum insulation and maximum U value and *Solar Heat Gain Coefficient* (SHGC) requirements listed by the DM. Better thermal performance by incorporating building entrance vestibules and thermal bridges at floor junctions and connection points of the building envelope will reduce the energy demand for cooling and prevent energy losses.

On the onset of a design programme it is essential to set minimum energy efficiency requirements for the project, for all the proposed building systems by complying with the mandatory provisions of ASHRAE Standard 90.1-2004 for the climate zone of 1A (Rogers, 2008). Design to accomplish energy demand reduction by optimizing building form and

orientation. Strategic planting can shade the building which can decrease cooling loads during warm months.

Due to the large temperature differential between the incoming and outgoing airstreams, such as that exists in Dubai, abundant waste energy can be recovered through exhaust air energy recovery systems, gray water heat recovery systems and cogeneration. Ducts, supplying conditioned air must be insulated to minimize heat loss and prevent condensation. TSE provided by the Municipality should be used for water cooled HVACs.

There is a growing demand for economical cooling alternatives in the UAE, such as District Cooling towers (Dubai News Online, 2008).The incorporation of district cooling should be an integral part of the building design. It helps to displace bulky equipment from the building facade and roofs as is often seen on Dubai. Thermal storage systems should be included inorder to offset energy demands from peak to off-peak periods and reduce electrical costs. Refrigerant management is often a concern with high volumes of air conditioning. The design should avoid the use of CFC-based refrigerants as CFC causes depletion of the Ozone layer.

Onsite renewable energy is gaining popularity worldwide. However there are difficulties associated with implementing it here in Dubai, as the technology is not developed sufficiently for it to be more cost effective than conventional energy sources, making it difficult to convince the market to invest in it. While companies like MASDAR are aiming at using an array of renewable sources, mainly PVCs for electricity generation to utilize the potential of the hot summer sun. The maintenance of Photovoltaic cells should be considered at the design stage and provisions made for the same. In the desert conditions of UAE, with high dust content and high humidity in the air there is a buildup of dust on the solar collector panels. This requires regular cleaning as the dust reduces the efficiency of the system.

Similarly, solar water heaters can be widely used. Solar Hot Water systems are the most cost effective means of using the power of the sun. Residential buildings, hotels, villas and labour accommodation with consistent need for hot water, and their large roof expanses can make the most of this technology. Design should consider incorporation of solar hot water systems as this will have a significant reduction on electricity usage.

Materials & Resources

Dubai is facing significant challenges associated with waste generation and disposal. Design of individual buildings should facilitate the appropriate collection and disposal of waste by sorting and reusing at preliminary levels. All efforts should concentrate on minimizing waste. Recognize that there is no such thing as waste, only resources out of place.

Along with the regulatory guidelines from DM, LEED construction credits for diverting waste from landfills, recycled content and the reuse of materials in design should be applied. Waste should be segregated at disposal and central collection and storage facilities provided during design. Provide sorting and storage facilities for recyclable materials. Involve local haulers to provide waste management services. Hazardous waste should be disposed as per regulations with authorized agencies.

Identify opportunities to incorporate salvaged materials into building design. Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal.

LEED encourages the use of locally sourced materials to promote local economy and provides impetus for growth. This may not seem very relevant now in UAE, but with the

proposed development envisaged for the manufacturing units, it may be a potential design consideration in time to come. Some of the regional materials available here in the UAE are glass, cement, concrete, ceramics which should be locally sourced.

Similarly Forest Stewardship Council's (FSC)certified wood for wood building components and lower grades of wood (grade 2 or 3 for lumber or veneer rather than grade 1) should be specified in design to reduce pressure on forests.

Air quality management

Dubai faces high levels of pollutions from man-made sources like motor vehicles and fossil fuel burning power stations, dust from construction and other such activities. Particulate matter, suspended in air found in desert regions are typically higher during the summer months due to more unsettled weather conditions and higher air temperatures. During building design high level filtration system should be employed in air handling units processing both return air and outside supply air. Design permanent architectural entryway systems to limit the entry of pollutants into the building.

With enclosed buildings and recirculating air in Dubai, it is necessary to monitor and improve indoor air quality with adequate ventilation requirements. Design should provide adequate ventilation with focus on cross ventilation. All naturally ventilated spaces shall be manually operable openings. CO and CO2 should be constantly monitored in car parks with constant outdoor air supply to car parks.

A governmental regulation has restricted smoking in public places and smoking rooms must obtain permit to allow smoking. Locate exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows inorder to prevent ETS intake during outside air intake. Locate designated smoking rooms to effectively contain, capture and remove ETS from the building.

Rooms with pollutants like ETS, chemical storage room, printing area etc must be directly exhausted to the outdoors with no re-circulation of return air and enclosed with impermeable deck-to-deck partitions.

Specify low- VOC materials in adhesives, paints and coatings and sealants. Assemblies that contain no added urea-formaldehyde resins are preferred.

A typical Dubai building has glazed facades with no shading structure. This results in higher cooling loads and increased energy consumption. In addition, excessive brightness contrast between externally lit surfaces and building interiors causes visual discomfort. This is altered by switching on internal lights permanently, leading to unnecessary energy consumption.

A well considered daylighting approach in buildings will not only reduce the incidence of glare and discomfort but also reduce the need for electrical lighting if part of an integrated daylight strategy with lighting controls and external shading devices. Blinds and shading fins helps in reducing solar gains in the buildings and is an old popular and efficient technique used in building design of all temperate regions. LEED recommends direct line of sight to the outdoor environment via vision glazing to achieve a minimum glazing factor of 2% in regularly occupied areas. This needs to be carefully incorporated along the north facade in Dubai considering the heat gains from exposed glazing and high occupant loads. Also allow for comfort control adjustments to suit individual needs or those of groups in shared space. Integrate individual controls with occupancy sensors.

Vernacular design features

The architecture of today calls for 'a modern vernacular that is inspired by a responsive and sensitive balance between the knowhow and wisdom of the past and that which is sustainable, yet modern.' Vernacular design critically examines the possibilities of implementing local know-how in both a developmental and modern context. In response, contemporary Gulf architecture should be about applying tradition, culture and modernity in equal parts, to create something that is undeniably 'Gulf' yet clearly modern.

A traditional design takes advantage of the existing natural resources. Passive building design and material choices that avoid absorption of the sun's heat to promote thermal comfort and energy conservation, are traditional methods used by early inhabitants of UAE. Dubai's traditional buildings, like the ones at the Bastakiya have light coloured exterior finishes and they help in reducing energy use. Light exterior colours with high SRI are highly recommended.

It is common to see water features in the UAE used for aesthetic enhancement. Well maintained water features checked regularly for Legionella bacteria prevalent in this region due to high humidity, can be incorporated to promote passive cooling during the hot summer months. Water bodies add to the humidity levels during the summer months, causing further discomfort, hence their usage thoughtfully designed.

Courtyards provide relief by creating negative pressure zones hence attracting air movement as well as creating interesting interactive spaces. These along with wind catchers can be positioned to trap and filter breezes aiding natural ventilation during the cooler months of the year. Mechanical controls can be incorporated to shut off or promote air circulation.

THE CASE STUDIES

Case studies are carried out in an attempt to understand the application of the principles and ideas reviewed above elements in project design and execution. Vast amount of information and project management techniques can be learnt from the practical experience gathered in case studies. Two projects were taken up to evaluate the current practices in green design and identify good practices.

The first project is a five star luxury beach resort in Dubai proposed to be a LEED accredited building. This is analyzed against evaluated LEED principles and compared against the list of green elements compiled from the study. A check list with reasoning for each of the elements was prepared and sustainability measure of the project verified. As the building is designed to be LEED rated, various design credit elements have already been incorporated. However, from the check list responses it was noticed that the five star nature of the project and the associated security and quality issue perceived has, in certain cases made it difficult to address a number of the sustainability criteria.

The case study revealed that a large number of design and execution points learnt in the planning techniques have been implemented to the design process of this resort building. A number of procedures have been put in place through an integrated design process to ensure the successful implementation right from the design stage. Careful execution forms a very important part for the success of the green initiatives endeavored in this project. A few

notable design measures implemented to increase the sustainability credentials of the Project include

- Translocating trees for reuse rather than removal;
- The use of native, desert adapted plants
- Cool roofs with solar thermal water heaters
- Graywater recycling through water saving shower heads, taps and low flush toilets etc;
- Energy saving technologies, such as insulation, building orientation, shading and energy saving bulbs;
- Use of locally sourced materials where possible,
- Waste management strategies during construction and operation;
- Sourcing of local and sustainably grown goods
- Sustainable transport linking of public transport systems to the Project
- Using savings on road and service infrastructure to invest in more energy efficient buildings, renewable energy systems and sustainable water management.

The need for no new infrastructure to be placed, due to the existence of the prior resort facility, has been a bonus to the site as no major excavation and laying of infrastructure lines is now required. The large expanse of building footprint spread all across the site necessitated by the nature of resort buildings, has disturbed the natural state of the site. Though this sort of spilling of building masses is dictated by the typology of resort building, careful addition of native planting and the restoration of existing site plant material being wisely incorporated in the landscaping scheme has added value to the quality of natural eco system created within the resort premises. An attempt is made to minimize disturbance to the eco system and factors to sustain and promote the existing system are put in place. Pointers from the sun and wind directions study have been utilized to enhance interior occupant comfort levels, which is seen through the in-corporation of architectural elements like a cascading roof providing shelter from the south sun, permanent manually adjustable wooden louvers and blinds, intermitted water bodies positioned in the flow of wind etc. Due to the lack of practice of sustainability elements within the region, there are no suppliers to provide specific green products. Local materials are very few and those available are not cost-effective.

It is noticed that sustainable design elements form an overarching component of the Project, and is considered in all aspects of the project design and execution. LEED is used to guide the Sustainable design process in which water, energy and resource demands as well as waste are attempted in being reduced without affecting the overall experience of the building and surrounding landscaping. To ensure efficient co-ordination between all team members, an integrated design approach was employed and LEED design workshops were help frequently. A LEED coordinator was essential in facilitating the progress of the design. The most difficult aspect was to reach at an environmentally friendly design while making sure that the commercial benefits were not impacted. On the whole this project is a good example of sustainable building design in practice in Dubai.

In the second case study sustainability was driven by what was considered to be “responsible” design. This project is a resort shopping destination (figure 1) within the urban city sprawl. It is a low rise building with a canal forming a central water body and smaller fragmented building masses connected to the main building through bridges facing the creek which ultimately culminates as the quayside.

This project was conceived in 2003; before the trend of green architecture and sustainability came about to Dubai. Nevertheless it was still considered as an excellent example of the use of passive elementary architectural features, which are easy to maintain and operate. Many systems and architectural elements were specifically designed to accommodate local conditions and create comfort zones.

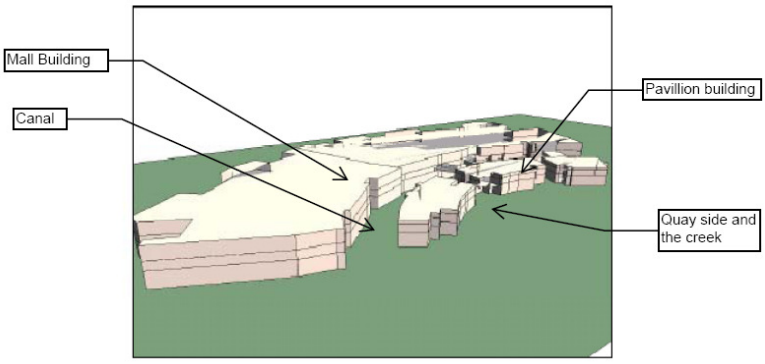


Figure 1: Mall Building Composition

This case study was compared against the green elements shortlisted through the study of sustainable techniques. Some of the outstanding sustainability elements incorporated are discussed in below.

The creation of Microclimate by intelligent planting, features like cool walls, topiary misting, waterfalls, shading devices like Teflon coated canopies, building mass shading, drop down shades and temporary screens, green roofs and wind shield structures is highly notable. Modifying factors like the air and radiant temperatures, wind conditions and humidity helps create microclimates for comfortable external spaces.

The microclimate zones are provided with fully shaded walkways (figure 2) with reflective canopies that provide shelter from occasional rainfall. By providing additional surfaces such as cooling walls, planting and grass cover, the resultant temperature has greatly improved. In addition, high thermal mass of surrounding walls aid the pre-cooling process keeping the outdoors ambient.

To encourage air exchange, lightweight fans are situated below holes in canopy frame reducing heat sensation significantly. The traditional internal courtyard provides good shading by virtue of the enclosing buildings, and is aided by relatively small overhangs. Water features and planting provide local evaporative cooling, and are most effective when the relative humidity drops, typically mid-afternoon. The courtyard effect is achieved in between the building masses, at the canal walk and between building blocks, where shading is provided by the buildings and air movement is triggered by the stack effect.

In order to protect the space from uncomfortable wind conditions, planted trellises are used as wind breaks. High levels of planting and a green roof used reduces surface temperatures and offer shading.

Water features used intermittently and abundantly throughout the project provides relief from hardscape. Light coloured deep shaded pools help to lower the temperature of the water body. Sun protection is provided by building overhangs after a computer generated shading model

was studied. Drop down shades, temporary screens, awnings and trellis have been used to mitigate the sun.

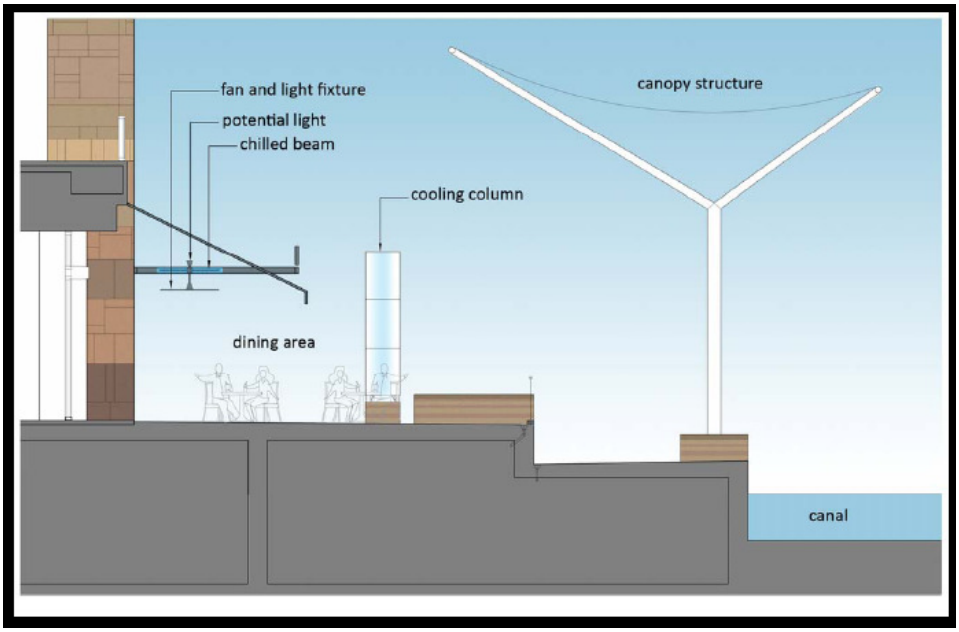


Figure 2: Cooling of the canal side

The external envelope consists of high performance insulating glass units with solar control tempered glass and ceramic fritting where required to reduce glare. External walls are of natural stone, ceramic tiles, terracotta tiles used to reduce energy losses. Most of the components can easily be recycled at the end of their design life for reutilization.

The analysis shows that sustainability was not a guiding factor during the planning stages neither was it not considered as one of the primary aims of the project, yet best practices were employed in all sectors of design which in itself incorporated sustainability elements. No benchmarks for green building design were set at the conceptual design stage, however a design in response to climatic conditions was a part of the design brief. Enhancing the comfort level of occupants and providing a comfortable pleasant outdoor and indoor ambience was a design need. This necessitated the need to consider the environmental impact while designing unlike typical Dubai buildings. A detailed climatic study with the movement of sun, temperatures, wind, the impact of the large creek water body and associated humidity factors were considered.

Creation of a controllable Microclimate is an effective strategy that can be implemented in Dubai. Passive techniques, inspired from vernacular local architecture should be implemented as being a low-tech, low maintenance sustainable design feature. Though not all aspects of green design are considered in this project a variety of design recommendations found in LEED design submittals are covered. The mall, currently operational since 2 years, is very popular with heavy footfall and high retail sales. The popularity of this recreational destination speaks in itself about the success of comfortable sustainable design conditions that the consultants have attempted to create and succeeded.

This case study demonstrates that the use of a rating system is not essential to ensure that sustainability factors are achieved. Responsible design along with an awareness of the deteriorating environment and concern for minimizing consumption is the need of the hour. The project inculcates basic design criteria for good responsible design with worldwide best practices being adhered to. Along with it are age old proved and recommended techniques of wind catching, courtyard effect, water body enhancement and passive shading elements infused into the design to suit the contemporary context of a modern shopping mall. The resultant is a user friendly, eco-friendly sustainable development which responds to its duty of environmental wellness.

DISCUSSION AND CONCLUSION

The case studies showcase that when we talk about green buildings, we are really talking about redesigning the design process – rethinking everything from the place to the schedule and pace of design.

Lessons learnt include that additional time and procedures need to be invested to formulate procedures and systems customized to individual site conditions. Thoughtful specification forms an important part of design development. It was also learnt that the Municipality procedures and infrastructure in place, like hazardous waste treatment facilities, an extensive TSE network to name a few, are very beneficial and aid the Green building design intent. The propagation and popularity of such projects will gradually tune the supply market too, for obtaining local and fair trade materials and stimulate the usage and market for green products and eventually successful green buildings.

Both the case studies highlighted the need for input from all members of the design and construction team. Building design requires the integration of many kinds of information. The construction industry is commonly characterized as technically and organizationally fragmented (Kaatz et al.2005 cites Egan,1998). This fragmentation is a key factor preventing a tangible transition to sustainable construction (Kaatz et al.2005 cites Sheath et al., 1996; Lee et al., 2000). In integrated design, process stakeholders are brought together at the earliest practical point in order to develop and execute a common project vision. These meetings create a communication space, where stakeholders work in close co-ordination and develop mutual understanding and trust. Integrated design clarifies client goals, design options and solutions, which allows for achieving the intended building performance.

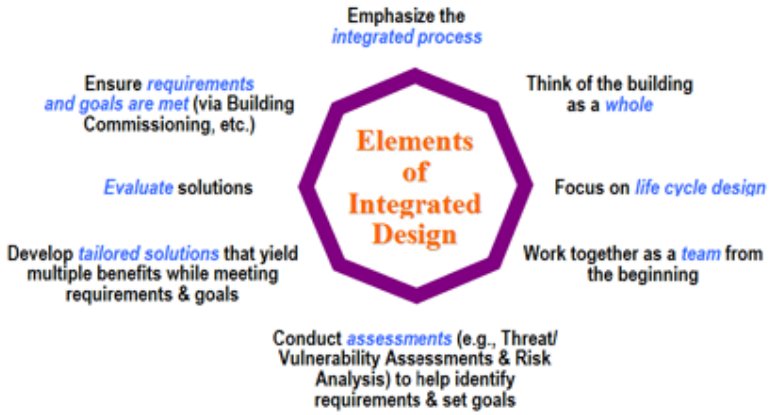


Figure 3: Elements of an Integrated Design (WBDG Aesthetics Subcommittee, 2009)

Good buildings result from an appreciation by all involved of the importance of formal consistency throughout the design. Every successful mission, in any field of work, relates to the consistent sincere commitment of all members of a team towards an integrated goal. The same holds true for our buildings.

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A SPATIOTEMPORAL PERSPECTIVE ON EMPOWERMENT IN PROJECTS

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ABSTRACT
The complex and dynamic nature of project environments presents both opportunities and challenges for the empowerment of individuals and teams. Yet, empowerment is a complex concept in its own right, taking on multiple forms across people, is contextually embedded and shifts over time. As research on empowerment in projects continues to grow, pertinent questions are emerging aimed at promoting the growth of empowerment theory and its applicability in practice. For example, how do organizations empower employees at different levels and still be able to achieve goal congruence across the organization?; how does empowerment manifest itself across project phases?; and how does empowerment manifest across co-located or geographically/physically spaced individuals on the same or different projects/teams across the same organization? The multiplicity and dynamism of empowerment in projects across three aspects - space, time and levels, and their intersections are examined within the context of the complex, dynamic and uncertain operational realities of projects. It is argued that such a spatiotemporal agenda is better understood through the lens of chaos and complexity theory, a perspective that reveals the way in which empowerment is intertwined with other managerial interventions and business strategies for the successful delivery of projects.

Keywords: chaos theory; complexity theory; empowerment; spatiotemporal

INTRODUCTION

The nature of work is changing rapidly and the impact is evident across all levels of business organisations (Conger 1988, Gray 2003). The change is altering the tempo of the environment within which construction organisations operate, compounded by emerging project delivery arrangements, increasing complexity of projects and client requirements and the temporary multi-organisational context of projects. Construction professionals are facing constantly changing organisational procedures, processes and requirements associated with increasingly demanding and ambiguous objectives of projects (Kűsel et al., 2001). This complex and dynamic situation has been described by Rowlinson and Mcdermott (1999) as one that makes the "control and command paradigm of project management inefficient" and requires resolving the emergent ambiguity through the construction of shared consensus of the project objectives. Complex and dynamic work settings such as in construction project environments have long been viewed as appropriately suited for the empowerment of individuals and teams (c.f. Kanter, 1977, Greasley *et al.*, 2005, Langfred, 2000, Loosemore *et al.*, 2003).

Empowerment has emerged as a popular concept in managerial rhetoric and the focus of numerous scholarly studies. Many of these suggest that empowerment practices are likely to offer substantial impact in many organisational contexts, including enhanced organisational agility and greater employee satisfaction (Chebat & Collias 2000). Nevertheless, despite its popularity, empowerment is still a term that confuses as much as it inspires (Simon, 1990). A review of the literature reveals little shared understanding of the term. Lincoln et al. (2002) describe it as a floating concept which means different things in different organisations, and to different organisational actors. Both management and employees interpret empowerment from their own perspective to suit their own needs and accordingly, have differing expectations.

This seemingly confusing view is compounded by the bolting of empowerment onto other managerial interventions such as total quality management (TQM), reengineering, lean concepts and just-in-time (JIT) aimed at improving the delivery of construction projects for example (Dainty, Bryman & Price, 2002). The pervasive process fragmentation and the mutual interdependence of interfunctional teams within the project delivery process, however, make it difficult to understand how empowerment intertwines with these organisational strategies. The complex and dynamic nature of the project environment therefore presents both opportunities and challenges for the empowerment of individuals and teams. Not least, its own complex nature, taking on multiple forms across people, levels, is contextually embedded and shifts over time (Tuuli and Rowlinson 2010; Foster-Fishman et al, 1998). This paper presents this spatiotemporal perspective on empowerment within the context of the complex, dynamic and uncertain operational realities of projects. It argues that the spatiotemporal nature of empowerment can be better understood through the lens of chaos and complexity theory, a perspective that better illuminates the way in which empowerment is intertwined with other managerial interventions and business strategies for the successful delivery of projects.

THE EMPOWERMENT CONCEPT

The empowerment concept is elastic and so it is not always clear what it means in different organisations (Dainty et al., 2002). It is also a contested concept whose meaning shifts

according to the interests and goals of those who use it. The concern however, is that, much of the literature on empowerment is both generalised and unitarised in orientation without cognisance to its multiplicity and dynamism (Foster-Fishman et al., 1998). McIntyre (1986) notes that, the way in which empowerment is conceptualised will influence the way in which strategies are developed for structural changes. This is because, different understandings of empowerment will shape the way in which we construct models of empowerment. Thus, actions considered empowering by an employee, may be experienced by management as stifling and vice versa (Pease, 2002). Solas (1996) has argued that some of the key assumptions, goals and practices of empowerment can actually perpetuate hierarchical power relation between employees and senior management. Those on top of the hierarchy are viewed as the ones who have the power to be given to employees below the organisational ladder.

Whether an empowerment strategy is successful or not is dependent on the organisational context and the mode of its implementation (Conger and Kanungo, 1988). Most of the management literature refers to empowerment from two distinct perspectives; the psychological perspective and the structural phenomenon (Spreitzer 1995; Thomas & Velthouse 1990). The former focuses on a psychological state encompassing the individual job incumbent‟ perception of a) meaningfulness, b) competence, c) self-determination, and d) impact (Conger & Kanongo, 1988; Spreitzer 1995). The structural perspective refers to empowerment as managerial initiated phenomenon. This perspective focuses on a set of organisational policies and practices initiated by management with a goal of addressing conditions that foster powerlessness and cascading decision-making authority down the organisational hierarchy (Conger & Kanongo, 1988; Eylon & Bamberger 2000).

An incomplete picture of the empowerment journey is presented when psychological and structural perspectives are considered as separate constructs, a perspective that ignores their complementarity as a case for integration (Tuuli and Rowlinson 2007). The empowerment process is therefore better conceived as an interactional process in which the perception of empowerment (psychological empowerment) is shaped through interaction with environmental factors (structural perspective), producing behavioural outcomes. Thus changes within the work environment perceived as empowering should influence and reinforce the cognitive state of employees and eventually affect outcomes and provide justification for continual reinforcement of organisational practices (Tuuli and Rowlinson 2007). However, there is a paradox that lies beneath the implementation processes. The very existence of circumstances that place the organisation or more precisely senior management in a position to provide another group with discretion to do their jobs well, through structural/managerial interventions implies that empowerment is a finite commodity controlled by a sub-set within the organisation (e.g., Eylon, 1998)

Examining empowerment from the psychological and structural perspectives alone, however, belies the complex and multiple forms empowerment manifests across people, levels, its contextual embeddedness and its shifting forms over time (Tuuli and Rowlinson 2010; Foster-Fishman et al, 1998). In the sections that follow we examine this spatiotemporal nature of empowerment with reference to the project context and allude to the paradoxical tendencies in empowerment implementation.

SPACIOTEMPORAL NATURE OF EMPOWERMENT IN PROJECTS

An important feature of projects is that each exhibits a unique lifecycle that defines its complexity and dynamic characteristics. These could relate to its site-specific nature, design and custom-built to unique specification, constant refinement of project outcome to meet emerging clients‟ needs. This dynamism is compounded by the use of specialised teams (Cherns & Bryant, 1984) that are usually geographically distant and functionally disparate (Murray, et al., 1999, Eccles, 1981) who convene as a temporary multi-organisation to complete the project (Cherns & Bryant, 1984). As each project organisation is temporary, there is no innate drive to build long-term relationships. Winch (2000) posits that the multi-organisation nature of projects creates an organisational dynamism, which can easily generate conflict rather than cooperation within the project coalition. The transient nature of construction projects and the temporary requirement of the project team make it difficult to develop the trust and the cohesiveness required for effective teamwork. Such dynamism significantly impacts employee‟s empowerment experiences. In project context therefore, the preeminent question that arises is: How does empowerment manifests across co-located or geographically/physically spaced individuals on the same or different projects/teams across the same organisation and throughout the project phases?

Contextual Dynamics of Empowerment

As a contextually determined construct, empowerment is particularly prone to fluctuations over time within the project environment (Foster-Fishman, 1998). Individuals‟ perception of their changing environment and shifting organisational demands highlight the elements of the contextual dynamism that are most salient to their empowerment experience. Koberg *et al.* (1999) posit that perceived empowerment is a process that expands an individual‟s power as opposed to merely a state of being and as such, it takes place in varying degrees throughout an organisation, with individuals experiencing different feelings of empowerment at different times. Hence, feelings of empowerment are not fixed. Depending on the organization and leadership‟s continued support, trust and value systems, empowerment levels will change. This dynamism may diminish significantly the efficacy of an intervention created from an understanding of the context and its members that is based on one point in time (Moos, 1996). Thus intervention plans should include ongoing measurement of the context, in order to assure a continuing alignment between contextual influences, participant needs, and intervention goals (Foster-Fishman et a., 1998). Understanding the dynamism of empowerment in project settings demands a theoretical position which illuminates the complex and interwoven set of perspectives and decisions which characterise the project environment.

Within a given project team, empowerment will take on multiple forms dependent on individual‟s sociocultural and political context and the internal climate of the project environment (Foster-Fishman et al., 1998). Empowerment has different meanings and different factors influence the employee empowerment experiences. Within a given project team, individual members will have unique personal histories, assume different roles and often come from different social background (Martin, 1992). It has been argued that these social and historical characteristics shape individual desire for empowerment (Zimmerman, 1995). Collins (1986) also emphasised that individuals with different racial, gender, ethnic, class, and social backgrounds will desire different forms of empowerment. Culture also

influences one‟s desire for empowerment. Every culture has a consistent core set of rules that influences people to act similarly in ways that help them understand each other. Family emphasis, individual preferences and other factors influence how deeply embedded one is in one‟s culture (King, 1994). If the internal climate of the project team is not in alignment with the individual‟s cultural influence and belief system, his behaviour and attitude towards his work will be impacted. Factors emanating from the individual, team, organisation and project contexts have therefore been found to exert significant influences on the empowerment experiences of individuals and teams (Tuuli, 2009). Without a supportive structure and an enabling context, any attempt to reinforce empowerment will be blocked, either by structural reasons or lack of support at both inter and intra personal levels. Thus, to overcome the empowerment paradox, that is, to achieve genuine empowerment, the organisation must constantly seek and be adaptive to contextual influences different levels.

Empowerment at Different Levels

Empowerment is relevant at the individual, team, and strategic levels. The capacity to organise and mobilise ideas to solve problems is a critical team level capability. The norms and network that enable collective action drives the project forward. There is a reciprocal relationship between individual capabilities and the capability to act collectively as a team (PREM World Bank, 2002). In a strategic context, organisational policies and culture shape the actions of all other actors within the organisation. There has been interest in the development of a conceptual framework, which explores the relationships among different levels of empowerment; how participation in organisations or communities concern can enhance individual empowerment and vice versa (Gutierrez, 1988). Different conceptualisations of empowerment have ranged from empowerment at the individual level as an increased sense of control, power, or personal life events (Schulz, et al 1993), to individual and teamwork performance behaviours (Tuuli & Rowlinson 2009), or multiple levels of interactions as individuals, organisations and communities act to create social change (Wallerstein, 1992). Examination of the empowerment process, which incorporates individuals, project, and strategic levels of analysis, will represent a more holistic picture of how empowerment manifests.

Perceived control at the individual level has been explored in research on self-efficacy (Bandura, 1982), and the ability to take action or improve interaction skills (Pinderhughes, 1985). Bandura‟s (1982) conception of self-efficacy involves beliefs about one‟s ability to produce and regulate events in life. Perceptions of influence or efficacy are explicitly linked with participation in organisational or team change efforts and the concurrent development of analytical and practical skills (Zimmerman, 1990). At the team level, empowerment involves the shared experience, analysis and influence of group on their own effort (Presby, et al 1990). Linkages between empowerment at the individual level and at team and strategic levels are made by linking development of personal power and ability to act to opportunities for support and development of interpersonal and required skills (Kieffer, 1984). At the strategic level, empowerment revolves around the utilisation of resources and strategies to enhance organisational control (Labonte, 1989).

Empowerment manifests at the strategic level when organisations provide opportunities for individual growth and access to decision-making process (Schulz, et al 1993). However, a levels perspective of empowerment raises the question of how organisations can empower employees at different levels and still be able to achieve goal congruence across the organisation. Empowering organisations are cooperatively controlled by their members and

work toward goals defined by those members within the parameters of external opportunities and constraints (Crowfoot, 1981). Individuals may develop skills and a sense of personal effectiveness through participation and leadership opportunities within the organisation (Schulz, et al 1993). The conception of strategic empowerment helps to link the individual and the project levels of empowerment. Individuals work within cooperatively managed organisations and become empowered through the development of skills and the opportunities to participate in process of decision making and goal setting with other team members. In turn, the individuals empower the organisation to effectively work toward the project goals within the context of the strategic organisational environment and external influences. Thus, perceived influence at the strategic and team levels both shapes and is shaped by perceptions of individual control.

THE EMPOWERMENT PARADOX

At the core of the empowerment paradox however, is the belief that there is some clear demarcation between management and employees - between those who have and those who do not have power (Eylon, 1998). The contention here is that, whatever the good intentions of those who seek to empower others through the levels as discussed previously, those intentions will be translated into concrete practical initiatives which set limits and boundaries within which the empowered operates (Potter, 1994). This notion was emphasised by Simons (1995) when he contended that „management must exercise levers of control in a climate of empowerment to harness employees‟ creativity. Empowerment thus becomes senior management controlled initiatives. Yet, the use of such barriers restricts the supposed freedom which empowerment is meant to offer employees. This is consistence to Argris (1998) assertion that empowerment process only appears to give employees greater control, but in reality, it remains dominated and restricted by management. He therefore views empowerment as still mostly an illusion. It is the practical objective limits set by management that raises tensions between the perceptions and needs of management and are likely to be set against the perceptions and needs of the empowered (Conger & Kanungo, 1988). This is consistent with circumstances where empowerment represents a “moral hazard dilemma” for managers, as the success or failure of empowerment then depends on the ability of managers to reconcile the inherent loss of control that empowerment brings with the fundamental organisational need for goal congruence (Mills and Ungson, 2003).

In addition to the need of resolving this paradox, as long as some organisational members do not have full access to information, autonomy, or the trust to plan and carry out improvement, then the need for empowerment will perpetuate the organisational process. Empowerment requires the belief that all have the right to be active and interactive participants of the organisation. It is only when all view each other equally that true empowerment will occur. Only under these circumstances can individuals truly unveil their unique experiences and abilities to the organisation (Eylon, 1998). Not subscribing to this notion will result in limiting the sphere within which empowerment is pursued, thus creating a condition which defeats the empowerment process. The paradox surrounding empowerment contributes in making the construct more complex than often realised. As Conger & Kanungo (1988) and subsequently, Lincoln et al (2002) note, „the management literature on empowerment often lacks clarity, is overly simplistic and is riddled with ambiguity‟ as the concept is difficult to grapple with in practice. The spatiotemporal perspective on empowerment coupled with the paradox surrounding its implementation emphasis it‟s complex and dynamic characteristics

and in particular how its manifestations shift over time, across space and levels in projects. Such a perspective is better understood through a theoretical lens that affords explicit consideration of the multiplicity, complex and dynamic characteristics of empowerment. In the section that follow, the principles of chaos and complexity theory are introduced and portrayed as representing such a theoretical lens. The key elements of chaos and complexity theory are seen as providing an interpretive framework for understanding the nature of empowerment in projects as it enables us to explore the context that governs project dealings and interactions among project participants, and enables us to address those aspects of the complex nature of projects that cannot be captured by project management processes for planning, prediction and control.

CHAOS AND COMPLEXITY THEORY

Chaos and complexity theory first rose to prominence through Lorenz‟s work on weather patterns and spread to other physical systems (Gleick, 1987). Complexity theory on the other hand, advanced through its application in biology where the search for an explanation to the apparently escalating evolutionary complexity of living organisms has been sought (Smith, 2004). Another stimulus to the advancement of complexity theory has been through work on systems theory in organisation science. General systems theory proposes that the universe should be recognised as a vast, interconnected, and interdependent whole (Kielhofner, 1995), where a system refers to "any complex of elements which interact and together constitute a logical whole with a purpose or function" (Kielhofner, 1995, p. 9). Open systems allow the dynamic, self-organisation that is exhibited during interaction with the environment (Allport, 1968). An extension of this, dynamical systems theory, assumes that when sufficient energy is channeled into systems of complexity, new states of organisation can emerge spontaneously, arising from chaotic states (Haken, 1987). The common thread in chaos and complexity thinking revolves around the idea of interaction of elements in a system.

Chaos theory deals with simple, deterministic, nonlinear, dynamic systems, that are sensitive to initial conditions resulting in an unpredictable chaotic response to any minute initial differences or perturbation, whereas complexity theory focuses on complex, nonlinear systems. Complex systems respond to perturbation by self-organising into emergent forms that cannot be predicted from an understanding of its parts (Reitsma, 2001). The focus of chaos theory is on the manner in which simple systems give rise to very complicated unpredictable behaviour, while complexity theory focuses on how systems consisting of many elements can lead to well-organised and predictable behaviour (Bloom, 2000). Smith (2004) argues that chaos and complexity need to be considered in unison from an organisational perspective. They are perhaps best viewed as complementary notions, at least from a managerial perspective, because they both encourage thinking differently about the way systems and organisations operate (Smith 2004). The two terms represent the ends of the same conceptual continuum. From complex systems comes simple behaviours and from simple systems comes chaotic behaviours. The appeal of such a theoretical lens for understanding organisation concepts emerges from the ability to illuminate how order, structure, pattern, and novelty arise from extremely sophisticated, apparently chaotic systems and conversely, how complex behaviour and structure emerges from simple underlying rules (Cook-Davies et al., 2007).

Although the conceptual basis of complexity theory arose from work undertaken in physical systems science, and subsequently from systems theories that have developed from organisation science, it is typically assumed that its popularity amongst managers has improved as a consequence of uncertainty in the future of organisations (Smith 2004). Similarly, Tetenbaum (1998) contend that complexity theory is gaining momentum as management practice as the new world is full of unintended consequences and counterintuitive outcomes where the map to the future cannot be drawn in advance as we cannot know enough to set forth a meaningful vision or to plan productivity. Complexity theory provides a way to understand the unknowns and uncertainties associated with complex systems. The management of projects transpire in a complex environment (Bertelsen, 2004) thus the application of complexity theory to the understanding of empowerment in projects may enable the systematic considerations of the conditions that give rise to such complexity (Antoniadis et al., 2009). Understanding the nature of empowerment in projects will enable management to respond with a design of more efficient project delivery systems to improve the setting up, management style and decision making processes for the delivery of projects.

Generally, project management practice understands the project as an ordered, linear and therefore predictable phenomenon which can be organised, planned, and managed top down. The project is therefore often divided into constituent parts such as contracts, activities, work packages, etc and assembled more or less interdependently to achieve the whole without considering the dynamics of the surrounding (Wood and Ashton, 2009). The frequent failures to complete projects on time, on budget and on quality (Bertelsen, 2004) give rise to the thinking that the process may not be as predictable as it may look. Complexity theory advocates perceive projects in a different light to that of the mainstream views. Through the perspective of chaos and complexity theory, a project is a nonlinear, complex and dynamic process which has within itself the capacity to interact with its environment resulting in a whole that cannot be understood by analysing it constituent parts (Cook-Davies et al., 2007). This perspective therefore requires that project team members should not be encased in a machine-like working mode which emphasises control, order and predictability but rather be more engaged with the environment and processes to encourage learning, creativity and flexibility.

Complexity theory advocates challenge two main assumptions of mainstream project management researchers and practitioners. First, they question the image of a project, and its human practitioners, as a predictable system or machine, that is predictable by understanding its functioning parts. Secondly, they resist the notion that the project manager is an objective, or impartial, agent of understanding and control (Sage, Dainty & Brookes, 2011); Masterpasqua & Perna, 1997). Sage et al (2011) have outlined manifold reasons for challenging machanistic views. They point out that it encourages hopeful long-term planning over continuous reflection and group communication, it does not address and value the dynamic and unpredictable emergence of social interactions through which project decisions are made, this influences project outcomes, goals, ethics and politics, it assumes stability and predictability is the ideal state for organisation, which prevents project organisations from understanding and bringing about the required change. It also reduces people to predictable parts in a machine hence it impedes learning and flexibility (Sage et al 2011; Cook-Davies et al., 2007). We contend here that these bottlenecks similarly inhibit a better understanding of the multiple, dynamic and complex manifestation of empowerment in projects and that a chaos and complexity perspective provides a more profound alternative view.

UNDERSTANDING THE SPATIOTEMPORAL NATURE OF EMPOWERMENT THROUGH CHAOS AND COMPLEXITY THEORY

Scholars of organisational studies have often used metaphors and models to help describe and explain the complex social phenomena observed in organisations (Lamberg & Parvinen, 2003). The metaphors applied to understanding behaviours and organisational change have included those derived from complex sciences, including chaos complexity theory (Olson & Eoyongi, 2001). Given that the impact of empowerment affects behaviour in ways that may not be entirely predictable (Wilkinson, 1998), it is reasonable to suggest that metaphors and models applied to organizations may transfer to the study of empowerment in projects. Complexity theory is negotiated and open to varied interpretation, which presents a wide range of possibilities in exploring its implications on social phenomena such as the project environment. Empowerment is seen here as a complex and iterative process, which can change, grow or diminish based on unfolding events; individuals and projects historical/social contexts, and organisational processes. It is not controlled or predictable in its outcomes. Eylon (1998) posits that empowerment is an ongoing development and will have lasting repercussion for organisational structure. Her argument suggests that organisational structure will need to evolve as empowerment initiatives are implemented. Organisational interventions are by their nature complex, dynamic and comprehensive. Interventions, which comprise simultaneously many target populations at various levels (individual, team and strategic), are complex to evaluate and comprehend. Chaos and complexity theory may provide a lens for understanding the complex and dynamic nature of empowerment in projects.

Empowerment in projects is dynamic as a consequence of the dynamic nature of project environments; a shift in internal and external factors impact on organisational processes and outcomes. People‟s perception of their work environment changes inline with the dynamic state of the organisation and external influences. Chaos and complexity theory recognises this dynamism and can help explain why empowerment feelings can be on a constant shift based on unfolding events as opposed to a state of being. Such a view is also consistent with the post-modern self perspective, whose basis can be found in chaos and complexity theory (Bloom 2000). In contrast to the modern man who could objectively discover the machine-like workings of the universe, the post-modern self is an open system, dependent on context, always in a state of becoming, actively integrating new information and exchanging that information with a changing environment (Masterpasqua & Perna, 1997). According to Smith (2004) the need for non-reductionist ways of approaching management problems has set the scene for complexity theory to be considered as management tool. The mechanistic approach of reducing all systems to their constituent parts is inadequate to allow managers to deal with the changing environment (Keene 2000). To keep with the flow, workers are required to adapt to environmental changes. Thus, empowerment interventions become processes for aligning individual needs with current environmental and organisational conditions. The output of empowerment initiatives can therefore not be controlled or predicted. In chaos, this can be likened to “sensitive dependence on initial condition”, expressing an understanding that even minute differences in input can quickly manifest as an overwhelming difference in output (Bloom, 2000). The implication for project organisation is that providing teams with necessary skills and training or the adoption of seemingly minor technology or software that could enhance job performance can have a substantial impact on project outcomes. Murphy (1996) suggests that this principle defines the very nature of nonlinearity in that, minute change in some system‟s initial conditions may actually amplify exponentially as their effects unfold so the end result bears little resemblance to the beginning.

There is a reciprocal relationship between empowerment at different levels (individual level, team level and strategic level). Chaos theorists hold the view that the proper role for organisations is to be a safe container for the chaos of individuals‟ experience, alternating between provoking enough anxiety to propel the person or team into the vortex of change while soothing anxiety that is threatening to overwhelm the system forcing it into regressive solutions (Bloom 2000). An organisation that encourages such type of empowering process is referred to in chaos theory as fractal organisation, one that trusts in natural organisational phenomena to order itself. McClure (1998), postulates that there is a process of chaotic transformation that can occur in a team if there is effective group leadership that does not seek to control and limit the group transit through the period of conflict and chaos. He sees groups that become regressive and even disruptive as those that have been unable to evolve and develop, to self organise out of the chaotic transition in a healthy way. Change is encouraged when organisational design is there only to gently direct informal behaviour toward goals. From a chaos and complexity perspective therefore, the development or implementation of empowerment accounts for the dynamic interaction and influence of empowerment at the individual, team and strategic levels.

At the strategic level, empowerment revolves around the provision of organisational resources and opportunities for individual and team support and growth. At the team level, empowerment manifests when those supports enable the teams to achieve the assigned projects goals within the context of organisational and external influences. By allowing members of the team within the organisation autonomy, this encourages the team to organise itself into emergent state, enacting multiple iterations of its own functioning until the various pieces of the team members can work together most effectively. Emergence is a characteristic of a complex system arising through the innovation and learning that occurs as the internal structures of systems evolves and changes (Mason, 2001). Under the right circumstances these emergent behaviours can lead to unpredictable innovations (Stacey, 2003). The emergent order represents a „bottom up‟ process arising when the collective behaviour of interactive individuals results in a system or part of a system adapting and creating new ordered state (Stacey, 2003). The implication is that the key strategic empowerment level will shift from maintaining control to supporting the emergence of new order where emergent innovations can react to market changes.

Individual perception of empowerment experience could take multiple forms dependent on demographic characteristics and social opportunities. Cultural values may highlight the fluctuation in the meaning of empowerment dimensions across peoples. Empowerment strategies that work well in the western world may not be valid in other cultures. Project teams could be bound by common objectives but difficult to capture the wholeness of the external influences that play on an individual‟s cognitive motive. Chaos theory holds the view that, systems operate in highly complex and instable manner, but a „strange attractor‟ which is an element of a complex system creates an order within chaos; it bounds the behaviour of the system (Thietart and Forgues, 1995). Strategic planning can thus be focused on a limited number of scenarios defined by the system‟s attractors (Levy, 1994). This encourages organisations to concentrate on the significant issues within the project team, which need to be handled in the short-term, and ensure that the debate about their long-term consequences is lively and engaged. Thietart & Forgues (1995) describe strange attractors within organisations as „organisational configurations which demonstrate regularities in their macro-characteristics even though they may reveal large differences in their internal process. Strange attractors are not steady state, but temporary patterns of behaviour that may be changed at any time (McBride, 2005). This therefore informs us that empowerment

interventions may be defined to acknowledge the contexts that impinge upon the short-term projects goals but not to focus on the entirety of the environmental influences. This will ensure more pragmatic balance between present concerns and future potentialities (Stacey, 1996). Empowerment decisions and factors both internally and externally may shift the project team focus out of stability and move the behaviour to a new strange attractor within a new outcome basin, the state to which a complex system is attracted after interactive process has taken place amongst the actors in the system (c.f. Young, 1997). Interpretive use of chaos theory as metaphor for exploring the multiple dimension of empowerment in project will involve recognising general patterns and looking for shifts between semi-stable attractors and exploring reasons for those shifts. Strange attractors enshrine „temporary stabilities in a sea of change" (Chia, 1998). The focus here is on this sea of change and the shifts that occur between strange attractors and its impact on the project.

The transition of complexity theory from the natural world to the world of management is still comparatively nascent and, although comparatively slow to gain widespread acceptance as a valid management perspective, it has increasingly attracted a number of followers despite remaining clouded in misunderstanding (Stacey, 1996). For converts, it is lauded as the next radical management paradigm for business developments (Lynch & Kordis, 1988). For others however, the popularity of complexity theory as an organisational tool is guarded at best (Merry, 1995). They argue that few examples exist of organisations, which have directly benefited from a practical form of the theory. This ongoing discourse seeks to take a more critical perspective toward chaos and complexity theory. An attempt has been made here to explain the philosophy, unveil the common metaphors employed by chaos and complexity writers, assess its unique application or new contribution to the understanding of project environment and ultimately enable a more critical assessment of the spaciotemporal manifestation of empowerment in projects. It will seem from the review of the literature that, chaos and complexity theory does offer the potential to better understanding the intertwine nature of empowerment in relation to managerial strategies. Mobilising such a perspective may help advance the study of the complex and dynamic manifestation of empowerment in projects.

CONCLUSION

Empowerment is an elastic concept that takes on multiple forms across people, levels, is contextually embedded and shifts over time. The construction process is also more complex than project management often envisage as the perceived ordered, linear view of project behaviour, reflected in the underlying project planning, management and delivery processes can be misleading. From the examination of the behaviour of complex systems, this is not the way the world operates. For example, even small uncertainties in the prerequisites add up to a significant uncertainty on the project"s workflow as a whole. Yet, as Olsson (2006) found, rather paradoxically, while flexibility is frequently needed in projects it is rarely prepared for.

Empowerment with its own complexity and dynamism however provides an opportunity to introduce flexibility and adaptive functionality that can enable individuals, teams and organisations to be more responsive to the complex and dynamic project environment. However, too often empowerment initiatives are smothered by organisational practices which discouraged collective participation. The tendency to think in terms of dichotomies, such as leaders and followers, superiors and subordinates or a rigid preoccupation with hierarchy

rather than function inhibit the recognition, development and utilisation of full human potential within the project organisation. When boundaries to involvement are defined by management, empowerment then appears merely as rhetoric and the centralisation of power and control as the reality (Sewell & Wilkinson, 1992). Thus, the removal of structural impediments to the full participation of the employees is at the core of resolving the empowerment paradox. Organisations which stop short of inviting full and equal interaction are not truly empowering.

As Eylon (1998) notes, „if an empowerment programme is executed without all those affected being included in its development, there is little chance that it will be successful". Understanding the nature of the interaction among empowered project actors in the context of chaos and complexity theory is illuminating as it affords sense making of how different actors respond to, and cope with, the complex nature and dynamic character of project settings. This opens up several avenues for new ideas on how to improve project management. For example, based on the way projects are organised, planned, managed and delivered, the discussion here will suggest that the understanding of the dynamics of project settings is still incomplete. Future research may therefore benefit from a much more critical perspective from the viewpoint of chaos and complexity theory of organisational interventions such as empowerment as a way of getting a deeper insight into the world of project organisations.

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'EXEMPLARY URBAN PRACTITIONERS'. PROFESSIONALS WHO MAKE THE DIFFERENCE IN URBAN RENEWAL

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Abstract
In our research, a joint project with Tilburg University and commissioned by NICIS, a scientific knowledge centre for the Dutch cities, our aim was to investigate the qualities of selected practitioners in their working context, namely deprived urban districts.
Our research will connect both in method (observation, interview and text analysis) as in chosen perspective (daily and intersubjective interactions in institutional settings) to two current and lively debates in mainly British and American research on urban policy.
The first one deals with the emergence of new forms of institutional arrangements (governance) and neo-liberal strategies of urban policy. The second debate is on the use of a social constructionist paradigm in 'housing studies'. In this debate urban renewal is not seen as a neutral and value-free domain, but as an expression and result of political influence and power strategies. Professionals and residents working in community organizations (proto-professionals) try to find ways to express their personal ambitions and qualities and to shape the space around them.
In our paper we give a theoretical description of this 'new (proto-) professional' and illustrate this practice with empirical case studies of 3 of these (proto-) professionals working in deprived districts in The Hague, The Netherlands. What they have in common is their attention to everyday life (in deprived urban districts) and a holistic problem orientation. They take part in relevant governance processes of policy making, but are not detained by the systematic and logic of their organization or by bureaucratic rationality. In the actual policy of neighborhood renewal this 'exemplary urban practitioner' gets/takes a new, integrated task to solve complex problems bottom up, and finds challenges in the everyday life in urban communities.

Introduction

In urban disadvantaged neighborhoods, it is not always the standard procedure that gets things done. In the Netherlands decades of urban renewal in its various forms have not solved problems permanently. This does not mean that success is never attained. What seems to have helped in some cases is the presence of a type of practitioner who goes beyond standard procedure. These are people who do not to give up and who are able to succeed where others have failed. Most likely these are experienced practitioners who learned how to cope. Most likely these are actors who inspire others. In the Public Administration literature and the literature of related disciplines we find examples of such exemplary urban practitioners (Van Hulst, et al, 2009). In this research we are looking for people who seem to be successful in pursuing the social goals they set

together with their partners[1]. What we ask is how these practitioners in urban districts do their job in controversial, politically sensitive policy processes that might develop in unintended and surprising ways. In other words we ask as a central question: *'Through what ways of working and relating do exemplary urban practitioner (try to) get things done?'*
The (proto-) professionals we call *exemplary* are not always taking the common routes to realize their goals. They will not automatic follow the routines of problem solving and because of that they can make a difference. They are critical about 'main stream' practices and try to find solutions starting from the perspectives of citizens. When we talk about *'ways of working and relating'* we refer to the qualities these professionals put to use in the planning and decision making processes of urban renewal. It has to do with personal qualities like attitude and experience, but also with strategic skills such as networking with policy partners. '*Getting things done'* will mean solving problems or better stated exploiting opportunities. More broadly is their aim to transform what is called 'urban problem districts' into 'livable neighborhoods'.

Opening the black box of urban renewal

The context of practice is the Dutch urban renewal in deprived neighborhoods; the working place of the exemplary urban practitioners. Urban renewal is no longer merely large-scale demolition and new construction. In policy circles urban renewal is seen as a profound form of comprehensive social, physical and economic renewal. This broad-based policy intervention includes both physical interventions in the housing stock and living environment as well as measures and activities to improve the social, cultural and economic conditions in deprived areas. Vulnerable situations should be adjusted in such a way that residents have more opportunities for social integration or even social mobility. This means that professionals who are involved in urban renewal come from several areas: local government, housing corporations, residents, police, education, health, welfare, art and media. It has long seemed self-evident to see urban renewal as a process of rational planning led by one dominant and controlling party, the (local) government. Urban renewal is then seen as a linear development process in successive stages over time, or viewed at the least as an attempt in this direction, in order to reduce structural uncertainties (knowledge, organizational and institutional) (See: Van der Pennen, 2005). But these uncertainties are also the reasons why urban renewal is termed complex, calling for a more flexible and context sensitive approach. If we regard the current developments in planning practices in the Netherlands, we can see that this leads to a more important role for citizens in decision making processes and that especially the social conditions of the citizens living in deprived districts, become increasingly central. So it can be stated that the relationships between practitioners and residents become crucial in urban renewal (Van der Pennen, 2010).

[1] The exemplary practitioners we studied are part of a research pool of 45 practitioners spread over 5 cities, which we observed in their daily routine and interviewed afterwards. For the selection a so called 'scouting' procedure was started in which an independent researcher tried to find 'exemplary' practitioners. Through recommendations and snowballing he found in each city a group of practitioners that were named by many for doing inspiring and exemplary work in urban renewal.

The exemplary urban practitioners seem to have a 'good' impact on complex policy problems, by working more bottom-up, bringing in social and citizen-focused orientations and experiences.

The exemplary urban practitioners are not driven by the logic of the institutional world, logic of rational planning in the time, to get a grip on the unexpected and uncertainties. They are driven by the logic of 'the everyday world', that is the notion that urbanity is a dynamic process that does not stop with planning urban space, with designing and realizing a building, a street, a square. Once realized there are the citizens who give their signature to the urban space, their expressions of their ways of life (Reijndorp & Reinders, 2010).

Research context

The theoretical origin of researching practitioners in public services can be found in the work of Michael Lipsky. Since the end of the 1960s Lipsky has researched the collective acts of public service agencies, resulting in his well-known book on street-level bureaucracy (Lipsky, 1980). Lipsky's focus was on the professional practice of street-level bureaucrats – e.g., police officers, teachers, social workers and judges- and on the way they (personally) experience their work. In general, street-level bureaucrats are motivated to serve the common good. Inspired by and in his line of thinking, other researchers came with new types of practitioners. Hulst, et al (2009) did a literature scan and distinguished characters like the Reflective Practitioner (Schön, 1983); the Deliberative Practitioner (Forester, 1999); the Everyday Maker (Bang & Sorensen, 1999; Bang, 2005) and the Everyday fixer (Hendriks & Tops, 2002; 2005).

The research question is connected to an assumption that is more and more heard in policy administration and in policy scientific debates. Effective neighborhood interventions would need a certain kind of professional. Several researchers have demonstrated the importance of such professionals as a result of increasing social and administrative complexity (Schön, 1983; Healey, 1992, Forester, 1999; Bosch & Van der Pennen, 2009). Like these other researchers, we are interested in their way of looking at the world around them, their problem definitions and aims, their qualities, the methods and strategies these 'new' professionals use in their practices / projects.

Talking of exemplary urban practitioners we think of individuals in various formal or informal positions (cf. Kingdon1984/1995:179).They might be working for the local government as a public manager, a policy maker or as a front-line worker. They might be working for a housing association, a community center or welfare organization. They might also be an active citizen working as volunteer. We think that the label of *exemplary urban practitioners* fits this category of individuals. We do not think that these practitioners do their work all by themselves. Nor do we believe in fairy tales of strong leaders who single-handedly dominate the discourse and fix problems once and for all. We think these practitioners are part of and work together with groups, teams and organizations. Moreover, the socio-political work of forming what has been called 'vital coalitions' (Hendriks & Tops, 2005) – that is, coalitions of people who are able to get things done and keep things going in and around urban districts - might be a central part of their practice. At the same time, we also believe that individual actors through their deliberative, reflective and/or credible acting can make important contributions to the way the collective tries

to deal with its problems. In sum, we believe that some individuals, alone or in collaboration with their partners, are able to positively influence the course of processes.

Qualities

What have these persons in common? If we add what we know about (working in) disadvantaged neighborhoods to what researchers like Schön (1983), Bang & Sørensen (1999), Forester (1993), Hendriks & Tops (2005) tell us, a first crucial conclusion is that practitioners working in this field are confronted with uncertainty and ambiguity. Reality does not fit the rules. These conditions are also the conditions in which many practitioners can make the difference. In other words, these situations potentially offer the possibility for 'making a difference'. Whether practitioners do exemplary work, however, depends on their (inter)personal qualities. Moreover, practitioners need a keen understanding of what is needed, taking into account that they will have to find out the specificities of problems and solutions every time they come into contact with new people, issues and situations. In other words, local knowledge (Yanow, 204) is needed to be able to connect the generic solution strategies of policy practices to problems experienced by residents in their everyday life world. Furthermore, we expect that in order to create these connections the practitioners have entrepreneurial ways of working; they have to start creating new solutions. This necessitates networking and management skills as well as a willingness to take initiatives. Lastly, these practitioners are no rookies. They are experienced practitioners. They have learned a craft and developed a 'repertoire' (Schön, 1983). On the other hand, even if experience has led practitioners to develop a repertoire, they maintain a receptive and involved attitude toward the changing life worlds of the people they work with and to which they respond. A particular part of practice where all these elements seem to come together is the way in which problems are approached. Problems are regarded as challenges, solving them is always on the mind of the practitioner. If that is not a simple short term opportunity, strategies are deployed that work on the long term.

Three examples of exemplary urban practitioners

Ahmed. A Coaching Resident

Ahmed, a resident of the neighborhood Transvaal in The Hague working as a tram driver, started eight years ago to organize activities to create a cleaner, more attractive street, with a group of local youngsters and mothers. In the beginning they mainly joined others' street activities, but in the time an active, independent organization "Jongeren4You(th)' had come into being. Today activities are organized by and for youngsters living in the neighborhood, who are mostly Moroccan. This old working class neighborhood has nowadays a relatively high share of young people (10 % more than is average in The Hague) and a large share non-western immigrant (80%). Ahmed wants to help and activate the youngsters, since boredom and lack of scope to develop one's talents are major problems for them. Activities range from sweeping the streets together, homework support, building a website, discussion groups for adolescents, supporting youths with their family problems, school internships and work, and celebrating new years' eve together on the streets. Many of these activities aim to connect the life worlds of Jongeren4You(th)'s members and that of other resident groups in the neighborhood. Ahmed shows young residents that it isn't strange or hard to make an effort for your neighborhood and

to take part in the world outside your social circle. Moreover, in his view, the neighborhoods' problems and the individual problems of the youths living here are connected. *"If things go wrong in this kind of neighborhood, a 'ghetto' atmosphere arises."* In this ghetto 'atmosphere' youngsters loose perspective on how they can take their lives in their own hands. On the other hand, loitering youngsters who misbehave in public space can be quite detrimental to public life in the neighborhood. He therefore strives to help the youngsters in many areas of their lives, and also work with them to improve the neighborhood. For this he cooperates with many organizations in and around the neighborhood.

Ahmed regards education as very important and sees a clear role for him to stimulate the youngsters. This can be very basic. Ahmed says that boys in the neighborhood often do not know what to do and where to go for certain things. *"They don't get a side job, they don't know the social procedures involved either. Shaking someone's hand, introducing yourself and things like that."* Part of his daily routines is walking the streets of the neighborhood. While visiting the streets and squares he has shorter and longer chats with older residents, but mainly with youngsters. Subjects can be anything, from fashion to the weather, but almost always education is a topic. Ahmed casually asks youngsters how they are doing in school. If there is a problem he listens and gives a word of advice. Interestingly, we overheard members of Jongeren4You(th) share educational success stories with each other. Also, youngsters use their educational assets for the club: one built a website, another uses his law degree to help Ahmed in his struggles with the municipality, a student of engineering gives homework support classes.

Even if youngsters help out with their capacities, Ahmed's qualities are still very much called upon. Ahmed guides and takes part in many activities and as the clubs president he is the contact person for other organizations in the neighborhood. Based on his acts we perceive a strong empathic attitude towards the youngsters. Besides his job as a tram driver, he spends a lot of time doing voluntary work to help and accompany youngsters. Listening and giving attention is crucial according to Ahmed. He told us: *"The power in our organization is attention. You have to have quite a bit of patience and an attentive ear. Listening to many stories."* At the same moment we see him practice this statement. He goes to Abdel who is in the office of their organization and wants to talk about his exams of that morning. But Ahmed is not only a listener, he is also very much a doer.

His walking around in the neighborhood is not a passive happening because he gives a helping hand to several events in the public domain. Anonymous public spots in Transvaal become familiar through his performance in the public domain. His encounters are short and fleeting with passersby and other residents but they are trustful in its kind (See: Sztompka, 1999). The comparison can be made with the theoretical concept of the public familiarity. (Milligram, 1977; Fisher, 1982; Soenen, 2006; Blokland, 2009;). Public familiarity stems from the repeated encounters of the same people in the public space through which we can more easily assess who we can trust and who not, which in turn can be related Jane Jacobs statement: " The trust for a city street is formed over time from many, many little public sidewalk contacts." Familiar places can also be meeting points for people with a common history. Places where they recognize a personalized treatment and feel them at ease and at home. Common trusted places make a sense of kinship between people possible. Based on this power of repetition is the quality of life and the social environment of an area served by various trusted sites for various mixes of user groups

across the area so the streets and squares, vibrant public spaces can be. (See: Van der Zwaard, 2010).

During a day of observation we saw Ahmed participating in a football tournament with the youngsters and a school class, climbing on the roof of the club house to catch a dog, walking the streets to see the neighborhoods' youngsters, and sitting in a square to hear from other parents what is going on in the neighborhood and watch the safety of the kids in the playground at the same time. His strategies are for the most part everyday actions together with others in the neighborhood. Many of them are solution oriented. During the activities with the youngsters he shows management skills. Ahmed, who knows how to take someone else's perspective, seems to enjoy it as well when his own efforts and the clubs successes are recognized. He enjoys praise and knows how to mobilize attention for the club. Apart from benefiting society, doing volunteering work can create its own rewards for the volunteer. It is nice to have a framework for your own talents and interests, which creates also respect for your efforts and ideas. As you will see tangible results of those efforts and ideas, the project can be a rewarding task and a vehicle for self-realization (Bosch, 2010). The role of 'active citizen' requires according to Wijdeven & Oude Vrielink (2008) a significant degree of organizational skills, perseverance, communication skills, bureaucratic skills and a personal network. Residents (groups) in whom these skills are well developed, are limited in problem areas. Since Ahmed, our practitioner, is operating in Transvaal, he is in any case for this aspect exemplary. Nevertheless, Ahmed does encounter problems with obtaining subsidies from local government, that sees the value of his organization but cannot make structural payments to volunteers because of its internal rules. Ahmed would like to see a more transparent discussion about how subsidies are distributed over the volunteering organization of the neighborhood but this is hard to achieve.

Hans. A Casting Cop

Hans is a police officer working in Escamp, more or less the southern quarter of The Hague. This part of the city was mainly built in the early post-war period. The now problematized walk-up apartment buildings where at that time part of a utopian vision on urban design. They were seen as the opportunity to create light, air and space in the living environment of every household; it was the expression of a new perspective of a post war generation. Today the residents of Escamp have on average a moderate income. Half of the population is of non-western descent; largest groups among these are Moroccans and Turks.
Escamp today is an environment that offers its residents possibilities for social mobility on the one hand, and social tensions on the other. The yearly bonfires around New Years' Eve are the public symbol of these social tensions. Ever since the nineteen fifties residents have organized bonfires, by setting fire to thrown out Christmas trees and other inflammables like cars and furniture they have collected in the streets. These bonfires are often moments of an urban conflict through fights among youths or between youths and the police. The escalations have earned political attention, and were explained through the decades by discussions that were part of the public debate at that time. In the eighties anti-social group behavior was the main explanation, in the nineties the focus was on the trend of individualization. In the last decade the ethnic diversity of the neighborhood is mirrored in the composition of the groups of youth having the bonfires, and today the New Years' Eve situation is connected to the debate on cultural integration. Following Leary (2004) the bonfire conflicts can be seen as 'critical moments' in which the

relations between groups are redefined. At critical moments an appropriate interventionist approach is of great importance.
Hans has developed the 'role models' project to address problems with youths in public space. According to him youths 'cooperate with professional partners to contribute their part to keeping the neighborhood clean, safe and free of vandalism. They are not police officers but stand together with police and youth workers on risk locations and speak to other youths if they misbehave. In this way they correct and direct the youths in the street so that little or no damage or nuisance will occur'. It is part of his strategy to go to youths that are threatening public order. *'This means that sometimes you have to drop by them, talk informally with them 'over a cup of coffee' etcetera. Also at night. They live at night'.* Hans' role models come from the mosque, the Morroccan cultural club, the football club, organizations that are formed along ethnic lines, but according to Hans they are people 'of flesh and blood', by saying this he means to put their ethnic background in perspective.
The disruption of public order in Escamp centers on youths. Hans sees results with his project: *'We have not had as much damage with New Years' Eve as other years. We almost had no car fires'.*
The youths in Hans' area do not only ask for attention around New Years' Eve. On several sites in the neighborhood there is trouble: they commit burglary, theft, muggings, arson, mischief, violence, drug dealing, intimidation, noise nuisance, fights, urinating in public etc.
Typical for the strategy is that the police call upon active citizens. Police and residents are put into action to correct known nuisance givers and to offer them alternatives for their behavior. In this way Hans also tries to attain a larger role for community police officers within the The Hague police force. With more and better community police officers citizens will get to know their police officer again, Hans claims. He characterizes his neighborhood based police work in this way: *"The police can act, but it always acts in ways of arresting people, fining people, or whatever is at hand (…) the only way in which it will work in the neighborhood is by doing it together. Let the police do its job, but in cooperation with you"*. 'You' is the neighborhood residents, which he addresses to make an effort for the neighborhood during a kick off meeting - we attended - for the role model project. *"Everyone is talking about that things are going wrong in this or that neighborhood. But the only one, who can change that, is you. That has to be understood. You are the one who will have a better neighborhood or will have a miserable neighborhood. The neighborhoods we now have are not miserable, but good. And that is because there are a lot of people living here that want it to be good."*
The way of intervening Hans promotes is known as the community police officer model. In this model the police are present in the neighborhood on a daily basis and keeps close contacts with the residents, entrepreneurs, shopkeepers, and teachers. It is not generic policy making, but 'fine tuning'; measures are taken at places and times when that is needed according to perception. This strategy to maintain safety in public space is not characterized by hiding behind shields, but by meeting potential threats openly, by listening and entering into conversation. *"No circumlocutions, but go straight to the matter. Just go and listen to what is the problem for once."*

Hans is given the freedom to do it in another way because of his personal qualities. He is an 'every day fixer' because of his focus on action in practice, his solution-oriented approach to occurring problems. But he also has the strategic ability to form appropriate working coalitions, which is typical for the figure of the 'deliberative practitioner' as known from scientific

literature. His project was not always understood and appreciated by his colleagues. He had to battle to get it through. But like a social entrepreneur Hans managed to put together his role model project. It is a 'police project' but it does not bear the dominant culture of that organization. Hans talks in this respect about three types of police professionals: "Managers, people who work with the police and cops'. He counts himself as someone from the last category, which is people with a certain professional passion, which means among other things that he cannot work 'nine to five'. He says about the other categories: *"They talk about the everyday reality of the street in abstract, in terms of rules and policy. They are remote from the people and speak a completely different language."* His role model project furthermore transfers an approach known in social work – where it has proved to be effective- to the domain of the police. This gives it a different angle. Hans is trespassing domain boundaries. Among many youths seeing the police as an institution of repression, the distrust is broken down. In trust, through confidants, these youths are approached.

Gerben. A Liaison Officer.

After working as a researcher of urban renewal for many years, Gerben took a job with housing corporation HaagWonen as a 'manager of social projects' for the Schilderswijk in The Hague. The corporation owns many of the dwellings in this large, deprived and dense central district (about 33.000 residents). Gerben is coordinator of the many social projects the housing corporation undertakes and / or is (co-) financer. In addition he is a member of the "Krachtwijkteam Schilderswijk', a project organization for realizing national policy goals in deprived urban districts. His activities centre on liveability issues and the emancipation of the residents and their participation in (the wider) society. Gerben stresses that it is important not to expand the great number of independent social projects even further; the problem of the so called 'merry-go-round of projects'. Many organizations take good intentioned initiatives, but are mostly realizing their own aims and don't know about the others. Knowing this, Gerben searches for connections and opportunities for cooperation between existing initiatives and organizations. This boils down to matching interests, needs and persons on many different levels. A clear example is his activities to support new resident participation processes. Here a large group of organizations works together to create more contemporary forms of resident participation consisting of more creative forms and more active involvement of residents. The Schilderswijk Communication bureau is an important project for him: it connects and strengthens existing forms of communication about what is going on in the district, made for and by its residents.

Gerben grounds his problem definition on the one hand in existing documents (the policy document 'The treaty of Schilderswijk' from 2007, which is the basis for the national governments' interventions in this district), as well as a independent study that investigated the possibilities for resident participation in Schilderswijk. This study is based on stakeholder interviews and ethnographic fieldwork in (semi-)public space, and concludes that the neighborhood is characterized by mono-ethnic communities living alongside but not with each other. Another conclusion is that Schilderswijk has a great number of resident (self)help- and participation initiatives, which show overlap, inefficiency and a lack of continuity.
The second starting point for Gerben's problem definition are his 'treks through the neighborhood'. Gerben: *"By listening well to the residents and professionals who put their shoulder to the wheel. In other words, by using the eyes and ears of concierges and people*

working in maintenance and mediation in the neighborhood. In this way you can connect to the needs and the possibilities and impossibilities of the neighborhood and its residents'.
The way Gerben formulated his problem definition seems to catch up with The front-line worker. A selection of quotes: "Implementation cannot be prepared in advance and from a distance" (…) "One has to be able to 'read' the situation" (…) "Every situation is different" (…) "One has to act in accordance with what the situation demands." (Tops & Hartman, 2003).

Gerben characterizes himself as a 'liaison officer'. In a more theoretical sense he can be typed as a boundary spanner (Steadman, 1992; Richter, et al, 2006). It's all about creating meaningful connections and this is the challenge and aim for a boundary spanner. Gerben explains that in many researches, advices and projects not enough connection is made between content and process. *"We know what we need to do and we write in memoranda that we will work demand-driven, area-based and integrated, but at the end of the day we go back to working in our old traditions and ways of working and thinking.* (…) *So in our thinking we should not so much start from a sector or organization, but start from the neighborhood and its residents."* In other words: connect to the life world of the neighborhood. Stop thinking activity-oriented and start thinking goal-oriented. For Schilderswijk this means to his opinion for instance that you have to deal with the Dutch culture of organizing official meetings in another way. Sending a letter to invite residents to a meeting will not yield many reactions in this neighborhood with a high rate of analphabetism. *"That seems logical, but nevertheless there are still a lot of organizations that offer their products in this way. (…) It also means looking for gains of working together, in stead of all working by ourselves. It is this mindset that has to change. That is a lot more difficult than just setting up a few new projects overnight."*

Gerbens strategy to connect organizations and people is, in his words, to seduce them. The descriptions he gives of his seductions make clear that it involves approaching other parties as equal to the corporation, and asking them to think and create ideas together, instead of forcing them into a structure. Gerben uses the words "looking together', 'thinking together', 'talking with our legs on the table', 'sticking post-its'. By giving other parties space, he tries to generate enthusiasm and corporation to eventually produce better, more efficient plans.

The Schilderswijk Communication Office which Gerben initiated is located in the neighborhood. *"That is more easily accessible for residents than city hall or the Haag Wonen office",* Gerben says. The office acts as a hub that connects small-scale but potentially very interesting resident initiatives about communication into a coherent whole that is usable for the whole district. There were already initiatives when the office started, but these needed a professional impulse and support. For example: *"(…) there was a paper called 'The Little Bridge', that wrote about a certain part of the neighborhood. These people wanted to grow bigger and they were interested in professionalizing. There also was a website HaagWonen had offered to residents but nobody was updating it. And then we said, ok, let's try and professionalize and expand that, together with the residents that are already involved. So use that existing power. Without doing new things, try to connect."* The office tries to reach all (ethnic) audiences in Schilderswijk through different media (text, sound, image, word of mouth). Additionally, these channels serve the many organization working in the neighborhood well. The office has many advantages, according to Gerben. First of all it works with the (initiatives of the) residents: In this way, from the start there is coherence in and support for the communication. It is close to home for the audience, it speaks

their language, it is reliable. Because for the main part they made it themselves. In addition the media reinforce one another, since they are made in the same place and are compatible. This creates synergy, effectiveness and efficiency. Lastly the communication office offers a future: it draws people out of their isolation and if needed educates them" according to Gerben. *"The office is close to our central thought: residents participate instead of consume. We give space to talent development and we strive for structural improvement and the structuring the jungle of existing projects."* This seems a thought that is not core-business to a housing corporation. Gerbens insistence on practicing cooperative and sector exceeding urban renewal, underlines his boundary spanning activities.

Conclusions

In this paper we have introduced the concept of the exemplary urban professional. They get their freedom in the policy network. They pick it up to realize their aims. Doing this by using their exemplary qualities. They are respected and seen by their governmental actors/colleagues and scientists analysts as a constructive and positive 'impulse' to get things done. In a literature scan we recognized qualities of these exemplary practitioners, we added to these and illustrated the practices of exemplary practitioners with three cases. Three projects in well known Dutch urban problem districts, in which they where involved and acted as such.

In the line of the literature scan we distinguished some relevant qualities for exemplary urban practitioners such as the solution oriented stance of the everyday fixers (Hendriks & Tops, 2005) and the aptitude for reflection of the deliberative practitioners (Forester, 1999). The three practitioners described here reflect on the role of the police (Hans), of the housing corporation and media (Gerben) and of volunteering organizations (Ahmed). However, they also have the entrepreneurial ways of working that involve looking for new opportunities and making connections a variety of people within and beyond the boundaries of the area in which they work. Often, we noticed, they have initiated their own projects. However, they are not entrepreneurs in managerial sense (Lowndes & Sullivan 2008). Being effective is just a part of what they are after. These practitioners are more likely driven by a wish to move society in a certain direction (Ahmed wants to prevent a ghetto atmosphere, Gerben wishes to connect citizens and stop the merry go round of projects, Hans wants to cooperate with residents to make the neighborhood as livable as the residents want it to be than by their professional standards or institutional rules of some sort. Their interest is not in keeping the system intact, they want to bend the system if needed. This is because they acknowledge that reality – the every day reality of citizens - does not perfectly fit the rules and policy traditions of problem solving. Our exemplary practitioners in the case see it as a challenge to make the difference and connect policy and interventions to the life worlds of citizens. Gerben in this vein stretches the professional domain of the housing cooperation, Hans tries to create more space for community police officers in his organization, Ahmed asks for transparency and professionalization in his own organization and in its relation with the local government. Furthermore, these exemplary professionals are more engaged with the life world of residents in need than most other practitioners. Their way of relating to the world is characterized by empathy, and frequent (everyday) social interactions with other professionals and residents are important to them. They 'talk over a cup of coffee' with youngsters creating nuisance in the neighborhood (Hans), visit them in the street on a daily basis (Ahmed) or talk to them 'with the legs on the table' in order to

find out about their interests and capacities (Gerben). It is mainly through these interactions that they gain local knowledge, which is essential to their work. Local knowledge is 'the very mundane, yet expert understanding of and practical reasoning about local conditions derived from lived experience' (Yanow, 2004: 12). The contact these practitioners have with people in and around the areas in which they work give them access to local knowledge and help them to develop their own local knowledge.
This translates in trying to understand the problems of the residents 'inside out', e.g. when investigating the challenge at hand they make an effort to take on the perspective of the residents they work with. In doing so they find out about the different problems a person has and the ways in which they are related, but also about this person's motivations and capacities. In the 'system' world of public help provision help is parceled over different professions and trajectories. In the 'life world' of residents problems and people are complex. By actively looking at the 'whole' problem owner, the (proto-) professionals are often brought to new, more integrated help strategies. We use the term holistic problem orientation to indicate practitioners' receptivity to the full extent of residents' problems and opportunities, and the willingness to bend the systematic of public services in such a way that they match these problems and opportunities. As a result, not only the exemplary (proto-) professionals problem orientation but also his or her interventionist actions can be seen as generalistic rather than specialized, they go outside of their domain and take on a variety of tasks ranging from watching over a kindergarten to creating a media centre. So, in order to deal with both uncertainty and complexity, our practitioners become creative. This creativity can involve matching rules with situations, but sometimes practitioners even need to cross institutional or professional rules and borders. In this sense, exemplary (proto-) professionals act as boundary spanners.

To sum up:

1. Their reality (problem definition and aims) does not fit the rules and regulations.
2. They move society in a certain direction than by professional standards or institutional rules of some sort.
3. They have a strong engagement with the life world of residents (empathic).
4. They gain local knowledge, which is essential to their work.
5. They have entrepreneurial ways of working.
6. Their context / orientation of handling can be labeled as 'every day urban world' versus the planned / institutional 'system' world.
7. In the 'system' world of public help provision help is parceled over different professions and trajectories. In the 'life world' of residents problems and people are complex. By actively looking at the 'whole' problem owner, the (proto-) professionals are often brought to new, more integrated help strategies.
8. They are generalists.
9. Their creativity can involve matching rules with situations, but sometimes practitioners even need to cross institutional or professional rules and borders. In this sense, exemplary (proto-) professionals act as boundary spanners.

Our list, however, is not intended as a full profile of an exemplary urban practitioner. Context of acting and qualities are different. Every situation, each district requires its own approach and therefore specific properties. "Good practice can never be bottled and applied somewhere else

like an ointment. There are no one-size-fits-all, magic solutions to complex social problems. The public sector is highly heterogeneous: entrepreneurial solutions will vary for different organizations, with different histories, cultures, users and political leadership" (Leadbeater & Goss, 1998: 22).

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HEURISTIC SOLUTION FOR RESOURCE SCHEDULING FOR REPETITIVE CONSTRUCTION PROJECTS

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Abstract
Construction project planning and control are core processes for building project management. In practice project time management is achieved by computer based techniques like Precedence Diagramming Method (PDM). Many researchers and practitioners claims that Networking techniques as such do not provide a suitable model for construction process, especially in repetitive projects. Construction process modeling, for repetitive projects in particular, should incorporate for specific features of resource flows through project activities. With the aim of improving resource scheduling with PDM, a heuristic algorithm for repetitive activity scheduling process is presented (REPNET), based on a precedence network plotted on a resource–space chart. The heuristics of REPNET are used to carry out resource timing in two phases: in the first phase as soon as possible project schedule is performed; in the second phase the REPNET algorithm search for resource scheduling optimization by minimization of resource idle time in repetitive activity performance. The work continuity constraint is relaxed in order to maintain the PDM minimum project duration. Optimized project schedule of case study is compared with original schedule and discussed.

Keywords: activity network, Precedence Diagramming Method, resource scheduling, repetitive construction, location based scheduling.

INTRODUCTION

Construction project planning, scheduling and control are core processes for building project management. The plan of a construction process should be a forecast of the best way to construct the building and to control the process itself. Thus a major objective of planning should be a tool by which to control the actual process (Birrel, 1980) to give feedback information in relation to the plan for the process. This can be done in an effective way mainly developing a realistic model of the construction process.
In practice project time management is achieved by computer based techniques like Precedence Diagramming Method (PDM). PDM is a network-based planning instrument where building processes are represented topologically by means of an activity network. Activity network is a time oriented building process model where resources are simply loaded to corresponding activities as an attribute or a label.

Networking techniques represent the state of the art of construction project planning and scheduling in most real life projects, but many researchers and practitioners claims that these techniques do not provide a suitable model for construction process, especially in repetitive projects. This is mainly because activity network is discrete while construction process is basically a continuous flow of working operation performed by specialized resources.
Many scheduling methods have been proposed in literature in order to improve repetitive construction project efficiency.

Literature overview

Building construction projects often include consirerable amount of repetitive activities that are carried out in a cyclic manner (start-operations-close) from one space unit to another one. Such efforts are called repetitive projects. In repetitive projects like high – rise building, housing, highway projects and pipeline constructions, resources are required to perform the work on similar activities in the various locations of the project. As a matter of fact construction crews move from one space unit (i.e. storey of the building) to another one in a sequence. This is manly because the building of a construction item performed by trade crews (i.e. floor concrete slab) can be divided into specific activities associated with particular units (i.e. floor concrete slab at each floor of a multi-storey building).
Repetitive construction projects can be classified according to the direction of sequence of work from one space unit to another one (Vanhoucke M. 2006). In horizontal repetitive projects the activities are performed horizontally e.g. highway or pipeline projects. These projects are also classified as continuous repetitive projects or linear projects due to the linear nature of the end product of the construction process. In vertical repetitive projects the repetitive activities are performed vertically e.g. multi-storey building or high – rise building. Discrete repetitive projects consists of a repetition of a unit network through the project, like floors of high – rise building, factory buildings of an industrial plant, housing projects. In continuous repetitive projects space is not discrete, like highways or pipeline networks (Yang and Ioannou 2001). Kang, Park and Lee (2001) argue that construction projects can consist of both horizontal and vertical repetitive processes among several multi-storey structures and classify this projects as multiple repetitive projects.
Basic instrument suggested by researchers and practitioners for the planning and scheduling of a repetitive projects are time / space diagrams, in which activities performed by resources are plotted as line or other geometrical shape on a time/space chart.
Researchers have proposed many scheduling methods, that can be classified as Line of Balance for Projects with discrete space units, and Linear Scheduling Method for continuous space projects. El-Rayes and Mosehli (1998) suggested that resource – driven scheduling accounts directly for crew work continuity and facilitate effective resource utilization. They suggested that resource – driven scheduling of repetitive activities requires the satisfaction of three constraint: precedence relationship, crew availability and crew work continuity. Basic concept of resource – driven scheduling of a repetitive project is to account for: a) numbers of crews to work simultaneously on different space units of repetitive activities; b) interruption of crew work continuity. Harris and Ioannou (1998) created the scheduling repetitive model that ensures continuous resource utilization with a flow view and a PDM view of the model. Arditi, Tokdemir and Suh (2001, 2002) integrated non – linear and discrete activities into LOB calculations and defined time and space interdependencies among activities as a base concept for repetitive project scheduling.
Kang (2001) observed that in a multiple repetitive construction project construction cost and duration are dependent on: number of work areas, proper crew grouping, size of work areas, frequency of repetition of each activity, and provided an heuristic approach to allow optimal

construction planning. Kenley and Seppänen (2009, 2010) observed that locations are important in construction because building can be seen as a discrete repetitive construction process, a series of physical locations in which work of variable type and quantity must be completed. They also observed that the location based methodology does not exclude Critical Path Method (CPM), in fact dependencies between activities in the various locations and between tasks that are made up of activities of the same work item are realized with CPM logic links. In general repetitive scheduling methods are more concerned with movement of resources through locations or places than with repetition of activities, so they introduced the Location-Based Management System (LBMS) which shifts the focus from individual discrete activities to managing the progress of repetitive activities as performed by crews moving through a building and completing all their work location by location.

Location Based Scheduling

A repetitive project is a multi–unit project where resources move through the various similar location of the project (e.g. multi – storey building, housing projects, highway projects), while a non-repetitive project is a building project that has a complex location breakdown structure and is mostly a set of one-off activities.

Construction process modeling, for repetitive projects in particular, needs a more detailed model regarding resource flows through project activities. Location Based Scheduling is a resource oriented construction process model. Location Based Scheduling produces schedule that achieve a continuous workflow by considering the relationship between the work to be done and the location of the work (Firat et al, 2010). In a repetitive construction project locations require the establishment of a hierarchical Location Breakdown Structure (LBS), where a higher level location logically includes all the lower level locations (Kenley and Seppanen, 2010).

In Location Based Scheduling working tasks, set of repetitive activities, are plotted on time / space chart using general principles of the Line of Balance (LOB). The essence of location based resource scheduling is the view of the movement of construction resources through the various project locations as a key to improve project performance.

Location Based Scheduling recognize that networking techniques like Precedence Diagramming Method does not well match the character of construction projects, which consists of large amounts of one site fabrication involving continuous or repetitive work. The character of a repetitive construction project can be defined as (Kenley and Seppanen, 2010):

- multiple working places;
- one site and continuous assembly of components;
- repetitive activities performed in different locations, but in which the amount or context changes;
- equally parallel and sequential paths;
- resource management is a flow-optimization problem, designed to achieve smooth flow and continuity in the use of resources.

So at least three basic item of construction project scheduling with precedence diagramming method must be implemented for repetitive project scheduling: resource – driven scheduling, work area or space definition and resource flow tracking. In the resource driven scheduling process resources must be committed on a specific range of time for one job, assuring maximum efficiency of committed resources. In fact any task or activity requires a specific work space, termed “Space demand” for its execution. This space demand is based on the space requirements of each resource allocated to the activity. If the required space becomes limited or unavailable, the activity or task can not be executed or performed with the required

productivity rate. Often critical path method ignore requirements of activities for work space or work area for specialized resources (Thabet W. Y., Beliveau Y. J. 1994).
Birrell (1980) highlighted that basically construction process is a set of construction operations performed by specialized resources who moves through the various locations of the project. Starting from the building to be done basic concept is to define the sequence of trades on every construction item, and to set the route of the work crews that will be moving through the various project locations or space units. Buffer space or time are needed to prevent crews from interfering. Once the first crew has started, the following crews will be added in the same sequence. This creates a flow of crews or a trade parade (Tommelein, Riley and Howell, 1999) moving through the space units of the project.
In summary, construction site space is an important concept and viewpoint for understanding characteristics of repetitive construction projects. The earlier research has covered already several important methodological characteristics of construction planning and scheduling with the site space on focus. Although not covered explicitly here some research has covered also computerized assistance for the generation of alternative plans and schedules – for example (Kahkonen, 1994; Märki et al, 2007). The research to be presented in the following chapters is also targeting to produce such a solution that would incorporate characteristics of repetitive construction operations and to present this together with computerized assistant that would enable efficient high quality scheduling.

REPETITIVE NETWORKING TECHNIQUE (REPNET): BASIC PRINCIPLES

With the aim of improving resource scheduling in repetitive construction projects with Precedence Diagramming Method, an heuristic algorithm for repetitive activity scheduling process called REPNET is presented, based on a precedence network plotted on a resource–space chart (Bragadin, 2010). In repetitive-unit projects it is important that repetitive activities are planned in such a way as to enable timely movement of crews from one repetitive unit to the next, avoiding crew idle time. This is known as the "work continuity constraint" and its application during project planning can provide an effective resource utilization strategy that can lead to: maximization of the benefits from the learning curve effect for each crew; minimization of idle time of each crew; minimization of the off-on movement of crews on a project once work as begun.

Resource-flow tracking

A Precedence Diagram Network of the repetitive project is plotted on a resource – space chart, with the x-axis representing resources and the y – axis representing space units of the project. So the network node representing the activity is identified by two coordinates: the main resource performing the activity and the work space in which the activity is to be performed. The procedure of plotting the network on a resource – space coordinates has been used by many researchers in the past. In particular Yi, Lee and Choi (2002) presented an heuristic method for network construction and development for repetitive units project, with the aim of minimizing total project duration by reducing idle time of resources and spaces. Actually the heuristic changes the sequence with which crews complete the scope of work encompassed in each repetitive activity. About this procedure Moselhi and Hassanein (2004) observed that this approach and general formulation has been applied in earlier and more accurate models (e.g. El Rayes and Moselhi, 1998) and that the Yi, Lee and Choi method does not guarantee a global optimum solution.

Resources in the x-axis of the chart are generally the work crews or the equipments that perform activities. When the activities are completed the crews are released to the next activities in the successor space units. Resources are grouped by work item i.e. masonry, plastering, floor concrete slab etc. Multiple resources, i.e. crews, are allowed for the same work item in order to perform parallel repetitive activities in different locations for the same task. In this way in every column of the chart activities are grouped by resources.
Space units of the projects are plotted on the y-axis. Space units are the locations where only one crew can perform one activity at a time. The Location Breakdown Structure is represented on the y-axis. The location breakdown structure (LBS) consists of an higher level of locations where it is possible to perform construction process independently of the other locations. The middle level should consists of locations where the flow of work can be planned across middle level locations. The lowest level are the space units of the project (Kenley and Seppanen, 2010). Space Units on the y – axis should be small, only one crew can work in that area and are identified by the k - code.
Activity is defined as the set of construction operation performed by a specialized crew or equipment in a space unit of the construction project. In a repetitive construction project a set of activities, performed by the same crew in more than one space unit is defined repetitive activity. Resources that perform a repetitive activity are identified by a j code. Task is defined as a set of repetitive activities performed by one or more than one crew for a work item, and is identified by the i code. So a resource path is completely identified as a repetitive activity by the ij code and a single activity is identified by the ij-k code (figure 1) where i identifies the work item or task, j identifies the repetitive activity or the single crew (i.e. resource path) and k identifies the space unit where the activity is performed (i.e. space path).
Plotting the PDM network on a Resource – Space chart makes easier resource tracking, in fact columns of the chart identify resource path through the project and the logical relationships between activities of the same task or repetitive activity represent resource flow tracking, while k rows of the chart identify space units of the project and make possible to detect unit path where the relationships between activities performed by different trades represent physical or technological dependencies (figure 1).

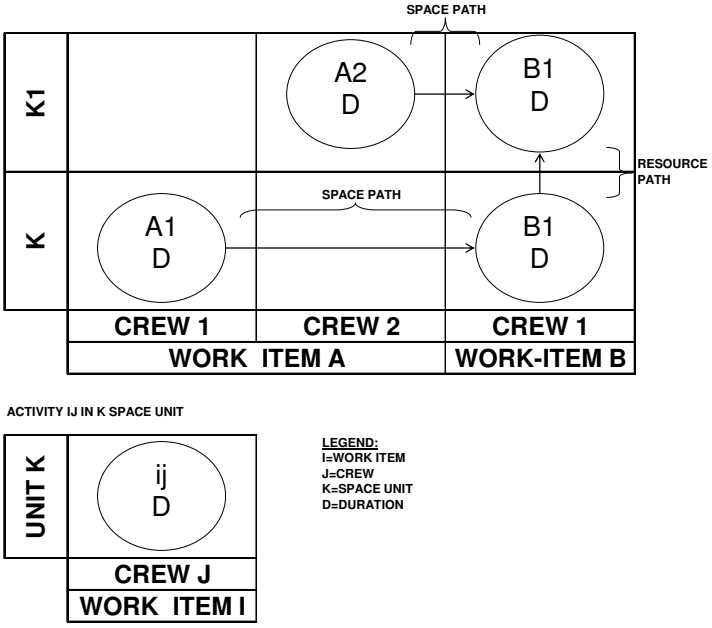


Figure 1: *Network Diagram plotted on a Resource-Space Chart (adapted from Yi, Lee and Choi, 2002).*

Work continuity requirement

After PDM critical path analysis, minimum construction project duration is found and as soon as possible project schedule is detected (ASAP) with Early Start (ES) and Early Finish (EF) of activities. Critical Path is detected and Free Float (FF) and Total Float (TF) for every activity can be found. In general non-zero link lags due to early time position of activities belonging to the same resource path prevent the ASAP schedule from satisfying the work continuity requirement. The proposed method aims at minimizing idle time of crews by activity shifting. Since that the optimization algorithm does not modify total project duration (TPD) as computed by traditional forward pass of Precedence Diagramming and resource flow continuity can be obtained only if made possible by network logic and activity float. If the work continuity requirement is satisfied for every activity of a resource path, the resource path is defined critical (figure 1).

The idle time of crew j on a resource path ij between the k' predecessor space unit and the k successor space unit, is computed as the difference between the early start of the successor ij-k activity and the early finish of the predecessor ij-k' activity:

$$\text{Idle ij } (k',k) = ESij\text{-}k - EFij\text{-}k' \qquad \text{(eq.1)}$$

Work interruption can be detected in the same way between activities of different tasks in the same space unit. If there are not any work interruptions between all the activities of the various task on a space unit, the space unit is defined critical.

The idle time of work on a space unit k, between activities belonging to the ij' predecessor task and the ij successor task is computed as the difference between the early start of the successor activity ij-k and early finish of the predecessor activity ij'-k:

$$\text{Idle k } (ij',ij) = ESij\text{-}k - EFij'\text{-}k \qquad \text{(eq.2)}$$

Rule 1: Critical Resource Path

If, for every k',k couple of space units of a resource path ij the idle time Idle ij (k',k) value is equal to 0, or for every single activity ij-k of the same resource path ij the Total float TFij-k value is equal to 0, the resource path ij is defined critical, although sub-critical.

Rule 2: Critical Space Unit

If, for every ij',ij couple of the resource paths of a space unit k the idle time Idle k (ij',ij) value is equal to 0, or for every single activity ij-k of the same space unit k the Total float TFij-k value is equal to 0, the space unit k is defined critical, although sub-critical.

Time Critical Path

Note that a critical resource path or a critical space unit are not critical path in the original CPM sense, because they are defined by the idle time (eq.1 and 2) which does not mean the absence of Total Float of the activities, but only the absence of a part or the entire Free Float (with the exception of the cases of rule 1 and rule 2, where actually the Total Float TFij-k is equal to 0). In fact the chain of critical tasks or of critical space units can still have float time in the CPM sense.

To highlight this difference the original CPM critical path can be called "Time Critical Path".

Also note that critical tasks are desirable, because of work continuity constraint, while critical space units are not desirable, because of the risk of interference between various tasks in the same space unit.

Contingency Buffer

The resource- space chart enhances Location Based Scheduling. The activities itself are defined as a set of work operations on a single space unit. The focus is on the process performed on a sequence of locations by resources. So the flow of resources must be protected with buffers to allow for variability (Kenley and Seppanen, 2009). Buffer is a time allowance provided to absorb any disturbance between two activities or tasks.

Contingency Buffers (CB) are placed at the end of every sub critical task (i.e. resource path ij) to protect Time Critical Path from overruns, and to maintain the minimum project total duration.

REPETITIVE NETWORKING TECHNIQUE: SCHEDULING PROCESS

The Repetitive Networking Technique (REPNET) is an heuristic solution for resource scheduling for repetitive projects. The proposed method is a PDM based optimization of resource constrained project scheduling. The project solution can be sub-optima, but it is a simple method, easy to perform by researchers and practitioners.

The heuristics of REPNET carry out resource timing in two phases: in the first phase traditional PDM as soon as possible project schedule is performed; in the second phase the REPNET algorithm search for resource scheduling optimization by minimization of resource idle time in repetitive activity performance. The work continuity constraint is relaxed in order to maintain the PDM minimum project duration. In this way, besides the classic time critical path, a resource critical path is detected. Space critical path can be highlighted if useful.

Phase 1 – Resource – Space Chart Network

In the first phase the resource – space chart is plotted. In the x – axis resources are grouped by construction item and work crews are identified. In the y – axis space units are plotted. Then PDM network is drawn on the chart. Activities on the same k row show the work flow in the k space unit (i.e. space path), activities on the same j column show the work flow performed by the same crew j on a work item i (i.e. resource path).

Note that network plotting on the chart is an important phase. In fact by means of ordering PDM network by resources and space units the sequence of work is set.

The traditional forward pass and backward pass are performed and early activity times (ES and EF) and late activity times (LS and LF) are detected. Free Floats and Total Floats for every activity are found. Time Critical Path is found ($TF_{ij\text{-}k} = 0$).

Phase 2 – Schedule optimization

Resource paths ij are analyzed and critical resource paths are found. Then every sub – critical resource path is processed, starting from the last one. A contingency buffer is inserted at the end of resource path. Then, starting from the last activity of the resource path, every predecessor activity with idle time of crew is shifted forward by the shift S. The shift S is equal to the minimum between the Free Float of the activity and the Idle Time of crew. By addition of early times (ES and EF) and shift (S) Planned Start (PS) and Planned Finish (PF)

are found for every activity. The optimization process go on until all the resource path is optimized, then goes to the earlier resource path and it is repeated starting from the last activity. The scheduling process is performed for every sub-critical resource path until all paths are optimized. The flow charts of figure 2 and 3 show this process.

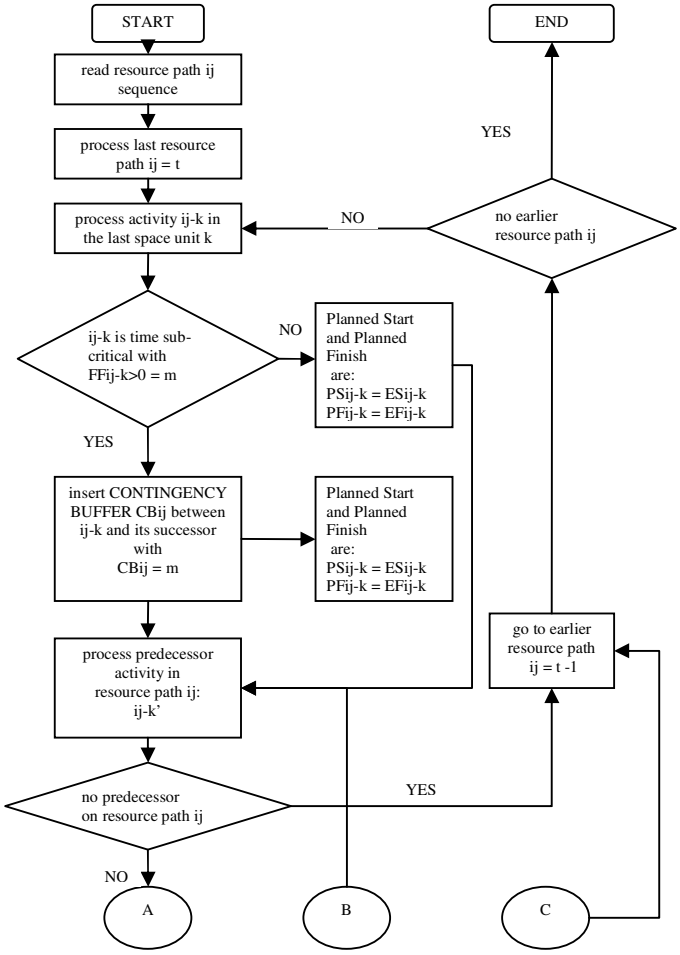


Figure 2: *Flowchart of REPNET – part 1*

CASE STUDY AND DISCUSSION

The REPNET optimization algorithm is tested using a case study from pertinent literature. The case study used for REPNET was presented by El Rayes and Moselhi (1998) and is a construction project which involves the construction of a three-lane highway for a stretch of 15 Km., and consists of five consecutive tasks: "A – cut and chip trees", "B – grub and remove stumps", "C – earthmoving", "D – base" and "E – paving". The space units are 15 segments of 1 Km each. The precedence relationships among these repetitive activities are Finish to Start with no lead time. For every task multiple crews are allowed. In the table of figure 4 activity data are presented. For simplicity activity data has been synthesized in crews allocated for each space unit k and the corresponding activity duration. The scope of the case study is to test the proposed heuristic solution with a simple but feasible project, which involves multiple crews in a multi-unit repetitive project.

The resource space chart with the PDM network is plotted in figure 5. The original ASAP schedule does not assure the work continuity requirement in 6 resource paths out of 13 (B1, B2, C1, E1, E2, E3). The flow line chart or production lines (Selinger, 1980, Kenley and Seppanen 2010) of figure 6 shows activities represented by lines on a time / space chart, where time (days) is plotted on the x-axis and space units are plotted on the y-axis. Activities are the lines starting from the lower left corner (start of location, start of duration) to the upper right corner (end of location, end of duration). In general, since activities are performed by a single crew, the lines represent crews passing through locations. The activities of a same resource path are linked each other by arrows representing the Finish To Start (FTS) relationships. Solid arrows are FTS links with no lag, dashed arrows are FTS links with non-zero lag, i.e. with crew work interruption. The flow line of the ASAP schedule shows work flow discontinuity between predecessor and successor space units in the afore mentioned sub-critical paths. Note that crew idle time, generally speaking, is more common in the last group of resource paths, due to network complexity.

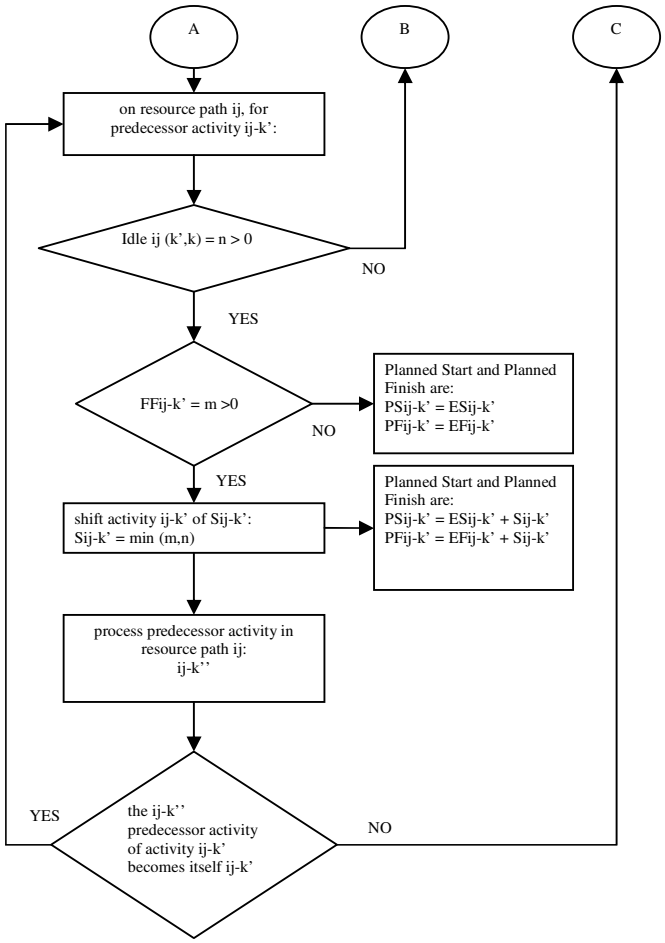


Figure 3: *Flowchart of REPNET – part 2*

The application of the REPNET heuristic solution reduces these non – optimized paths to 3, and the work continuity is not assured only in 3 resource path and in four cases (resource path B1: between unit 1 and 3; resource path B2: between unit 2 and 4; resource path C1: between unit 1 and 3, 3 and 5). Also, in the found solution all resource paths except B2 and C1 are

resource critical. The REPNET optimized schedule flow line of figure 7 shows resource path compression due to activity shifting, and at the same time work continuity requirement satisfaction in most paths.
Further optimization of the REPNET schedule can be made by hand manipulation of the network. Nevertheless the semi/automatic found solution seems ready for building site execution without further in depth study. This could be very helpful in real life project where the time for the scheduling phase itself is often very short.
The REPNET found solution is different from the solution found in the original case of El Rayes and Moselhi, because the objective of the REPNET is to implement a simple semi/automatic optimization that maintains PDM total project duration without changing activity sequencing imposed by the project planner. With this aim the REPNET keeps the PDM project duration of 100 days as a data of the problem, which is the result of the activity duration and sequencing imposed by the planner, and critical path calculation. On the other hand El Rayes and Moselhi found 83 or 87 days respectively with or without the satisfaction of the requirement of crew work continuity in every resource path, but this with semi/automatic activity sequencing. Scope of the REPNET is not to automate crew work sequencing, but to automate work idle time reduction, thinking that crew work sequencing is a strategic objective of site managers due to context, productive and contingency requirements.

Work item i	A		B		C		D		E	
Space Unit	Crew Number	activity duration	Crew Number	activity duration	Crew Number	activity duration	Crew Number	activity duration	Crew Number	activity duration
k	j	D	j	D	j	D	j	D	j	D
1	1	4	1	3	1	5	1	10	1	8
2	2	4	2	3	2	8	2	10	2	8
3	3	6	1	5	1	5	3	10	3	8
4	4	4	2	3	2	9	4	10	1	8
5	1	6	1	5	1	7	1	10	2	8
6	2	10	2	8	2	9	2	10	3	8
7	3	12	1	9	1	6	3	10	1	8
8	4	10	2	8	2	8	4	10	2	8
9	1	8	1	6	1	5	1	10	3	8
10	2	8	2	6	2	8	2	10	1	8
11	3	6	1	5	1	5	3	10	2	8
12	4	4	2	3	2	8	4	10	3	8
13	1	4	1	3	1	5	1	10	1	8
14	2	4	2	3	2	8	2	10	2	8
15	3	4	1	3	1	5	3	10	3	8

Figure 4: *table of activity input data*

CONCLUSION

The REPNET heuristic procedure for resource based construction process preparation is presented. The REPNET is a semi/automatic procedure that can help inexperienced planner in repetitive construction project scheduling. The optimization process carry out resource timing in two phases: resource – space network implementation and schedule optimization. In the first phase a traditional PDM network is plotted on a resource – space chart and the as soon as possible project schedule is performed. In the second phase the REPNET algorithm search for resource scheduling optimization by minimization of resource idle time in every

resource path on repetitive space units. The work continuity constraint is relaxed in order to maintain the PDM minimum project duration. In this way, besides the classic time critical path, a resource critical path is detected. Space critical path can be highlighted if useful.
Some of the critical elements of traditional Network Scheduling for repetitive projects are tackled by implementing Location Based-Scheduling in the proposed method. In particular the resource driven scheduling is implemented by network definition and activity sequencing on the resource paths plotted on the resource – space chart. The work space definition is implemented by location based scheduling due to allocation of activities on specific space units. These two features make possible to implement resource flow tracking, i.e. the movement of resources through the construction project. Thus resource flow can be easily optimized reducing idle time of resources as much as possible. Also the resource - space chart shows the workflow and the use of resources (e.g. crews and equipment) on the same graph, thus providing an easy-to-control schedule, improving the control phase during project execution.

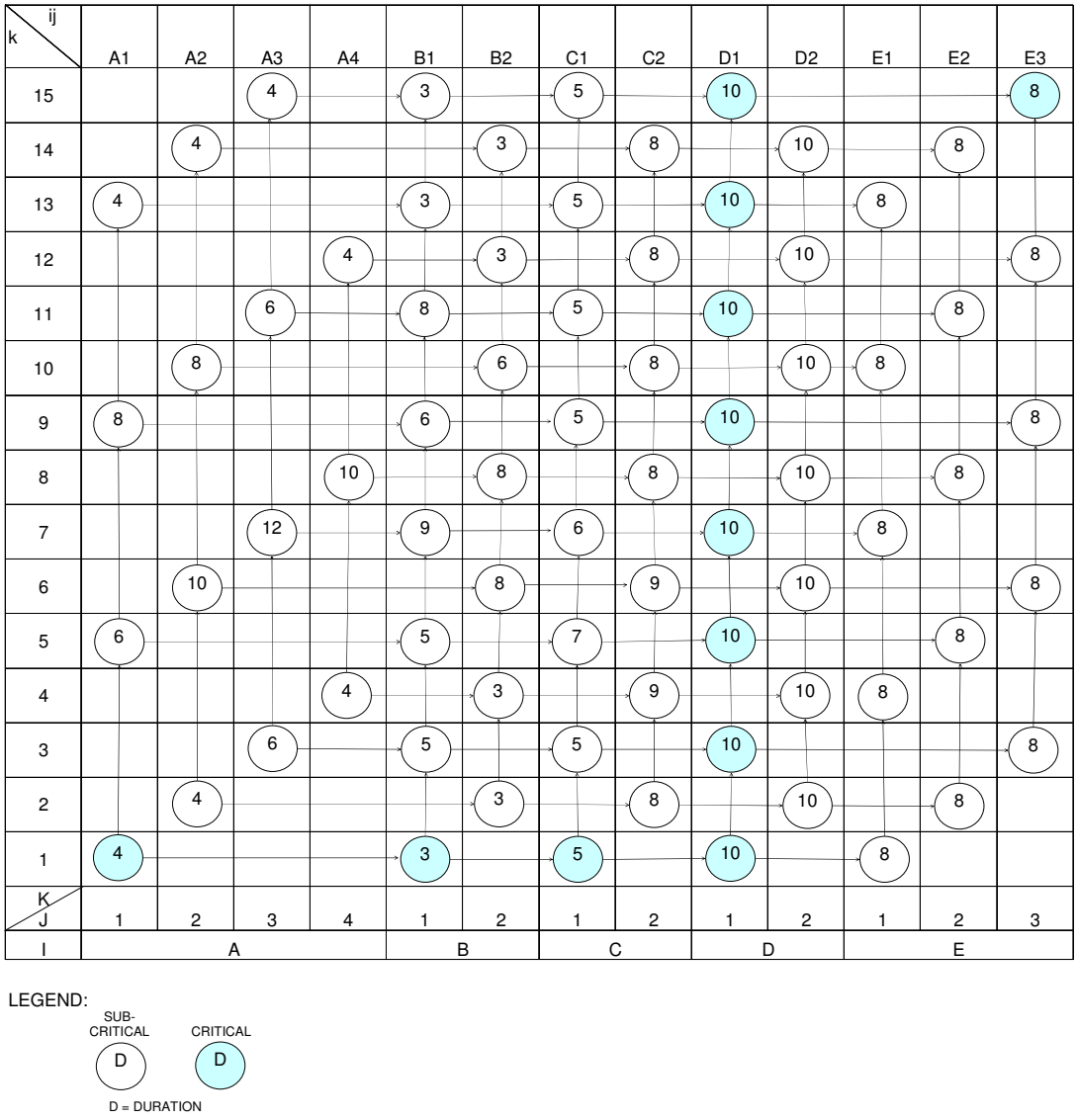


Figure 5: *REPNET: resource – space network*

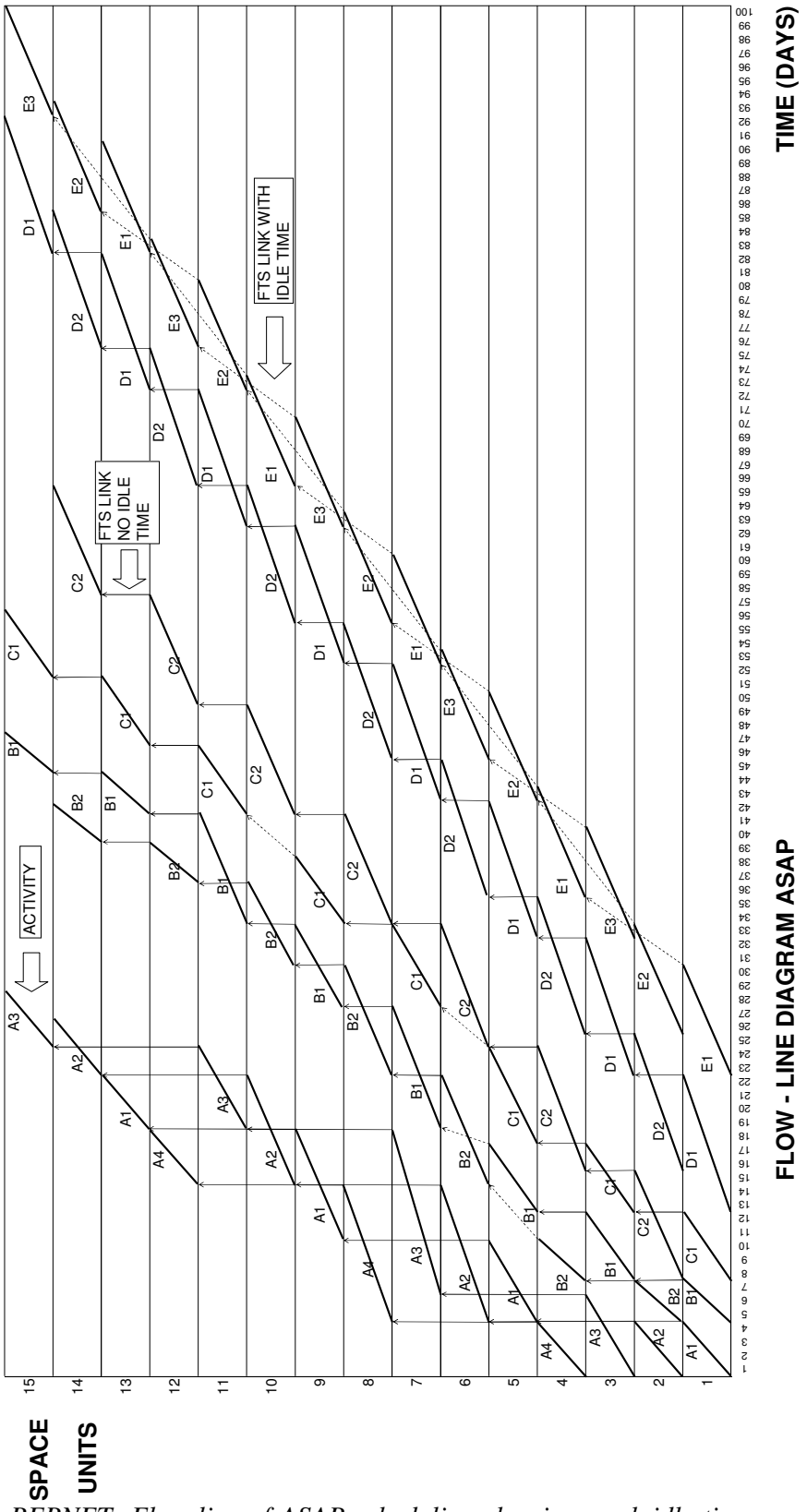


Figure 6: *REPNET: Flow line of ASAP scheduling showing work idle time on six resource paths. Lines are the activities performed by specialized crews on every space unit. Arrows are FTS link between activities of the same resource path (Solid line arrow is a link without idle time, dashed line arrow is a link with idle time).*

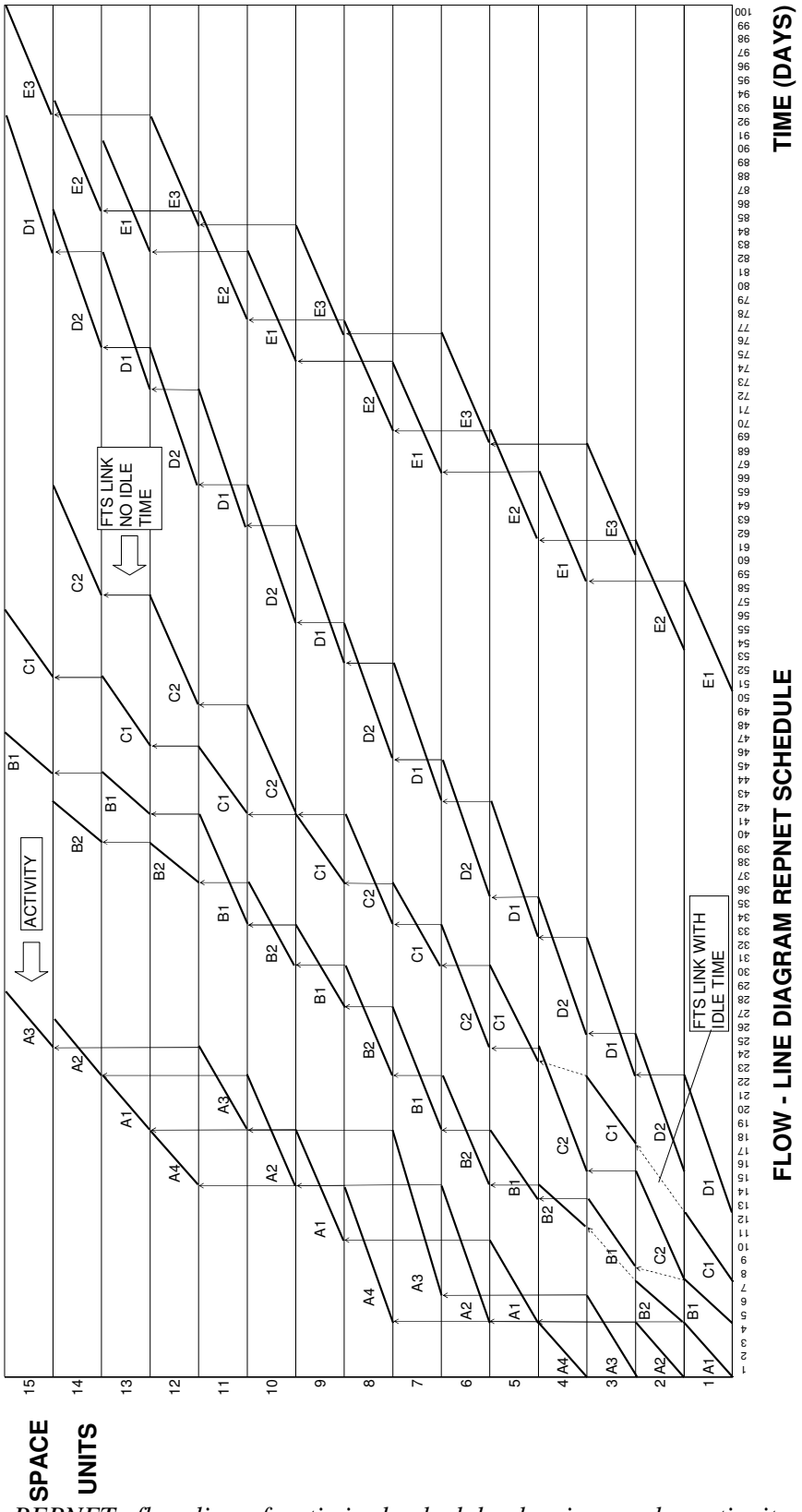


Figure 7: *REPNET- flow line of optimized schedule showing work continuity requirement satisfied on most resource paths. Lines are the activities performed by specialized crews on every space unit. Arrows are FTS link between activities of the same resource path (Solid line arrow is a link without idle time, dashed line arrow is a link with idle time).*

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SUSTAINABILITY AND URBAN DENSITY
A DECISION BASED DESIGN APPROACH

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Abstract
This paper concerns the definition, construction and application of a decision based design model which able the integration of the allocation of a variety of urban land uses with the distribution of different urban densities, in particular of residential urban areas. Urban planning is, among others things about the spatial distribution of human activities and their physical facilities like buildings, roads, green areas etc. in amount, place and time over a well-defined area. Today, sustainable urban development and sustainability in urban areas are important issues in urban planning. The aspects related to these issues have to be taken in account when developing urban areas. One of these aspects is urban density. Nowadays, it is generally assumed (and accepted) that urban density is related to sustainability. New urban planning approaches, loosely based around new urbanism, are successfully reducing environmental impacts by altering the built environment to create and preserve sustainable cities which support sustainable transport. Residents in compact urban neighborhoods drive fewer miles, and have significantly lower environmental impacts across a range of measures, compared with those living in sprawling suburbs.

Keywords: Sustainability, built environment, urban density, urban design and decision making.

URBAN DENSITY

The concept of density in urbanism is frequently used to describe the relationship between an area and the number of certain entities in that area. These entities might be people, dwellings, services, or floor space. However, the simple fact that density is used in, for instance, design requirements, plan descriptions and communication between parties, does not mean that it is used correctly or to its full potential.
One of the problems of defining density in operational terms is the relatively weak relationship between density and building type. The same density can be obtained with radically different building types, and the same type can be used to obtain different densities.
It is important to make a distinction between urban density used to describe a built environment (*descriptive* use); and urban density used as a norm in the process of planning and designing the city (*prescriptive*, or normative, use). Prior to the 20th century, density in cities was merely a result of the complex process of city development. Building techniques, legal constraints, traditions, the requirements for economic profitability, etcetera determined the possible resulting densities. However, no conscious use was made of density. As a matter of fact, density as a concept in urban analysis and planning probably did not exist until the second half of the 19th century. During this period, high densities in industrializing cities

were argued to be one of the major causes of fires, disease and social disorder. Mainly through critical publications in England and Germany, the awareness of the problem grew among legislators and urban planners. As a result, planning controls were developed that prescribed *maximum* allowable densities (M.Berghauser Pont and P. Haupt, 2010).
Urban density can be expressed in many ways. A widely used measurement is the number of dwelling units per unit area (acre, hectare). This measurement gives only information about the number of dwellings, not about their size or the way they are grouped. More general and precise ways of measuring density are measurements based on built area or gross floor area, respectively named ground space index and floor space index.
Using these measurements in urban design processes cannot guarantee a good or bad urban area because they are only measurements about the ratio of built and non-built spaces and give no information about the activities and functions within these spaces, neither about their distribution. Therefore, the outcome of an urban design model based on only density factors (as the amounts of built and non-built areas) gives no information about contents of these spaces. Consequently, these types of models are not applicable in a context of social oriented decision making, as in urban planning.

In this paper we present the integration of an urban function or urban activity based model with an urban density based model.
The first part will give an overview of the definitions, differences and similarities of both function based and density based models, as well as definitions of the combined model.
The second part describes the application of the combined model in a number of tests, including a final conclusion.

THE BASIC MULTI ACTOR URBAN PLANNING MODEL

We begin with an example for which a mathematical urban planning model can be constructed (Van Loon, 1998).

The decision-making problem of a housing association

A housing association wants to build a number of blocks of residential property and facility units (shops, school, social and cultural centre, etc.) on a particular site. The site covers 14,000 m^2. The association hopes to complete the project within 16 months. A block (construction time 2 months) covers 1,000 m^2, while a facility unit (construction time 1 month) covers 2,000 m^2. A residential block costs 8.10^6 Euros, and a facility unit costs 5.10^6 Euros; the overall budget is 80.10^6 Euros. It is not necessary to cover the entire site. A survey has been conducted among the future residents. This has revealed that they value housing blocks and facilities at a ratio of 5:3. The aim is to ensure that the future residents are as pleased with their neighborhood as possible.
This problem can be represented mathematically in a LP model. X_1 is the number of blocks of residential property and X_2 is the number of facility units. Two decision-makers are involved in this problem: the housing association and the future residents. The housing association decides what site area is to be built on, how long the building work will take, how much it will cost and sets out the timetable for the project. The future residents decide on their opinion of the houses and facilities. These give us the decision variables. The input variables are the total budget (80.10^6 Euros maximum) and the land available (14,000 m^2 maximum). These have been determined by the local authority within the constraints of its overall urban plan and the regulations governing its housing budget. The future residents want to see their views taken into account to the greatest possible extent, so $5 X_1 + 3 X_2$ must be maximized. The housing association wants to complete the project within 16 months and

stick to its decisions regarding construction costs, construction time and site area. These are the goals, and they can be represented as follows:

MAX! $5\ X_1 + 3\ X_2$ (appreciation)

Sub:

$1{,}000\ X_1$	$+ 2{,}000\ X_2$	$\leq$	$14{,}000$	(site area)
$2\ X_1$	$+ X_2$	$\leq$	16	(construction time)
$8.10^6\ X_1$	$+ 5.10^6\ X_2$	$\leq$	80.10^6	(budget)
X_1		$\geq$	0	
	X_2	$\geq$	0	

The simplex algorithm (a mathematical procedure which allows an LP model to be solved with 2 or more unknown variables) can be used to find the mathematical solution to this problem. Since the example has only two unknown variables, it can be solved using a simple drawing. This can be explained quite simply and allows the mathematical solution to be presented graphically. The problem facing the housing association is represented in Figure 1

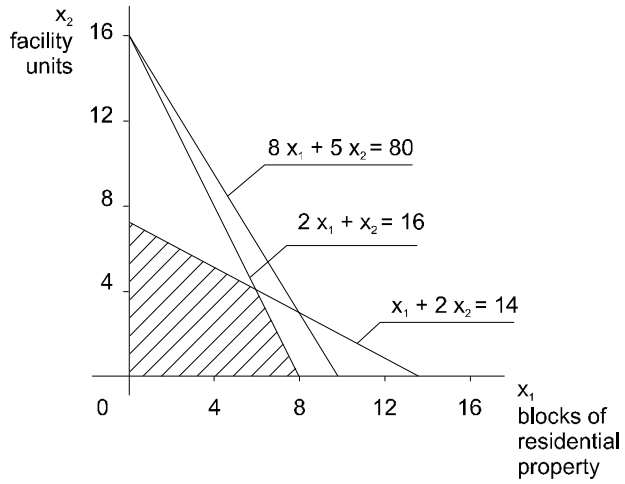


***Figure 1**: The solution space (shaded)*

The maximum value of the linear equation $5X_1 + 3X_2$ (the objective function) must be found within the shaded area. Consider the group of parallel lines $5X_1 + 3X_2 = c$. The highest possible value of c has to be obtained, within the constraints. This can be achieved when $X_1 = 6$ and $X_2 = 4$, because $c = 42$. The best outcome is achieved with 6 housing blocks and 4 facility units (Figure 2).

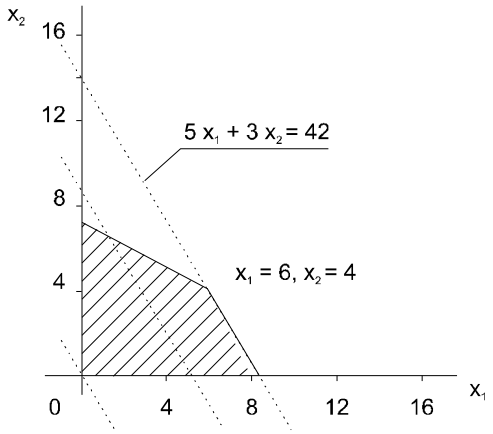


***Figure 2**: The objective function*

This modeling of the decision problem faced by the housing association is represented in diagrammatic form in Figure 3

The housing association and the future residents will undoubtedly continue negotiating their decisions and goals after this 'initial' solution has been found. Such negotiation is useful in order, for instance, to establish whether a change in the construction costs might better suit the preferences of the residents. Other, cheaper building materials could lower the costs, which might lead to a better distribution of houses and facilities.

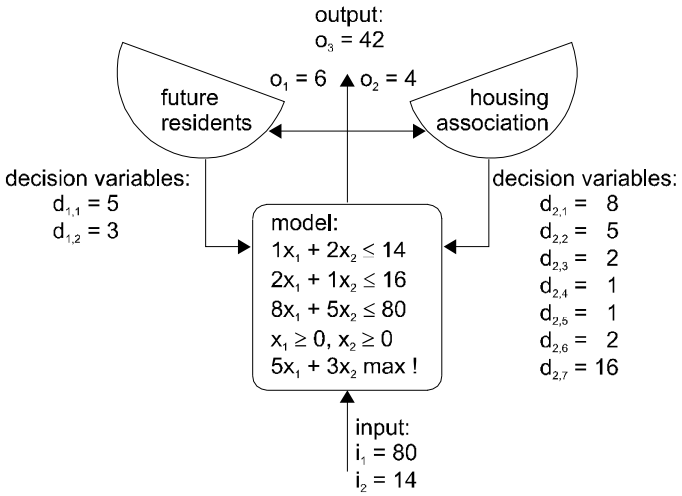


***Figure 3**:The decision model for the problem faced by the housing association*

The general structure of this model is as follows. This model is to select the values for the decision variables $x_1, x_2, \ldots, x_n$ so as to:

Maximize $\quad Z = c_1 x_2 + c_2 x_2 + \ldots + c_n x_n$

Subject to

$$a_{11} x_1 + a_{12} x_2 + \ldots\ldots a_{1n} x_n \leq b_1$$
$$a_{21} x_1 + a_{22} x_2 \ + \ldots a_{2n} x_n \leq b_2 \quad :$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + ...a_{mn}x_n \le b_m,$$

and

$$x_1 \ge 0,\ x_2 \ge 0,...,\ x_n \ge 0.$$

For the sake of brevity, we use Σ notation and write:

Maximise $\quad Z = \sum_{j=1}^{n} c_j x_j$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j \le b_i \qquad \text{for } i = 1, 2, \ldots, m$$

and

$$x_j \ge 0 \qquad \text{for } j = 1, 2, \ldots, n .$$

This is adopted as the *standard form* for the linear programming problem. Any situation whose mathematical formulation fits this model is a linear programming model.
The function Z being maximised, $c_1x_1 + c_2x_2 + \ldots + c_nx_n$, is called *the objective function.* The *decision variables* – the x_j – are sometimes referred to as the *uncontrolled* or *endogenous* variables. The input variables – the a_{ij}, b_i , and c_j – may be referred to as *parameters* of the model or as the *controlled* or *exogenous variables*.
The restrictions are referred to as *constraints*. The first m constraints b_1, b_2 , …, b_m (those with a function $a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n$ representing the total usage of resource i, on the left) are called functional constraints. The $x_j > o$ restrictions are called non-negativity constraints. In this paper the non-negativity constraints of the variables xj and xij will be implicitly assumed.

ALLOCATION OF URBAN ACTIVITIES TO SPACE

First extension of the basic model

In urban planning not only the quantities of and the preferences for the resources (like land to be used, buildings, infrastructure) to be allocated play a role, but also the location of the resources in the urban space. (R. Binnekamp, e.a. 2006). With an extension of the basic multi actor urban planning model – the linear programming model with negotiable constraints – we are able to model the allocation of urban activities to space (urban land use). In urban design and planning, a dominant spatial dimension of resources is the position of resources in two- and three-dimensional space. This position is commonly expressed in floor plans, land use plans, and three dimensional models of buildings and their urban environments. In terms of allocation of resources, a floor plan is a proposal for allocation of architectural spaces to accommodate human activities such as living, shopping, eating, and office work: Which spatial layout of the resources fits the activities to be accommodated best, in accordance with stakeholders' wishes, goals, and constraints, and with the architectural style chosen?

If we define the activities as demand (d) and the resources as supply (s) we can represent this problem (which is called in Operations Research literature the transportation problem or the distribution problem) in an LP model as follows:

Minimise $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\sum_{j=1}^{n} x_{ij} \geq d_i \qquad \text{for } i = 1, 2, \ldots, m$$

$$\sum_{i=1}^{m} x_{ij} \leq s_j \qquad \text{for } j = 1, 2, \ldots, n$$

In this model x_{ij} is the representation of an activity i in space j. c_{ij} is the representation of the cost (expressed in money, energy, appreciation, and the like) of the realisation of activity i in space j. This representation can be explained with two aspects of the relationship between activities and spaces as follows: Since in buildings and urban areas human activities are not fixed to one unique space – or in other words activities are spread out over more spaces, like rooms, auditoria, corridors, zones, areas – a design expresses, among a lot of other things, a spatial pattern of different architectural and urban spaces to fit a set of different activities allocated to the designed spaces. In the remainder of this paper the index i refers to an activity, j to a space or zone, k to a lot, m to number of activities, n to number of zones and pj to the number of lot within zone j.

The second aspect concerns the fact that most of the urban spaces are suited for more than one activity, but of course not all. This means that the designer can propose alternative arrangements of the activities required, for a given spatial arrangement of spaces. Also the other way around: for a given spatial arrangement of activities, alternative layouts of urban spaces may be proposed. By changing the input values of c_{ij}, a representation of the design process on both aspects becomes available. With this mechanism, a designer can represent his pattern of possible activities in such a way that he can see how well this pattern fits the activities required.

While urban spaces may be suited for more than one activity, they are not necessarily suited for all activities due to technical constraints such as daylight, noise hindrance, permitted location in the building, or conceptual constraints such as structure of spaces and patterns of connections.

The model for this design problem (the limited distribution problem) can be formulated as follows:

Minimise $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_{ij} \geq d_i \qquad \text{for } i = 1, 2, \ldots, m$$

$$\sum_{i=1}^{m} a_{ij} x_{ij} \leq s_j \qquad \text{for } j = 1, 2, \ldots, n$$

and

$$a_{ij} = \{0,1\} \qquad \text{for } i = 1, 2, \ldots, m \quad \text{for } j = 1, 2, \ldots, n .$$

Due to the LP problem solving algorithm, x_{ij} will be zero if $a_{ij} = 0$, and x_{ij} will get a value greater than or equal to zero if $a_{ij} = 1$. This means that if the designer decides that space s_j is not suited or otherwise not appropriate for activity i, he sets $a_{ij} = 0$ and automatically x_{ij} becomes 0. In other words, using the zero and one value of a_{ij}, the designer uses the model to calculate the best allocation of activities to the designed pattern of spaces.
In the representation of the space allocation described above, it is assumed that the total demanded space for activities equals the total supplied space for the activities. In the beginning of a design process this is often not the case. In architectural design and urban planning, demand and supply are independent of each other. They are not fixed at the start of a design process. Designers propose spatial arrangements of spaces based on their ideas, style, and concepts. Of course, these proposals are not that far from the required spaces, but they are not equal. So, a design can give ideas for activities one was not thinking of. Similarly, a designer can discover that he does not yet have space for an activity which certainly should be in the building. The designers have to find the best fit. With two extensions to the above model, it is possible to cope with this design question.

Minimise $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\sum_{i=1}^{m} a_{ij} x_{ij} - S_j = 0 \qquad \text{for } j = 1, 2, \ldots, n$$

$$\sum_{j=1}^{n} a_{ij} x_{ij} - D_i = 0 \qquad \text{for } i = 1, 2, \ldots, m$$

$$D_i \geq d_min_i \qquad \text{for } i = 1, 2, \ldots, m$$

$$D_i \leq d_max_i \qquad \text{for } i = 1, 2, \ldots, m$$

$$S_j \geq s_min_j \qquad \text{for } j = 1, 2, \ldots, n$$

$$S_j \leq s_max_j \qquad \text{for } j = 1, 2, \ldots, n$$

and

$$D_i \geq 0 \qquad \text{for } i = 1, 2, \ldots, m$$

$$S_j \geq 0 \qquad \text{for } j = 1, 2, \ldots, n$$

$$a_{ij} = \{0,1\} \qquad \text{for } i = 1, 2, \ldots, m \quad \text{for } j = 1, 2, \ldots, n .$$

where

S_j	Allocated space in zone *j*.
D_j	Allocated space for activity
s_min_j	Minimum available space in zone *j*.
s_max_j	Maximum available space in zone *j*
d_min_i	Minimum demand for activity *i*.
d_max_i	Maximum demand for activity *i*.

GROUND SPACE VERSUS FLOOR SPACE

Second extension of the basic urban planning model

The above described model deals with the distribution of a number of activities (demand) to a number of available urban areas (supply) both expressed as surfaces. Within an urban context the available space is commonly assumed to be ground space. Consequently, the demand of space is also assumed to be ground space. However, in many cases the supply of as well the demand for (urban) space is expressed as floor space, for instance the supply of space for schools is expressed in floor space, which can be distributed to one or more stories.
In order to facilitate this floor space in the described model, a new object is introduced, called a *lot*. A lot can be considered as a universal object for describing all built.
Related to this model, the most important spatial properties of a lot are:

- the base area of the lot (ground space),
- the area of the lot to be built also called the footprint of the building (a footprint is the amount of space on a surface that something needs),
- the floor area, which can be distributed to several stories.

Between these properties a number of relations can be defined, expressed as ratios, called the Ground Space Index and Footprint Ratio.
The values of these ratios can be defined within a margin between a given minimum and maximum value.

Ground Space Index

The Ground Space Index defines the relation between the built and non-built area of the lot, expressed as a ratio.

$$A_BLT \geq p_min_a_blt \cdot A_LOT$$
$$A_BLT \leq p_max_a_blt \cdot A_LOT$$

where

A_LOT	Total area of the lot.
A_BLT	Total amount of built area of the lot (at ground level).
p_min_a_blt	Minimum percentage of built area of the lot.
p_max_a_blt	Maximum percentage of built area of the lot.

Footprint Ratio

The Footprint Ratio defines the relation between the area of the footprint built and total floor area, expressed as a ratio. Or, the percentage of the floor area at ground level.

$$A_BLT \geq p_min_a_ftp \cdot A_GFA$$
$$A_BLT \leq p_max_a_ftp \cdot A_GFA$$

where

A_BLT	Total amount of built area of the lot (at ground level).
A_GFA	Total amount of floor area.

p_min_a_ftp	Minimum percentage of floor area at ground level.
p_max_a_ftp	Maximum percentage of floor area at ground level.

The basic planning model can now be extended using these two constraints, first on the supply site, second on the demand site.

Supply of urban space
In order to be able to allocate the activities in several buildings, one or more lots are added to each resource or space (called zone), each lot having its own properties.

$$S_j = S_TOT_LOT_j \qquad \text{for } j = 1, \ldots, n$$

$$S_TOT_LOT_j = \sum_k S_LOT_{jk} \qquad \text{for } j = 1, \ldots, n$$

$$S_TOT_BLT_j = \sum_k S_BLT_{jk} \qquad \text{for } j = 1, \ldots, n$$

$$S_TOT_GFA_j = \sum_k S_GFA_{jk} \qquad \text{for } j = 1, \ldots, n$$

$$S_LOT_{jk} \geq p_min_s_lot_{jk} \cdot S_j \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

$$S_LOT_{jk} \leq p_max_s_lot_{jk} \cdot S_j \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

$$S_BLT_{jk} \geq p_min_s_blt_{jk} \cdot S_LOT_{jk} \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

$$S_BLT_{jk} \leq p_max_s_blt_{jk} \cdot S_LOT_{jk} \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

$$S_BLT_{jk} \geq p_min_s_ftp_{jk} \cdot S_GFA_{jk} \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

$$S_BLT_{jk} \leq p_max_s_ftp_{jk} \cdot S_GFA_j \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$

where

S_j	Total available area in zone *j*.
$S_TOT_LOT_j$	Total available lot area in zone *j*.
$S_TOT_BLT_j$	Total built area within all lots in zone *j*.
$S_TOT_GFA_j$	Total floor area within all lots in zone *j*.

S_LOT_{jk}	Total available lot area of lot *k* in zone *j*.
S_BLT_{jk}	Total built area within lot *k* in zone *j*.
S_GFA_{jk}	Total floor area within lot *k* in zone *j*.

n	Total number of zones
j	Index of a zone

p_j Number of lots within zone j.
k Index of a lot within a zone
$p_min_s_lot_j$ Minimum percentage of lot area in zone j.
$p_max_s_lot_j$ Maximum percentage of lot area in zone j.
$p_min_s_blt_{jk}$ Minimum percentage of built area related to lot area within lot k in zone j.
$p_max_s_blt_{jk}$ Maximum percentage of built area related to lot area within lot k in zone zone j.
$p_min_s_ftp_{jk}$ Minimum percentage of flootprint area related to floor area within lot k in zone j.
$p_max_s_ftp_{jk}$ Maximum percentage of flootprint area related to floor area within lot k in zone j.

Demand of urban space
The demand for space for activities is now expressed in floor area instead of ground space.

$$D_GFA_i \geq d_min_gfa_i \qquad \text{for } i = 1, \ldots, m$$
$$D_GFA_i \leq d_max_gfa_i \qquad \text{for } i = 1, \ldots, m$$

where

D_GFA_i Total allocated floor area of activity i.
$d_min_gfa_i$ Minimum demand for floor area activity i.
$d_max_gfa_i$ Maximum demand for floor area activity i.

Allocation of demand to supply
The allocation in this extended model concerns the distribution of floor space for activities to the lots of each zone.

$$\sum_{i=1}^{m} a_{ijk}\, x_gfa_{ijk} - S_GFA_{jk} = 0 \qquad \text{for } j = 1, \ldots, n \;\; k = 1, \ldots, p_j$$
$$\sum_{j=1}^{n} a_{ijk}\, x_gfa_{ijk} - D_GFA_i = 0 \qquad \text{for } i = 1, \ldots, m \;\; k = 1, \ldots, p_j$$
$$a_{ijk} = \{0,1\} \qquad \text{for } i = 1, 2, \ldots, m \;\; j = 1, 2, \ldots, n \quad k = 1, \ldots, p_j$$

where

S_GFA_{jk} Total supply of floor area within lot k in zone j.
D_GFA_i Total allocated floor area of activity i.
a_{ijk} Indication whether activity i may be allocated to lot k of zone j.
x_gfa_{ijk} Allocated floor area for activity i in lot k of zone j.
i, j, k, m, n, p_j As above

The described model only allocates activities to floor areas within lots and does not provide in the allocation of "non-built" activities, like pavement or parks. This can be solved by considering one lot as being open space. Its floor area is considered as non-built space and the values of both its Ground Space Index and Footprint Index are fixed to one. Also, the floor areas of the activities which will be allocated to these non-built lots are considered to be open space.

URBAN DENSITY AND MULTI ACTOR DECISION MAKING

Third extension of the basic planning model

The third extension of the basic planning model is urban density. As stated in the introduction, the concept of density in urbanism is frequently used to describe the relationship between an area and the number of certain entities in that area, for instance people, dwellings or floor space. This means that density is a feature of a set of objects, in case the urban system. And features are always expressions of relations between objects.
In order to be widely applicable urban entities are chosen that do not depend on the specific urban use of space, like dwellings, offices, shops. Therefore, entities based on built space and non-built space are used as entities of densities.

Building Intensity (FSI)
FSI reflects the building intensity of a base land area independently of the programmatic composition and is calculated as follows:

$$FSI = \frac{A_GFA}{A_BAS}$$

where
A_GFA Total gross floor area.
A_BAS Total base land area.

Coverage (GSI)
GSI, or coverage, demonstrates the relationship between built and non-built space of a base land area and is calculated as follows:

$$GSI = \frac{A_BLT}{A_BAS}$$

where
A_BLT Total built area (footprint).
A_BAS Total base land area.

The formula for *GSI* can be rewritten as.

$$A_BLT = GSI \cdot A_BAS$$

In this form it can be added to the LP-model if the value of *GSI* is fixed and known in advance. Both A_BLT and A_BAS are assumed to be endogenous variables. Unfortunately, in case the variable *GSI* is introduced as an endogenous variable the LP-model becomes non-linear because of the multiplication of two endogenous variables within this constraint. However, in case *GSI* is *only* used in this constraint *and* is bounded between a known minimum value gsi_{min} and kown maximum value gsi_{max} the variable *GSI* can be eliminated from the LP-model without violating the boundary constraints by replacing the constraint by two other ones.

$$A_BLT \geq gsi_{min} \cdot A_BAS$$
$$A_BLT \leq gsi_{max} \cdot A_BAS$$

The endogenous variable *GSI* has now been eliminated from the LP-model. Its actual value can be calculated afterwards, i.e. after (successfully) solving the LP-model.
In a similar way the endogenous variable *FSI* can be eliminated from the LP-model and be replaced by two constraints defining a minimum value fsi_{min} and maximum value fsi_{max}.

$$A_GFA \geq fsi_{min} \cdot A_BAS$$
$$A_GFA \leq fsi_{max} \cdot A_BAS$$

These basic constraints can easily be applied to both the supply and demand variables in the LP-model. For instance, the overall *FSI* and overall *GSI* of a particular zone *j* can be defined as follows (the first lot having index 1 is considerd to be a non-built lot):

$$\sum_{k=2}^{p_j} S_BLT_{jk} \geq gsi_min_j \cdot S_TOT_LOT_j$$
$$\sum_{k=2}^{p_j} S_BLT_{jk} \leq gsi_max_j \cdot S_TOT_LOT_j$$

$$\sum_{k=2}^{p_j} S_GFA_{jk} \geq fsi_min_j \cdot S_TOT_LOT_j$$
$$\sum_{k=2}^{p_j} S_GFA_{jk} \leq fsi_max_j \cdot S_TOT_LOT_j$$

EXAMPLE.

The described model is tested in a case: the development of a residential area of 100 hectares including space for green areas, pavement and basic facilities like schools, shops, medical and cultural centres.

The municipality of the city to which this area belongs, wants to achieve a dwelling density between 45 and 70 dwellings per hectare. The dwellings to be built are divided into twelve possible dwelling types. For each dwelling type (average) values are given for the size of its parcel, the size of the footprint (built area of the parcel), the dwelling size and the number of dwellings per parcel.
In order to create a variety of dwellings for each dwelling type mimimum and maximum percentages are given according to the housing needs.

Three different models have been applied. In all models the total number of dwellings has been maximised. As an output, the GSI and FSI of the area for only housing are calculated. The area for housing comprises the area of the lots, the space needed to access these houses, green area nearby the housing blocks, small parks (e.g. childrens playground) at a short distance of the housing blocks and parking lots for the inhabitants and their visitors.

Area needed for other facilities like schools, shops, large parks, water are not included in this calculation.

First, the municipality wanted to determine the maximum number of dwellings that can be built without dividing the area into subareas. The result is 6,219 dwellings. The GSI of the whole area for housing is about 0.62; the floor space index is about 1.1.
Table 1 outlines the results of the dwelling distribution of each model as well as the dwelling density, the total GSI and total FSI of the area for housing.

Table 1: Distribution of the dwellings in the three models

	Basic (no zoning)		**Zoning without density constraints**		**Zoning with Density constraints**	
Dwelling type	**Number**	**%**	**Number**	**%**	**Number**	**%**
Terrace houses	622	10%	536	10%	468	10%
Apartments youngsters	933	15%	803	15%	702	15%
Apartments elderly	933	15%	640	12%	702	15%
Terrace houses small	311	5%	268	5%	357	8%
Terrace houses	311	5%	431	8%	468	10%
Semi-detached medium	0	0%	0	0%	0	0%
Semi-detached family	311	5%	268	5%	265	6%
Apartments seniors	933	15%	803	15%	702	15%
Semi-detached family	311	5%	268	5%	234	5%
Apartments	933	15%	803	15%	0	0%
Large Apartments	311	5%	268	5%	547	12%
Villas	311	5%	268	5%	234	5%
Total	**6219**		**5356**		**4678**	
Density (Calculated)						
GSI	0.6265		0.6277		0.6639	
FSI	1.1136		1.1257		1.0495	
Dwellings per hectare	62		54		47	

In order to achieve a more the whole area has been divided into six subareas called zones. For each zone, one can define which dwelling types *may* be built in that zone. The two central zones, numbered 4 and 5, are reserved for other activities (education, leisure, shopping) primarily meant for the inhabitants of this area. Table 2 shows to which zone a dwelling type may be allocated.

Table 2: Possible allocation of dwelling types to a zone

Possible allocation of dwellingtypes						
Dwelling type	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**
Terrace houses	*					
Apartments youngsters	*					*
Apartments elderly	*					*
Terrace houses small	*					*
Terrace houses medium	*					
Semi-detached medium	*					
Semi-detached family	*					

Apartments seniors	*		*			
Semi-detached family		*				
Apartments			*			
Large Apartments		*				
Villas		*				

Taking in account these allocation constraints, the total number of dwellings that can be built, reduces to 5356 (See table 3). In comparison with the first model, both the FSI and GSI (for housing) of the whole area do not change, but there are significant differences between the zones. The GSI varies between 0.55 and 0.73, the FSI between 0.90 and 2.12.

Table 3: Allocation of dwellings to zones without density constraints

Allocation without Density constraints							
Dwelling type	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Total**
Terrace houses	536						**536**
Apartments youngsters						803	**803**
Apartments elderly						640	**640**
Terrace houses small						268	**268**
Terrace houses medium	431						**431**
Semi-detached medium							
Semi-detached family	268						**268**
Apartments seniors	413		390				**803**
Semi-detached family		268					**268**
Apartments			803				**803**
Large Apartments		268					**268**
Villas		268					**268**
Total	**1648**	**803**	**1194**			**1711**	**5356**
Density (Calculated)							
GSI	0.6413	0.5526	0.6654			0.7348	0.6277
FSI	1.0175	0.9002	2.1287			1.2133	1.1257
Dwellings per hectare	55	32	92			101	54

The municipality does not want the FSI to exceed 2.0, except the one of zone 6. This zone is considered as an extension of the neighbouring residential area. Therefore, its GSI and FSI must correspond to the ones of this neighbouring residential area. Consequently, the built area of zone 6 is set to at least 70% and its FSI is set to a maximum value of 1.0.
For similar reasons, the GSI in zone 1 may not be less than 0.67.

These extra requirements cause the total number of dwellings that can be built decreases to 4678 (see table 4). Because the FSI in zone 3 may not exceed 2.0, it is not possible to built dwellings in this zone (in favour of other facilities).
In order to agree the additional constraints more large dwellings will be realised in this new residential area.

Table 4: Allocation of dwellings to zones with density constraints

Allocation with Density constraints							
Dwelling type	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Total**

Terrace houses	468						**468**
Apartments youngsters	151					550	**702**
Apartments elderly	521					181	**702**
Terrace houses small	0					357	**357**
Terrace houses medium	468						**468**
Semi-detached medium							**0**
Semi-detached family	265						**265**
Apartments seniors	702						**702**
Semi-detached family		234					**234**
Apartments							**0**
Large Apartments		547					**547**
Villas		234					**234**
Total	**2575**	**1015**	**0**	**0**	**0**	**1089**	**4678**
Density (Calculated)							
GSI	0.6700	0.5381				0.7000	0.6639
FSI	1.1830	1.0630				1.0000	1.0495
Dwellings per hectare	86	41				78	47
Input Data							
Min GSI	0.67					0.70	
Max GSI							
Min FSI							
Max FSI	2.00	2.00	2.00			1.00	

CONCLUSIONS

In spite of the practical advantages of the concept of urban density in urban planning, critics have argued – especially since the revolt in the 1970s against the quantitative methods of modernist planning – that the use of density for anything but statistical purposes is questionable, as it is perceived as a too elastic concept that poorly reflects the spatial properties of an urban area. Professionals, as well as researchers, hold the opinion that measured density and other physical properties are independent of each other: Very different physical layouts can have similar measured densities. (M. Berghauser Pont and P. Haupt, 2010)
Often people confuse density with building type and assume, for example, that detached houses are lower density than attached housing types. While this is generally true it is not always the case.

Besides the argued lack of relationship between density and form, density is also considered with suspicion because of the confusion regarding the definition of plan boundaries and the scale at which these are measured. Although it is common to distinguish between net and gross density, the definitions vary from place to place parcel density, net-net density, net and gross residential density, general density and community density are some of the units of measure used.

Since the urban planning model we described, represent building types as well as density parameters it is possible s to decide on both aspect of urban areas in one

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EDUCATION & EMPLOYMENT: A PRELIMINARY STUDY OF FEMALE BUILT ENVIRONMENT UNDERGRADUATE STUDENTS IN SOUTH WALES

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Abstract
Recently available figures for South Wales' university's and college's intake indicate a ratio of 83 male to 17 female students on undergraduate built environment courses. It could be contended that any increase in the numbers of females attending such courses should reflect more females at the 'coal face' but what of the experiences, perceptions and expectations while on those courses? The female respondents were questioned utilising semi-structured, digitally recorded discussions in relation to education, employment and how and why they arrived at their careers determining the influences in choosing that career path. Issues arose including poor careers advice, inappropriate work experience, lack of peer support, a general lack of knowledge of the industry and the perception of outmoded male attitudes. The aim is to ultimately gain a longitudinal view of female experiences over the 'life' of their courses and concurrent employment, to ascertain over time if the respondent's views have changed and original expectations met. It is suggested a better understanding of women's experiences through a longitudinal study may support the sector to improve the number of successful female built environment technicians.

Keywords: Women, built environment, careers, education, longitudinal study

INTRODUCTION

The imbalanced ratio of female to male construction workers in the built environment sector is well documented (Chwarae Teg 2009; Kirkup et al. 2010) and that gender imbalance is reflected in the ratio of female to male built environment undergraduates in the South Wales education sector (Unistats 2009). Anecdotal and documentary evidence has been provided various reasons for the low uptake of women into the industry; outmoded sexist attitudes and discrimination; negative stereotyping of construction; lack of peer support and work-life balance (Loosemore *et al* 2003; Gurjao 2006; Clarke and Gribling 2008; Watts 2010) to list but a few. With an aim to counter the industry image debate organisations such as CITB-ConstructionSkills have presented promotional campaigns in order to attract more females into the sector; campaigns such as "*Positive Image*" (2007) and "*Girls Allowed*" (2010); ConstructionSkills reporting favourable results following the *Positive Image* publicity.

Construction industry labour shortages are reported in times of high industry output as opposed to the economic nadir we currently find ourselves in. Indeed, McDermott (2011) of KPMG reported in *Construction Manager*, construction firms are "*...pricing below break-even levels*" but it can be argued that 'good times' always follow 'bad' and the call for more professionals will increase again. Greed (1991) suggested "*At at a time of 'man' power shortages, we must do all we can to enable, and not deter, women to participate fully...*" indicating a benefit it "*...actually saves money...*" through the "*...efficient use of...*" human resource management, reducing the "*...cost factor at all stages of the development process*". A factor reiterated as a benefit of diversity by David (2010) restating McEnrue (1993). Of particular concern is Fulcher's (2010) report indicating "*...practising female architects has dropped an alarming five per cent since 2008...*" although contradictory to that "*...statistics suggest an increase in women registering...*". The contention '*man*' power shortages will continue to be reported, particularly at high periods of construction output, will prevail unless real positive actions are taken to entice more professional women and possibly alleviating both the HRM issues and gender imbalance. It is also contended that until female pre-school leavers and women of working age are made aware of the full range of disciplines available; both the 'clean' and 'dirty' jobs; continuing evidence of the gender imbalance on built environment courses will remain. In providing clear information and continual positive promotion of the industry, a change of more women's attitudes will be witnessed as far as industry stereotyping is concerned and highlight the positive aspects and not only the negative characteristics of the sector. Industry stakeholders must ensure is women realise construction is not merely *muck and bullets*! (Murphy and Ren 2010).

This paper aims to provide a preliminary perspective of female experiences at the early stages of their built environment courses primarily through open question interviews. The questions purposely focussed on previous school, current education and their concurrent employment experience. This paper contains some of the responses provided by the interviewees and an analysis of the discussions followed by my conclusions from the analysis. It is envisaged to follow on with consequent research over the 'life' of their programmes through yearly staged interviews, the overall aim of ascertaining a long-term portrayal of those experiences will hopefully provide a clearer picture of the issues that arise. Also, their perceptions over time and a measure of their original expectations are to be considered. It is suggested a better understanding of women's experiences through a longitudinal study may support the sector to improve the number of successful female built environment technicians.

LITERATURE REVIEW

Industry Awareness and Image

A number of organisations and institutions have researched and advised on the causes for the lack of females in construction occupations and are consequently attempting to reverse the trend; an example in Wales is the *Women in Construction* initiative. Others such as Salford University's *Construction & Women* (2009) project and the National Association of Women in Construction (NAWIC 2009); NAWIC attempting to improve the opinion of women toward the industry, provide support in their chosen professions and ultimately elevate the image of female professionals. Similarly, the Women in Project Management (WiPM 2010) Specific Interest Group (SIG); an arm of The Association of Project Management (APM) (2010); aim to provide information for those interested in working in the discipline, declaring a focus on *"…school leavers, graduates and returners to work"*. Crucially, the focus on diversity and not separation or segregation is professed to promote good working practices

amongst both sexes. Watts (2010), chief executive of the Construction Industry Council (CIC) reported and enforced the issue of the image problem but also added on a positive note the role of the Royal Town Planning Institute (RTPI) in faring better than most institutions questioned on diversity employment practices. Examples provided construction organisations who have *broken the mould*, Mott Macdonald and Mace specifically named as two firms demonstrating good practice. Watts' argument is the industry will always have image problems and competitive disadvantages if it continues in the same vein, notwithstanding the slow growth in female employees.

Influences

Amaratunga et al. (2008) provides an encouraging image through the *Construction & Women* project with vignettes of women with a professional involvement who generally speak positively of their experiences. In contrast the project also refers to the fact "*…women tend to lack access to informal networks…and wide range of developmental experiences...that build the credibility to advance..."* Positive images are also provided by ConstructionSkills (Northern Ireland) (2008) with case studies of young women working in civil engineering, quantity surveying and health and safety. Good and bad points of their job roles are given but two replies reflect previous assertions being stereotypes and lack of women, although the advice is *"…not to be put off by stereotypes"*. Powell et al. (2006) reported issues of women within engineering, responses similar to previous researcher's findings; particularly women being amongst the minority. Reasons proffered include, poor careers advice, lack of family support, lack of supporting professional engineers as *role models* and quoting Dryburgh (1999) similar *cultural and occupational barriers* experienced in construction; mirroring those discussed in depth by Dainty et al. (2000) considering the broader aspects of female underachievement. As an antidote, Shanmugam et al. (2006) suggested "*…raise awareness…*" by "*…women working on construction committees…*" utilising them as "*…role models*"; the concept discussed by Lu and Sexton (2010), highlighted by McCarthy (2010). Lu et al. (2008) confirm in the managerial context, the need for role models to encourage and champion female employees, developing burgeoning careers. Clarke and Gribling (2008) argued the industry's structure and intrinsically created barriers influenced employment also reaffirming promoting the industry and better utilising schools as breeding grounds.

Education and Training

The drive by organisations including SSCs and Chwarae Teg in Wales to improve the uptake of women arguably should be making inroads on the professional female presence. This drive primarily concentrated on trade aspects; carpenters, decorators and the like but what of the boost for technical and managerial? SummitSkills (2010) highlighted the need for lines of learning and professional routes to be made clearer in schools as opposed to current practice, stating they *"…are guilty of not supporting females in their career choices if they are seeking non-traditional employment…"*

Table 1 **Male to Female Ratio of South Wales Built Environment Students**

	Ratio		Numbers	
Total Students	Male	Female	Male	Female
1570	83	17	1180	390

Historical statistics available to the CIB (1996) from the University and College Admission Service (UCAS), indicated an average 12% of the student cohort on built environment courses as female; similar to contemporary figures (11.6%) provided by bConstructive

(2009). The currently available figures for South Wales' universities' intake (*Table 1*) indicate a ratio of 83 male to 17 female students (Unistats 2009). It could be contended any improvement in numbers of females attending courses should indicate more females at the 'coal face'; is a student increase of 5% in 13 years acceptable? On the contrary the Royal Institute of British Architects (RIBA) (2009) provided information to *The Panel on Fair Access to the Professions* comparing male to female entrants on RIBA validated courses. According to their figures, 42% of *Part 1* entrants were women compared to 35% on the *Part 2* course, an increase between the two years. What are the experiences of female students while in education and employment? Powell et al. (2009) discussed a number of issues ranging from tutor positive discrimination to feeling they were only there in an attempt to improve numbers in the gender divide. Fulcher (2010) provides concern stating "*Universities have achieved close to 40 per cent female participation on architecture courses, indicating that the profession is still failing to make use of the pool of qualified labour*".

RESEARCH METHOD

Naoum (2007) stated unstructured interviews tend to be *very general* and used mainly when the researcher wants to see where the respondent will lead the interview. Merton and Kendal (1946) are quoted by Naoum in discussing the semi-structured approach and reiterate the characteristics; interviewees are known to be or have been involved in the situation under review. The semi-structured approach was preferred alluding to the above; the aim to research the respondent's experiences following the processing of an interview guide. As Caven (2008) argued referring to Jones (1983) and Evetts (1996), the interview method of information gathering is appropriate, the views of participants subjective and broadly career based. The internal validity of the findings, discussion and conclusions were tested by seeking feedback from the respondents as Burns and Grove (2005) attest, to ensure the results of the study truly reflect the views of the respondents.

Prior to the discussions/interviews commencing, participants were assured confidentiality of information proffered; consent for digital recording also requested. Enquiries sought the influences in choosing their careers and who were party to that influence. Much has been discussed regarding the quality of careers advice provided by advisors and schools; similarly of work experience so associated information was sought. Questions were included to discover how information relating to the built environment was provided, their experiences in employment and views on the role of training agencies in engaging females into the industry. Opportunities to provide further comments or observations allowed participants to add personally considered comments.

INTERVIEW RESPONSES

Career Choice

Of the respondents, four chose their current career; otherwise the careers "*chose them*" through progression or as some stated "*by luck*". Of those four, one always wanted to be a surveyor, following her father into the industry, an 'engineer', "*I used to occasionally go to work with my father to jobs*"; another showed interest "*...before I was ten*" in engineering. The other had some idea of what she wanted to do (architectural technician), received careers advice and thought "*...that sounds good...*" the career followed. While another worked in a

social housing organisation, a post "*...that sounded interesting...*" was advertised in another department and successfully gained the position.

Family Influences

Family influences varied including "*…they didn't mind as long as I went into something sensible*"; another's parents "*…advised from their own experiences…of the education system.*" A respondent's father arranged for her to speak to a local authority surveyor regarding built environment routes but "*…was focussed on what I wanted to do anyway...*". Another was influenced by her uncle, a QS; another, her family from a farming background, stated "*...my parents talked to me and asked what I wanted to do and tried to push me in the right direction. They said they would support me…*" whatever she decided. Fathers and brothers in the industry initially had no influence "*...my brother is civil engineer and my father a mechanical engineer...*"; "*...my father is a QS but I became a teacher…and hated it! I* (then) *decided to go into construction*". Others were influenced on their parent's careers and attitudes towards career advancement, some working in the industry not discussing the option including one father who "*…tried to put me off construction…I was too young and shy!*".

Another used to draught jewellery as a profession "*...and was good at it...*" in some respects an architectural profession "*...naturally followed...*" applying the design aspect. Others enjoyed buildings generally, "*I was always interested in buildings…pubs not houses*" (for aesthetic reasons!) found it interesting. Another established, she built up her curiosity as her "*...mother used to do a lot of decorating*". A non-British student was influenced by her uncle a QS who "*...taught her about building*". Family support differed "*…I used to go home crying from work…*" but was told by her family "*…keep with it, it would be fine"*, aged 16 working in a smoke-filled builder's office. A small number of respondents did not talk of careers at all with family.

Career Paths

The original careers of respondents varied significantly, including stable hand, teaching, travel agent, medical researcher, nanny, accountancy, administration and shoe factory worker. Some changed employment reasoning boredom, needing a career change and in one case, repetitive strain injury. Most worked their way "*up the ladder*" or between departments into their current positions. The majority received careers advice at some time, the perceived standard of advice varying; most did not know what they wanted to do while in school. Advice provided was generally perceived the "*...usual suggestions...*" of nursing, chemist, child-carer or teacher, not having mapped out a career path advice considered inappropriate or poor. Typical responses were "*...advice may have been useful if I had taken more notice*"; "*...had little bit of advice after O levels but in retrospect it was poor*"; "*...not much advice… only girl's jobs*".

School and Teacher's Advice

Whether teachers advised on construction depended mainly on the age of respondent, the youngest of them receiving some information, as one confirmed "*...they were happy to talk if you had any questions, but only knew a great deal about their own subjects*" another confirmed they (teachers) "*...knew the job titles but did not know what went on in the jobs…could not say what a QS or structural engineer did*". One declared she attended woodwork and metalwork classes and "*...enjoyed it...*" If advice was offered by teachers it was more in the vein of becoming teachers, working in travel and tourism or taking science at university. When questioned if the built environment had been discussed as a career option,

not one replied positively, information aimed at the boys and not girls. One individual declared "…*teachers seemed surprised when I said I was applying to do architecture*".

Work Experience

Work experience is arguably an important stage toward a working life for schoolchildren nearing school-leaving age. Almost half of participants did not receive work experience. Those that did, experienced working in hotels; two in equine centres; one being "*...bored at an accountancy office*"; two in pharmacies, one just "*...sweeping up at the end of the day*". Another described "*...sweeping up cockroaches*" at a stadium and at a swimming baths "*...waiting for someone to drown*"! Only three declared work experience worthwhile and relevant to construction.

Recruitment, Training and Work

Participant's experiences during recruitment and/or training provided a variety of responses; both positive and negative. An assistant QS confessed her recruitment "*...was easy*…" and now "…*if any help was needed I could ask anyone*"; even though they are all male "*...I am the only female who goes to site*". A similar response was "…*the boss took me out onto sites during my initial training…I now go on my own but if I have a problem my boss will help me*". Others had worked in sectors such as the fire service, "…*a male dominated environment…so it does not faze me…*" and have "…*never felt discriminated…wherever I have worked has always been positive*". Another recounted the informality of her interview process, "…*I took in a portfolio of my work and was told I had the job...*" as an architectural technologist.

A concerned participant stated "*... I wanted to be a trainee…it took me three 'shots' to be where I am now...there is an element of 'old school'...*" A piece of advice she provided when applying for jobs was "…*not to indicate you're a woman to get to the interview stage…it happened in a few places where I have been invited to interview…when attending the interviews, there were a few 'raised eyebrows'...*".

A negative experience in work placement "…*in a private practice, I often felt subject to sexual discrimination. There would always be comments from one of the directors and after 6 months I got moved into a room with him by myself. This made me feel very uncomfortable on a daily basis and the comments continued…even always assumed I would make his tea!*" Now working for another employer "…*it is completely the opposite…encouraged to progress and I feel as if I am part of a team…I know I have a lot to learn I feel like they want me to be here and want me to learn…not sure if this is the difference between private practice and local government?*"

One confessed she came into construction *late* and considers construction a "…*negative environment to be in for a woman. It may sound harsh and may not be an intentional thing; a lot of men I work with and around tend to see you as the little girl in the office…does not matter how bright you are, it is very hard for them to see past that barrier…it has been hard for my boss to accept what I can do…as I become more confident and realise what I know and my value* (is to the company)*…I find it hard to step out of the role I did before…"* Ironically, she admitted "*...the foremen and tradesmen are more accepting in the change in my role…more difficult for the manager…the policies are in place, it's just the acceptance of them*".

Some advice proffered to women was "*...be confident and give commitment, it seems as if commitment is one of the big issues…childcare...and young parents having to finish at 3.30…if you're a QS or an architect it's a long day, you have to be there for the full days and full weeks*".

Further Thoughts

Respondents opinions for the gender imbalance included "*...industry image*"; "*…confidence to get into the industry*"; "*...traditionally a male dominated environment, women probably worry that prejudice will occur*"; "*...not many women are aware of the various options within the construction industry from school age*". One suggestion was "*…more a fact that women don't choose to come into the industry….needs more advertising…I grew up in that environment* (father a QS) *but if not in it, it can be daunting but it's not bad actually…things have changed a lot*". Another suggested to "*Look at recruitment as a whole…careers have changed…advice needs to change…lot more information to* (school) *children*". One concern was "*No media coverage…* (her) *daughter would not be given advice at all about construction at school*".

Almost half mentioned SSCs targeting schools offering advice to potential candidates; comments such as "*Go back into schools more often…improve image…still think of 'girls jobs' and 'boys jobs'*; and "*…more hands on experiences and experiments from primary school age…imagination needs to be stimulated early*". Another confirmed "*More promotion within schools, the younger schools, primary schools. The last year of primary school is where you really think, when you are going up to comprehensive…target the younger years…not just year 9 or 10 where they have to make a decision*". She added, *"Knowing what I know now I would have done design technology* (in school) *but nobody told me*" of the options available.

Some enforced the need for change. "*People in industry* (training) *need to get used to women being in the industry…marketing…showing women*"; and "*...introduce girls early through work experience…vet placements early on for suitability*". A criticism railed at an SSC was they "*...are only good for chasing bills at the end of the year…don't support the employer to support apprentices…no idea of taking on females*".

ANALYSIS OF DISCUSSIONS

Careers advice for school leavers remains effectively under-utilised, not providing the full range of employment opportunities, significantly construction (SummitSkills 2010). If school teachers cannot provide the information, more thorough careers advice must be provided to include visits by suitably vetted built environment employers, considering Clarke and Gribling's (2008) assertion, to attract the required calibre of prospective candidate at an early age whether male or female. Successful women may help to improve diversity (Gurjao 2006, Lloyd 2009) in targeting schools more effectively, schools otherwise tending to guide towards the stereotypical male/female careers. The choice of subjects including woodwork, the 'male' fields of study, must be encouraged improving the reported stereotypical nature of learning in school.

Generally, any initial careers advice provided was either inappropriate or poor, on the whole directing the recipients towards the aforementioned stereotypical occupations; only those with a career in mind used the service effectively. Some admitted they did not listen to advice

and could not comment on the usefulness of the process. Subsequent advice prior to or during career changes from services such as Careers Wales was deemed to be more appropriate but used by only a small number of the women.

Issues were encountered during work experience (if provided); participants expected to generally work at 'conventional' female workplaces, three arranging their placements at built environment related organisations. Work experience was in the main unsatisfactory, participants utilised as 'cheap' labour by the hosts. A more rigid system of work placement is necessary, hosts vetted for suitability. By utilising an effective process with worthwhile realistic training for the incumbents, arguably more candidates of the calibre required for the industry will progress. It must be ensured both sexes are provided with equal opportunities and offered the chance of attaining qualifications outside the stereotypical job roles. Most of the interviewees did not initially choose to be involved in construction, those that did, influenced by parents or close relatives in the industry. Bearing in mind Lu and Sexton (2010), even parents in the industry may dissuade their daughters from taking construction careers but some will have a positive effect if only by osmosis. Those that end up in construction tended to 'fall' into the positions than arrive there with a clear career path, begging the question if clearer career paths are mapped out with pre-school leavers, would more females take on the technical roles in the built environment? Many participants did not remain with their original professions but eventually moved to their current positions by a chain of events and by chance.

A concern is the poor image of the built environment amongst the general public, until that issue is thoroughly addressed it will continue to pervade public psyche. To counter that, as a contractor referred, there are fantastic landmark buildings to be proud of so stakeholders must promote that it can be a very rewarding industry to be employed in. There are not many sectors where its incumbents can stand back and proudly say "*I was involved in part of that*".

The significant gender imbalance can in part be connected to the lack of effective media coverage, as one interviewee stated "*…women don't choose to come into the industry…*". A problem of the general lack of awareness of the possibilities is; everyone is a "*builder*" in the negative sense. To counteract O'Donnell's (2008) ineffective promotion assertion, a broader spread of parents and prospective school leavers may be targeted to effectively highlight the range of careers on offer.

The apparent lack of knowledge of industry networks requires addressing to offset McCarthy's (2010) view of the lack of provision of a supportive network. Used effectively the networks can provide further support to complement *ambassadors* as discussed by Murphy and Ren (2010). The use of peers providing support and advice to individuals (Lu et al. 2008; Lu and Sexton 2010) is not a new phenomenon but the call from most interviewees for more of this form of encouragement provides added weight for a clear structure of peer support and networks. The ConstructionSkills model of 'ambassadors' should be utilised thoroughly and from evidence provided, employed to encourage not only females already working in the industry but those considering a construction career whether school leavers or those considering changing vocation.

The ConstructionSkills-Wales (2010) document "*Be part of tomorrow*" enthuses careers opportunities available in construction. It would be interesting to follow up how effective such publications are in terms of attracting youngsters into the industry, particularly girls, as it includes two case studies of successful women. It is apparent, reiterating O'Donnell (2008)

there is a lack of sustainable and thorough promotional campaigns and ongoing review to deduce the effectiveness of those campaigns. Campaigns are seemingly initiated in waves pertaining to contemporary issues and themes at the time. Comments made by a number of respondents were they had seen little or no publicity for opportunities in the built environment, if it was there; it was not reaching those that mattered.

To test the internal validity of my interpretation of the discussions, the participants were requested to provide feedback on my analysis, from that a number of similar replies were returned. Responses ranged from simple confirmation or agreement of the accuracy of the reported results or as in one particular case a further affirmation of the issues already discussed. H, a female trainee QS employed by an SME, confirmed the need for better promotion of successful women in the industry, the success of that arguably increasing female uptake, "*...if they are aware of the roles and possibilities that are within the industry for them*". She continued, "*Career's advice needs to be much broader...with the acceptance of women doing 'men's work' such as roles within construction and men doing 'women's work' such as nursing. Career advice should not be aimed at the stereotypical roles for the different sexes, but should give everyone a broad range of advice*.

H did not differentiate between the sexes and confirmed, "*Specialist career days should be set up where each sex can find out about the roles without discrimination*". The issue of poor built environment advice provided in schools was also touched upon continuing on the *Career Days* theme, stating, "*These should be made compulsory within school so that girls would attend instead of thinking they didn't need to go as it was for the boys. Without the knowledge of the roles, then many women will not find construction as an attractive industry to work*". H summed up her response declaring, "*With knowledge and acceptance, it will be a big help to allow females into the industry*".

CONCLUSION

Considering the Eaton and Morton's (2008) scenario and employing that method with role models as Lu et al. (2008) and McCarthy (2010) discuss, opportunities will arise to provide for realistic and effective work experience for both sexes, the objective being to attract more females into the industry. It could be considered a 'token' gesture towards women but Lawrance's (2009) argument counters that with the "*…massive under representation … undermines…a sense of social justice*…" albeit relating to an engineering context. Similarly, as Keith Clarke of Atkins was reported by Swiszczowski (2007) "*Diversity and differences enrich organisations and are the opposite of tokenism…achieving diversity is not convenient but is a right*".

The inclusion of the built environment (reflecting the CIB's (1996) emphasis) as part of the school curriculum in the 14-16 provision and in the process of being "rolled out" in Wales as a 'pilot' is the Principal Learning qualification. Already used in England, it may be arguably provided at the moment, only to 'disaffected' schoolchildren. Included in the qualification is a wide range of learning criteria connected to the industry with a provision for work experience. By utilising effective placements with worthwhile realistic training for the students, hopefully more candidates of the calibre required for the industry will come forward as a result of the process. An assurance and willingness from all educational establishments must be provided that both sexes are presented with the equal opportunity of attaining the qualification, not guiding the girls into stereotypical job roles as reported. Whether male or

female, it is recognised that a "sense of humour" is required for what can be a very demanding and challenging industry to work in regardless of occupation or profession. The case of "*getting used*" to old industry attitudes is another matter and is unacceptable, the industry needs to move on and accept modern values to become a modern, unbiased industry.

Finally, the question posed by Dainty et al. (2005) why should women (and ethnic minority and disabled people, not discussed here) be attracted to an industry where evidence of negativity apparently remains? Do women need to 'undo' (Powell et al. 2009) their gender to cope with the industry? What changes are needed to make the industry not only attractive but also a viable option for others other than men to build a career in it?

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RETROFITTING COMMERCIAL OFFICE BUILDINGS FOR SUSTAINABILITY: TENANTS' EXPECTATIONS AND EXPERIENCES

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ABSTRACT

Introduction
Buildings, which account for approximately half of all annual energy and greenhouse gas emissions, are an important target area for any strategy addressing climate change. Whilst new commercial buildings increasingly address sustainability considerations, incorporating sustainability technologies in the refurbishment process of older buildings is technically, financially and socially challenging. This research explores the expectations and experiences of commercial office building tenants, whose building was under-going sustainability retrofitting.

Methodology
Semi-structured in-depth interviews with seven residents and neighbours of a large case-study building under-going sustainability refurbishment in Melbourne, Australia. Built in 1979, the 7,008m² 'B' grade building consists of 11 upper levels of office accommodation, ground floor retail, and a basement area leased as a licensed restaurant. After refurbishment, which included the installation of chilled water pumps, solar water heating, waterless urinals, insulation, disabled toilets, and automatic dimming lights, it was expected that the environmental performance of the building would move from a non-existent zero ABGR (Australian Building Greenhouse Rating) star rating to 3.5 stars, with a 40% reduction in water consumption and 20% reduction in energy consumption. Interviews were transcribed, with responses analysed using a thematic approach, identifying categories, themes and patterns.

Results
Commercial property tenants are on a journey to sustainability - they are interested and willing to engage in discussions about sustainability initiatives, but the process, costs and benefits need to be clear. Critically, whilst sustainability was an essential and non-negotiable criterion in building selection for government and larger corporate tenants, sustainability was not yet a core business value for smaller organisations – whilst they could see it as an emerging issue, they wanted detailed cost-benefit analyses, pay-back calculations of proposed technologies and, ideally, wished they could trial the technology first-hand in some way. Although extremely interested in learning more, most participants reported relatively minimal knowledge of specific sustainability features, designs or products. In discussions about different sustainable technologies (e.g., waterless urinals, sustainable carpets), participants frequently commented that they knew little about the technology, had not heard of it or were not sure exactly how it worked. Whilst participants viewed sustainable commercial buildings as the future, they had varied expectations about the fate of existing older buildings – most

felt that they would have to be retrofitted at some point to meet market expectations and predicted the emergence of a 'non-sustainability discount' for residing in a building without sustainable features.

Discussion

This research offers a beginning point for understanding the difficulty of integrating sustainable technologies in older commercial buildings. Tenants currently have limited understandings of technology and potential building performance outcomes, which ultimately could impede the implementation of sustainable initiatives in older buildings. Whilst the commercial property market is interested in learning about sustainability in the built environment, the findings highlight the importance of developing a strong business case, communication and transition plan for implementing sustainability retrofits in existing commercial buildings.

Keywords*:* commercial buildings, retrofitting for sustainability, qualitative research

As buildings are responsible for nearly half of all global energy and greenhouse gas emissions, there is increasing pressure for the design, construction and maintenance of the built environment to be environmentally sustainable (Brown *et al.*, 2005; Commission for Architecture and the Built Environment, 2007). Indeed, internationally, many government agencies and private organisations are mandating the integration of environmentally sustainable development (ESD) principles in commercial buildings and enforcing sustainability benchmarks for buildings (Madew, 2006). Yet, whilst it is relatively easy to incorporate sustainability technologies and initiatives into new buildings, retrofitting existing buildings for sustainability is much more difficult Thus, to better understand the challenges, this paper explores the experience of residents and neighbours of a large case-study building under-going sustainability refurbishment in Melbourne, Australia.

Sustainable commercial buildings

There is a wide diversity of definitions for a 'sustainable' building, but the Green Building Council of Australia (Madew, 2003, p.15) defines it as one that "incorporates design, construction and operational practices that significantly reduce or eliminate the negative impact of development on the environment and occupants with strategies for addressing: energy efficiency; greenhouse gas emission abatement; water conservation; waste avoidance, reuse and recycling; pollution prevention - noise, water, air, soil & light; enhanced biodiversity; reduced natural resource consumption; productive & healthier environments; flexible & adaptable spaces". Similarly, Lucuik (2005) argues that the essential difference between a sustainable and conventional building is that sustainable buildings offer healthier interior spaces and include measures which reduce a building's ecological footprint. Critically, there has been significant market transformation towards sustainable buildings due to their environmental, social and economic benefits. As well as reducing environmental impact through energy and water efficiency, research suggests that sustainable buildings are cost-effective and enhance occupant wellbeing and productivity (Madew, 2003). Yet, whilst it is relatively easy to integrate standard sustainable features and products into new buildings, a key challenge is the retrofitting and refurbishment of existing buildings.

Retrofitting commercial buildings for sustainability

Existing buildings, designed without sustainability as a key consideration, are much less energy and resource efficient then most new buildings. Retrofitting existing buildings for sustainability is much more challenging, however, than designing a new sustainable building from scratch. Retrofitting for sustainability is typically viewed as expensive and disruptive, with building owners wary of the design challenges and costs and building users resistance to change and the disruptive process (The Royal Institution of Chartered Surveyors, 2007). Fortunately, there is increasing international pressure for action; for example, in May 2007, under the banner of the Clinton Climate Initiative (CCI, 2010), former President Bill Clinton announced the creation of a global Energy Efficiency Building Retrofit Program. In an attempt to reduce energy consumption in existing buildings, the program brings together energy service companies, banks, and fifteen of the world's largest cities, including Melbourne in Australia. The participating city councils will retrofit buildings and develop incentives to encourage private owners to audit and retrofit buildings, with the energy service companies conducting audits to identify energy efficient opportunities and the banks financing these retrofits at no net cost (paybacks for the loans plus interest will come from future energy savings). Initiatives such as these are designed to foster the implementation and uptake of sustainable interventions into existing commercial buildings.

In Australia, the reality is that older existing buildings comprise the bulk of commercial office accommodation: according to the Property Council of Australia's (PCA) Major Office Market Report (2005, cited in Madew, 2006), existing B and C grade (i.e., non sustainable) buildings comprise over half (53%) of the existing office building stock. Thus, like many developed economies, making the transition to a sustainable built environment will require significant investment from developers and property owners. And despite the environmental benefits of retrofitting for sustainability, there remain significant economic and social barriers. First, from an economic perspective, although several studies have demonstrated that sustainability initiatives are, in the long-term, cost-neutral and often significantly reduce expenses deriving from water and energy consumption (see Davies 2005; Lucuik, 2005), the reality is that an initial financial outlay is necessary to install sustainability features in existing commercial buildings. Second, from a social perspective, there needs to be a demand for supply – for substantial change to occur, citizens (especially tenants) need to place a value on sustainability and demand that existing buildings adopt sustainable initiatives and practices.

The reality is that, regardless of the ability of designers and constructors to create high quality sustainable built environments, the cost involved with incorporating sustainable features in either new or existing assets means that it will only become mainstream when tenants demand it. This is particularly problematic given the almost inevitable degree of disruption associated with any building renovation – as Pivo (2010) explains through eight examples from the United States, Europe, and Australia, whilst improving existing commercial buildings is better than demolishment, it is often more difficult because there must be cooperation between owners and tenants. Indeed, even the development and construction of a new sustainable building can be very challenging, as Brown and Vergragt (2008) documented via a recent case study and interviews with six project management team

members (architects, developer, urban planner, energy analyst) involved with a new zero-energy residential building in Chicago. Focussing on problem definition, learning style and processes, Brown and Vergragt (2008) found that ensuring key stakeholders share the same vision, and are open to sharing ideas and learning together was critical to the success of the project. Rohracher and Ornetzeder (2002) explored the impacts of living in green buildings on occupants and found that only owners of apartments, who participated in planning, design and construction decisions accepted and incorporated new sustainable energy-saving technologies into their daily lives. Apartment tenants, who did not participate in the decision-making process, were much less positive. Such findings raise interesting questions about how tenants of existing non-sustainable commercial buildings might experience and react to decisions to retrofit for sustainability, especially when the retrofitting process is disruptive and owner-driven.

To date, very little is known about how commercial building occupants view and experience retrofitting for sustainability. Thus, to begin to fill this knowledge gap, our exploratory qualitative research explores the experience of residents and neighbours of a large case-study building under-going sustainability refurbishment in Melbourne, Australia. Three research questions drove this study: (a) do commercial building tenants perceive sustainability as a key criterion in building selection; (b) what is the existing knowledge base and relative importance of sustainability for commercial building tenants and (c) what is the actual experience of undergoing sustainability refurbishment.

Method

Participants and procedure

Five residents (50% of the current tenants) and two neighbours (a state government representative and a leasing agent) of the case-study building in the central business district of Melbourne, Victoria were interviewed. Whilst only a relatively small number of participants were interviewed (n=7) in this exploratory study, it is important to remember that in qualitative research: "the success of a study is *not* in the least dependent on sample size, it is *not* the case that a larger sample necessarily indicates a more painstaking or worthwhile piece of research. Indeed, more interviews can simply add to the labour involved without adding anything to the analysis" (Potter & Wetherell, 1987, p. 161). Potential interviewees were contacted via email and phone and invited to participate in an in-depth interview exploring sustainability issues in commercial buildings. Participants received an information packet and consent form which provided details of the project. The interviews, which lasted between 45 minutes and 2 hours, were conducted in a convenient location chosen by the participant. A semi-structured discussion format was utilised to explore perceptions of sustainable features and services in existing commercial buildings, focussing on the interviewees' experiences and understandings. The following areas were broadly covered: key factors influencing commercial building selection, experience in case-study building (including refurbishment process), knowledge of sustainable initiatives, designs and technologies, and the relative appeal of sustainability from personal and corporate decision-making perspectives.

Case Study Building and Locality

At the time of interviews (late 2007), the large case-study building was under-going refurbishment for sustainability. Built in 1979, the 7,008m² 'B' grade building consists of 11 upper levels of office accommodation, ground floor retail, and a basement area leased as a licensed restaurant. After refurbishment, which included the installation of chilled water pumps, solar water heating, waterless urinals, insulation, disabled toilets, and automatic dimming lights, it was expected that the environmental performance of the building would move from a non-existent zero ABGR (Australian Building Greenhouse Rating) star rating to 3.5 stars, with a 40% reduction in water consumption and 20% reduction in energy consumption. This building was located in the central business district of Melbourne, the state capital of Victoria in Australia. Whilst sustainability considerations are increasingly important in all of Australia, Victoria in particular has made sustainability in the built environment a top priority and views itself as a world leader in this area. This is demonstrated by Melbourne's participation (one of only 15 cities worldwide) in the Clinton Climate Initiative's Efficiency Building Retrofit Program (CCI, 2010).

Analysis

Transcripts and responses were analysed using a thematic approach, identifying key categories, themes and patterns. The process of identifying, categorising and coding data, described by Punch (1998) as "putting tags, names or labels against pieces of the data" (p204), helps reduce and simplify the vast amount of data and identify dominant themes. A key focus was to identify the extent of convergence or divergence in views on the relative importance of sustainability in existing commercial buildings.

Results

All participants felt there had been a significant growth in demand for sustainable buildings, as people have become more aware of the importance of conserving the natural environment and the impact buildings have. As the quote below illustrates, making commercial buildings sustainable was seen as the responsible and '*right thing to do'*. In particular, tenants described how staff and clients expected their business to be sustainable, and the younger generation in particular were increasingly expecting to "*help save the environment at home and work*". Having a sustainable office was increasingly viewed as a factor in recruiting staff, with several participants indicating that potential staff (primarily Generation Y) had asked in interviews what the organisation did to promote sustainability.

> Residing in a sustainable building is very important – it reduces my outgoings which means I make more money. It creates a better work environment which means my staff will want to come to work because the place is attractive, pleasant and comfortable. And I think consciously or subconsciously they feel that they are making a contribution because they are working in a work environment that is in a sustainable building and the other things is that I can say to my clients this is part of my commitment.
>
> To me it would be ridiculous to be looking after the staff's wellbeing without having environmental policies in place. I occasionally get asked about our environmental policy. They want to know what we do – if we have a social conscience. They want to know what we do for the environment, whether we give to charity and what charities we give to.

Making older buildings 'sustainable'

With sustainable commercial buildings viewed as the future, participants had varied expectations about the fate of existing older buildings. Although most felt that there would

always be a place for older non-sustainable buildings, there was an expectation that most would have to be retrofitted at some point to meet market expectations.

> I think there are people out there looking for that competitive edge. Not only in terms of being able to brag about the fact that they have 5 star [sustainability] rating, but also increasingly with the cost of overheads

> Owners who don't take this [sustainability] approach now or in the near future will basically rule themselves out of obtaining about 70% of the marketplace. If you don't address this, you are going to be left behind the eight ball and you will find it will eventually hit your hip pocket because you haven't done it.. so you are better off spending the dollars now, meeting the tenants needs.. where the market is going now.

There was a view that older commercial buildings could not be brought up to the ideal sustainability standard and thus should be either demolished or turned into residential apartments. Others suggested that as sustainable buildings become mainstream, there may be a 'non-sustainability discount' for residing in a building without sustainable features. The argument was that as operating costs (i.e., water & energy) would be lower in a sustainable building, there should be a rental subsidy in non-sustainable buildings to compensate for this.

Sustainable technologies: aware, but not knowledgeable

For many, sustainability in commercial buildings was currently a relatively abstract concept. Participants frequently described themselves as '*aware, but not knowledgeable*' about sustainable technologies. In addition, although generally supportive of sustainable technologies, occasionally there were questions about whether there was the same standard of quality in services (particularly among the potentially less well tested and developing technologies) and demand for specific cost-benefit analyses. In discussions about different sustainable technologies (e.g., waterless urinals, sustainable carpets etc), participants frequently commented that they knew little about the technology, had not heard of it or were not sure exactly how it worked. Comments such as the following, in response to a question about waterless urinals, were common: *"I've heard of them but I don't know a great deal about it. If they do the work as well as the ones with the water in them and they are still as clean and sanitary then I think it is great"*. Many current tenants of the case-study building also wanted to be convinced of the financial value of sustainable initiatives. They wanted tangible evidence through exposure to case-study buildings, detailed cost-benefit analyses, examples, and the ability to trial and 'see it in action'. The cost was critical, with sustainability "*not a big factor, not overtly prioritised….need to convince him [management] why this would be good for 'me' – I think it is always for 'me' first then the environmental benefit because it is really all about me – in the society we are living in and the business definitely it is always at the bottom dollar"*.

Role of organisational size in commitment to sustainability

Interestingly, the relative importance and experience of sustainability in commercial buildings differed considerably as a function of organisation size. For smaller organisations, sustainability was not yet a core business value. The greatest barrier to sustainability raised by smaller organisations was cost, with participants expressing a desire to see detailed cost-benefit analyses and pay-back calculations of proposed technologies and, ideally, wished they could trial the technology first-hand in some way. Notably, although current tenants did not

want to pay more rent, most were open to discussions about the implementation of sustainable initiatives, particularly those associated with reducing energy (i.e., lighting and air-conditioning). In general, smaller organisations were relatively unaware and uninterested in cost-sharing arrangements and partnerships, such as 'green' leases, which were perceived to be too complicated. For government and larger corporate tenants, however, sustainability was a critical factor and they *expected* to reside in sustainable and green star rated buildings. Sustainability was the norm and residing in non-sustainable buildings was *not an option*. Essentially, sustainability was a non-negotiable criterion in building selection for government and larger private organisations. To capture this market, some participants recommended that owners and landlords seize opportunities (i.e., vacancies) to integrate sustainable features and 'future-proof' buildings or they would be ruled out of the majority of the market in the future.

Experience of refurbishment in case study building

In terms of the case-study building, tenants were clear about their likes and dislikes. Participants were extremely satisfied with the natural light and views offered by the building, emphasising the benefits of the layout and location. On the other hand, the lifts and general 'oldness' of the building were negatives. The refurbishment process was described as never-ending, with some noting that if the installation of sustainable initiatives took as long and was as disruptive they would have to think 'long and hard' about the cost-benefit balance.

> One thing we have noticed here is how disruptive the work is progress are – we've had constant clients come in and there is noise. And if someone said to us for the next five years to upgrade to set to a certain standard there would be noise all the time there would be some kind of consideration about leaving the building and obviously that wouldn't be so great for us... but ultimately that building would be up to scratch eventually

Case-study building tenants emphasised the importance of retrofitting in a manner which is cost-effective (i.e., immediately obvious initiatives, such as smart/low-energy lighting and air-conditioning) and socially-acceptable (i.e., minimal impact on existing tenants). However, on the other hand, one tenant encouraged the owners and management to be innovative and 'think outside the box' in terms of retrofitting the building, possibly via the development of a roof-top garden and communal space.

Discussion

This research offers a beginning point for understanding the difficulty of integrating sustainable technology in older commercial buildings. Tenants currently have limited understandings of technology and potential building performance outcomes, which ultimately could impede the implementation of sustainable initiatives in older buildings. Whilst the commercial property market is interested in learning about sustainability in the built environment, the findings highlight the importance of developing a strong business case, clear communication about the benefits and a transition plan for implementing sustainability retrofits in existing commercial buildings. Whilst conducted in Australia, we believe these findings are applicable to commercial building sustainability retrofitting and refurbishment programs in most Western contexts and provide some valuable lessons for those wishing to implement such initiatives.

Overall, there is little doubt that participants were supportive of sustainability as a general principle and the idea of residing in a sustainable commercial building. They felt that residing in a sustainable building is a relatively easy way through which organisations can

demonstrate their commitment to the TBL philosophy, integrating economic, social and environmental considerations. This research suggests that the tenants of the case-study building are interested and willing to engage in discussions about sustainability initiatives, but that the process, costs and benefits needed to be clearly delineated. In light of these findings, there are three key recommendations.

First, with participants unanimously expecting sustainability in commercial offices to become standard in the next decade or so, it is clear that making the transition to sustainability should be a priority. Larger and government tenants will not consider non-sustainable commercial office buildings, with smaller tenants anticipating the emergence of a 'non-sustainability discount' for residing in a building without sustainable features that would cost them more in terms of utility outgoings (e.g., electricity, water). This is consistent with two recent Jones Lang La Salle reports (Hilderson, 2004; Wallbank 2006), which have highlighted the possibility of market-driven non-sustainability discount, which is essentially the opposite notion of a 'green' lease. Specifically, the reports raise the possibility that while "*tenants currently may not be willing to pay a premium rental for buildings with sustainability features, some tenants will very soon come to expect a discount to occupy buildings that do not have these features*" (Wallbank, 2006, p6). Thus, although change is not easy, given trends in the marketplace indicating 'sustainability' is good for asset value and may soon be non-negotiable, building owners need to consider building a sustainability retrofitting program into their planning.

Second, whilst generally accepting of the main environmental, financial and social benefits of sustainability, smaller organisations needed to see tangible proof and detailed cost/benefit analyses of specific sustainability features. Thus, occupant education regarding these issues (and particularly the cost benefit of them) needs to clearly quantify the financial and non-financial costs and benefits of each feature. Of concern is the finding that most participants reported relatively minimal knowledge of specific sustainability features, designs or products. Such limited knowledge highlights the importance of generic industry and consumer awareness-raising activities, illustrating that researchers need to work harder to ensure that the business case for sustainability is clear and convincing. Third, unlike new buildings, existing buildings need to be retrofitted, which inevitability involves some disruption for existing tenants. With case-study building tenants currently experiencing significant disruption due to ongoing refurbishment, they felt that the benefits of further retrofitting would have to be very clear; thus, we recommend the development of a clear transition plan, outlining the timeline, information and cost benefits of each sustainable feature or new technology essential.

Finally, we must acknowledge the limitations of our exploratory qualitative research, which is based on in-depth interviews with seven commercial building tenants in Melbourne, Australia. Obviously, we cannot draw generic conclusions from one small case study and our hope is that these findings will inspire other researchers to explore the experience of sustainability refurbishment and retrofitting. We would argue that although the attitudes and experiences described are not that dissimilar to those highlighted in other economies, future international and quantitative research is clearly needed to further explore these issues. Critically, whilst our study is obviously small scale, it has considerable depth: the building is

quite typical of much of the stock in central business districts across Australian cities and the profile of their tenant base. Our findings provide a unique insight into the challenges of retrofitting existing commercial buildings for sustainability and the expectations and experiences of tenants.

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CONCEPTUAL FRAMEWORK FOR POTENTIAL IMPLEMENTATIONS OF MULTI CRITERIA DECISION MAKING (MCDM) METHODS FOR DESIGN QUALITY ASSESSMENT

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Abstract

Architectural design can be considered as a process influenced by many stakeholders, each of which has different decision power. Each stakeholder might have his/her own criteria and weightings depending on his/her own perspective and role. Hence design can be seen as a multi-criteria decision making (MCDM) process.

Considering architectural design, its evaluation and quality assessment within a context of MCDM is not regularly performed within building processes. The aim of the paper is to find/adapt proper methodologies of MCDM, used in other domains for assessment of design quality, adapt them to the construction domain and test their applicability.

Current tools (for instance DQI, DEEP, AEDET, HQI, LEED, BREEAM, BQA) for quality assessment will be reviewed and compared with several MCDM methods (ie. AHP, ANP, PROMETHEE, SAW AND TOPSIS). Advantages and disadvantages of gathered outcomes from comparisons for assessment and applicability within architectural design will be discussed. Finally reflections on the outcomes will be provided.

Keywords: Architectural Design Quality, Analytic Hierarchy Process (AHP), Design Quality Assessment Tools, Multi Criteria Decision Making (MCDM)

INTRODUCTION

Dickson (2004) stated that, the overall design and procurement process can be seen as a series of decisions that lead progressively towards the built reality. Analysing a design process, as the sum of decisions made by each stakeholder with decisive power, is not the most often used way of approaching design (quality) within architecture. Considering design as a multi-stakeholder decision making process, it seems reasonable to apply multi criteria decision making (MCDM) techniques to asses design quality. MCDM can be defined as the evaluation of the alternatives for the purpose of selection or ranking, using a number of qualitative and/or quantitative criteria that have different measurement units (Özcan et al., 2011). Remarkably the most often used tools nowadays are based on evaluation of chosen criteria via Likert/rated scoring systems. The aim of the paper is to find out the potentials of MCDM methods for development of architectural design quality tools. For that reason existing quality tools will be analysed to bring out their strong and weak points. Methods used in other domains for decision making will be analysed to find possible potentials of them to cope with the weaknesses of current tools used in architectural design.

"Since solid theoretical foundation and best practices are rare in architecture and construction, it is recommended to learn from state-of-the-art in other relevant domains, i.e. social and organizational psychology, organizational management and behaviour, and other industries" (Sebastian, 2003, 2007). Built on this statement, this study aims to improve existing quality assessment tools used in architectural design, by using MCDM methods which are used in other domains for decision making. Quality assessments of multi-stakeholders might be useful in terms of providing designers with input for improving their design according to stakeholder preferences. Besides, their attitude is beneficial for taking decisions at design team meetings at stage boundaries, for selection between different design alternatives in case of disputes or design contests, or for post occupancy evaluations. The strategy within this research is to evaluate the most often used current tools more specific on the applicability seen from a multi stakeholder perspective, and to review existing MCDM methods as regularly used within other domains comparing them on their applicability within building processes.

The first part of the paper will cover a review of current tools used for assessment. After this, a discussion will follow to review their strengths and weaknesses, from a multi stakeholder decision making perspective. In the second part, MCDM methodologies will be analysed with the to what extend they might cope with the specific weaknesses which are defined in the first part of the paper as being characteristic for the existing tools most often used in practice. Also comparative analysis of Likert/rated scale to pair wise comparison will be revealed. Finally the outcomes will be discussed to reveal potentials of MCDM methods to use for architectural design quality assessment.

RELEVANCE AND BACKGROUNDS OF THE RESEARCH

Each architectural design most often typically can be seen as a one off production. The design process is complex, considering its content, context, stakeholders, ill-defined problems and moreover multifaceted interactions of them to each other. Design is obviously not a linear-running but an iterative process which is analysing through synthesizing (Sebastian, 2003, 2007). Each design process has special characteristics which cannot be standardized easily. Since buildings are so diverse, serving many different types of occupancies or functions, any attempt to develop a single system to define and rate performance of these buildings will not

be perfect and will even be unsatisfactory for many potential users (MacDonald, 2000). This might be the reason so many different assessment tools are developed for building processes.

As stated, within this research architectural design is considered to be a decision making process. Within the process, decisions are taken by the evaluation of criteria and sub-criteria from the perspectives of stakeholders related to various limitations, so called multi-criteria decision making (MCDM) processes. This might be seen as a valid approach as even in the simplest cases today at least architects in design processes have to cope with their clients or/and users, specialist engineering advisors, governmental bodies and the contractors. This approach is especially valid in case of, complex buildings for instance designs for the Health Care sector, in which projects (depending to a certain extend to their organization and national context) have a multi-facetted client situation (the diverse specialist and health groups and a wide variety of users) whose expert knowledge is an absolute necessity in terms of the future usability of the building and of which many have decisive power within the design and construction process.

In complex circumstances, our practice based experiences, interviews held and literature survey executed are shown that easy-to-use tools may provide unsatisfactory outcomes while intending to use efficiently and repetitively.

ARCHITECTURAL DESIGN QUALITY

Literature was reviewed for a common understanding of architectural design quality. In the history, one of the first written definitions date backs to 20's BC. Utilitas, Firmitas and Venustas – commonly translated as Commodity, Firmness and Delight- was one of the first defined frameworks for criteria used to asses architectural design quality as developed by the Roman architect Marcus Vitruvius. This Vitruvian framework has been an essential base for forthcoming architectural theory later on. The framework up till today is also the most addressed trilogy to define excellence. (Vitruvius, 1993; Volker et al., 2008; Prins, 2009)

Related to Nelson (2006), quality is the degree to which a set of inherent characteristics fulfils stated, implied or obligatory needs or expectations. Nelson (2006) defines quality for domain of architecture as improving the degree to which design fulfils needs and expectations. In the building environment, Volker et al. (2008) outlines that architectural quality embraces all the aspects by which a building is judged while in the construction industry, quality is associated with competency and proficiency levels as a route to customer satisfaction. (Thomson et al., 2003)

Throughout the history of architecture, definitions of criteria and their sub-criteria differ according to era, technology, culture and the society. Quality is a subjective matter meaning different things to different people depending on perceived priorities. (Choy and Burke, 2006) That is to say, quality is in the eye of the beholder. Within this paper, it is intended not only to explore methodologies but also to explore the criteria which may be effective about getting the ideas of stakeholders involved to the quality, rather than trying to create or contribute to the existing series of holistic attempts to define architectural quality.

RESEARCH METHODOLOGY

This paper aims to structure the conceptual framework of an assessment tool for architectural design quality based on MCDM methods. The research is based on an explorative analysis using an inductive approach according to the steps listed below:

- Current design tools –DQI, DEEP, AEDET, BREEAM, LEED and BQA-will be introduced and reviewed. (Tools are selected due to their reputation in academic papers and use in practice)
- Outcomes will be discussed to reveal strengths and weaknesses of the current tools from a multi stakeholder decision making perspective.
- MCDM methods, as widely used in other domains will be introduced and reviewed on applicability for architectural design and construction and compared with the earlier mentioned tools most often used today within the domain.
- The specific potential of MCDM methods will be discussed, more in special compared to the weaknesses of the current tools used in architectural design and construction.

Research questions related with the steps are:

- How are the tools linked to architectural design quality assessment?
- What are the criteria and sub-criteria of the currently used tools for architectural design quality assessment?
- Are the tools flexible/adaptable enough to change the criteria for different types of buildings and for different project teams?
- What are the assessment methodologies?
- What is the difference between Likert/Rated scale and pair wise comparison? Which one should be used for design quality assessment?
- What are the strengths and weaknesses of the current tools?
- Can MCDM methods be used for assessment of quality?
- Can MCDM methods cope with the weaknesses of the current tools, more in special as discussed in an MCDM perspective and for the different usages mentioned?

CRITICAL REVIEW OF ARCHITECTURAL DESIGN QUALITY ASSESSMENT TOOLS

What cannot be numerically measured is deemed not to exist (Prasad, 2004)

Design quality is a complex phenomenon. Everybody has an opinion about buildings and quality, but consensus and scientific explanations are difficult. (Dewulf and van Meel, 2004). Nevertheless to cope with the problem of evaluation, several tools have been developed which have different approaches for assessment. DQI, AEDET Evolution, DEEP, HQI, LEED, BREEAM and BQA are the tools chosen for analysis within this paper. They are selected due to their reputation in academic publications and their usage frequency in practice depending on literature review. (Dewulf and van Meel, 2004 - Gann et al., 2003 - van der Voordt, 2009, 2005 - Volker et al., 2008 – Volker , 2010 - Giddings et al., 2010 - MacMillan, 2004 CABE, 2011) Following brief explanations about the tools, they will be reviewed especially for their criteria selection, methodology, scope of assessment possible usage phases in building process and their efficiency and applicability.

DQI (Design Quality Indicator)

The Design Quality Indicator (DQI), maybe the best known tool amongst the others, was developed based on a "rational-adaptive approach" (Volker, 2010) as an extension of the "*Rethinking Construction Agenda*" for targeting, mapping, measuring and managing performance improvement in construction. (Gann et al., 2003) There is a general DQI for all building types and a specific one for school buildings; together with two subsets, AEDET which focuses on hospitals and DEEP, which is exclusively for military housing (Giddings et al., 2010). The tool is based on a method that integrates measures of 'hard' physical attributes and 'soft' perceptual viewpoints about the performance of buildings in relation to design decisions. The former are typically found in areas such as build quality and function. (Whyte, j. et al., 2004) More detailed information can be found, in Gann et al (2004).

AEDET Evolution (Achieving Excellence Design Evaluation Toolkit)

The AEDET Evolution (Achieving Excellence Design Evaluation) Toolkit -the latest version of AEDET- is a subset modification of DQI, aims to be used in case of healthcare facilities to evaluate architectural design quality. It delivers a profile that indicates the strengths and weaknesses of a design or an existing building. AEDET is a tool specifically directed towards achieving 'excellence in design' rather than ensuring compliance with legislation, regulation and guidance (Aedet web page). It can be used from initial proposals through to post project evaluation. It is also being used as a benchmarking tool. The toolkit comprises a series of key questions supported by lists of related issues that need to be considered (AEDET webpage) (van der voordt, 2009, 2005). A detailed review can be found in Gesler et al. (2004).

DEEP (Design Excellence Evaluation Process)

The DEEP (Design Excellence Evaluation Process) Toolkit is also a subset modification of DQI to be used in buildings of the United Kingdom Ministry Of Defense to evaluate architectural design quality at the key stages in the project life cycle. DEEP determines both the required design standard (usually expressed as a percentage) and compliance with required minimum standards. DEEP provides the technical assurance that a military construction project is both compliant with Government construction policies and of a sufficient design quality to ensure fitness for purpose and value for money over the whole life of the facility. (DEEP web page)

HQI (Housing Quality Indicator)

Housing Quality Indicator (HQI) measures the quality of housing schemes funded through the United Kingdom National Affordable Housing Programme (NAHP)(HQI web page). It was developed with ease of use in mind. The HQI system allows an assessment of quality of the key features of a housing project in relation to location, design and performance. The system was developed such that quality is evaluated from many different aspects (Wheeler, p., 2004). According to Giddings et al. (2010), design quality assessment using this tool, is limited to standards and measurement. More can be found at Giddings et al. (2010) Wheeler,P. (2004) and Franklin (2001)

BREEAM (Building Research Establishment Environmental Assessment Method)

BREEAM (Building Research Establishment Environmental Assessment Method) is one of the oldest building assessment systems. Developed in 1988 by the Building Research Establishment (BRE), the national building research organization of the UK, it was initially created to help transform the construction of office buildings to high performance standards (Ulukavak Harputlugil and Hensen, 2006). BREEAM which covers a range of building types, including offices; industrial premises; retail outlets; schools, etc has been an inspiring tool which

further developed tools have adapted as a reference model, and also is widely used in other countries (Lee and Burnett, 2008). BREEAM nowadays developed into one of the leading and most widely used environmental assessment methods for buildings. It sets the standard for best practice in sustainable design, describing a building's environmental performance. (BREEAM web site)

LEED (Leadership in Energy & Environmental Design)
LEED is an internationally recognized green building certification system. It provides third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most in this respect: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. (LEED website)

BQA (Building Quality Assessment)
BQA is a tool for scoring the performance of a building, relating actual performance to identified requirements for user groups in that type of building. The quality of a building is defined in BQA as the degree to which the design and specification meets the requirements for that building (Clift, 1996). The BQA system divides the building into nine categories that establish a broad classification of user requirements. The performance and quality of a number of office buildings can be compared at all levels – the overall BQA total, the category and/or section totals and down to the individual factor levels. Individual clients using BQA can choose their own weightings if they wish to emphasize a particular characteristic.

SYSTEMATIC REVIEW OF MOST COMMONLY USED QUALITY ASSESSMENT TOOLS

There are several tools to assess, evaluate and define architectural design quality, some of the most important of them described above. Developing such tools in a wide variety, for different types of buildings system represents the struggle to improve the quality of buildings and the build environment in general (Wheeler, 2004). The quality assessment tools discussed above were reviewed to bring out strengths and weaknesses depending their usage for certain building types, methodology, scope of assessment, their use in the building process, organization and finally their criteria and sub-criteria selection. (Table 2)

	DQI	AEDET	DEEP	HQI	LEED	BREEAM	BQA
1)Building Type	Educational Buildings Specific. (Can also be used on wide variety of buildings)	Hospitals (Health Care facilities)	Military Housing	Housing (schemes)	All types of buildings (residential to commercial)	Housing Eco-homes Office Schools Industrial build. Courts Healthcare Prison Retail education (Other types of buildings)	Office buildings
	DQI, LEED and BREEAM can be used for a wide variety of buildings, while the rest is more or less related with a specific building type.						
2)Aim of Use	-Architectural design quality (ADQ) assessment	-ADQ Assessment -Benchmarking	-ADQ Assessment -Generic Checklist	-Measurement and assessment of potential and existing house schemes based ADQ	-Green building certification system	-Sets the standard for best practice for sustainability	-Performance assessment
	DQI, AEDET, DEEP and HQI aim to assess architectural design quality. LEED and BREEAM try to set the standards for certification of green buildings, while BQA aims to assess the performance of office buildings.						

3)Main Criteria **Sub-Criteria**	**-Functionality** Use Access Space **-Build Quality** Performance Engineering sys. Construction **-Impact** Character &Innovation Urban&social Integration Staff Environment	**-Functionality** Use Access Space **-Build Quality** Performance Engineering sys Construction **-Impact** Character &Innovation Urban &social Integration Staff& Patient Environment	**-Functionality** Client Operation Single Living Accommodation Innovation **-Build Quality** Performance Engineering sys Building Fabric Innovation **-Impact** Context&estate Planning Form&appearance Internal Environment Conversation of buildings Sustainability	**-Location** **-Site** Visual Impact Open space Routes &movement **-Unit** Size Layout Noise,light, services and adaptability Accessibility Sustainability **-External environment** Size	**-Sustainable Sites** **-Water Efficiency** **-Energy and Atmosphere** **-Materials and Resources** **-Indoor Environmental Quality** **-Location& linkages** **-Awareness &education** **-Innovation in design** **-Regional Priority.**	**-Management** Life cycle cost Site investigation **-Health and well Being** Lighting Water Noise control **-Energy** Co2 emissions Energy use Noise control **-Transport** Public Transport Cyclist Deliveries **-Water** Recycling Irrigation sys. **-Materials** Re-use Insulation **-Landuse &Ecology** Re-use Ecological value Bio diversity **-Pollution** Water sources Refrigerant leaks **-Innovation**	**-Presentation** **-Space functionality** **-Access and circulation** **-Business services** **-Amenities** **-Working and environment** **-Health and safety** **-Structural considerations** **-manageability**
	The tools use adapted Vitruvian frameworks which can be defined as functionality, build quality and impact, extended with ecological approaches like sustainability, health, wellbeing and preserving resources for assessment of architectural design quality. For assessment, design quality is seen as a degree of excellence within the intersection of the main criteria with their sub-criteria.						
4)Adaptability /Flexibility	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	Adaptability for each building type	No adaptability
	No flexibility to change or adapt the criteria for different tasks. General modifications or updates on the system take time to get in action in further versions, which makes it hard to adapt the tools case based specific						
5)Methodology	Structured workshop, online form and questionnaires	Stand alone forms, Workshops	Stand Alone Forms Workshops (in some cases)	Stand alone forms	Online certification	Stand alone form	Software based survey
	The tools make assessment via standalone forms or in some cases with web based online surveys/questionnaires to reflect stakeholders' priorities. DQI, AEDET and DEEP also use workshops to get individual priorities. LEED, BREEAM, BQA use threshold levels for assessment of quality.						
6)Scope of Assessment	Achieve the best building possible based quality.	Evaluate the quality of design in healthcare buildings.	Identify and minimize risk in the design of projects (MOD Building)	Measurement and assessment of potential and existing house schemes based quality	Accelerate the adoption of green building practices	Energy and sustainability	Assessment of Performance of a building
	DQI, DEEP,AEDET, HQI assess the design quality. LEED and BREAM certificates buildings related to energy usage and sustainability, while BQA assesses performance of a building						
7)Phase of Building Process	All stages of building process including all design stages.	All stages of building process including all design stages.	All stages of building process including all design stages.	Design and in use	All stages of building process including all design stages.	Design and in use	Post occupancy evaluation (can be carried out to design stages)
	All tools claim that they can be used within the all stages of building process from briefing to in use. Although the tools are introduced as they can be used in any stages of the building process, they can be used effectively in post occupancy evaluation (POE).						

8)Organization (stakeholders)	Internal and external stakeholders (Especially users)	Internal and external stakeholders	Internal and external stakeholders	Internal and external stakeholders	Commercial building project stakeholders or project team members	Internal and external stakeholders	Internal and external stakeholders
	The intention behind the tools on design quality is to get ideas for the stakeholders, especially from users, for the assessment of architectural design quality. Getting stakeholders ideas is a big plus to achieve success for integrated design teams, however transferring ideas to design process as knowledge for design teams can be underlined as missing part of the tools. Tools generally aim to score a building in general, rather than transferring knowledge to design teams.						
9)Weighting System	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale, Yes/No Questions	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale
	All of the tools use adapted Likert/rating scale system for assessment. Some of them are using verbal scales while others use point scaling system. HQI also asks Yes/No questions.						

Table 1: *Design quality assessment tools review.*

Strengths

- Tools tend to be used for assessment of design quality in a wide variety of buildings, although there are still limitations.
- Criteria selection mostly are based on a Vitruvian like framework and sustainable principles often after extended discussions and many iterations before these terms were agreed upon.(Gann et al., 2003)
- Dewulf and van Meel (2004) stress that the recognized importance of the built environment makes it absolutely necessary to discuss design quality with laymen, architects, government and other stakeholders. Proving the statement, there is a growing intention of the tools to get stakeholders ideas, especially users, for assessment of architectural design quality. Reflecting stakeholders' priorities in building processes is a big plus to achieve success for integrated design teams.

Weaknesses

- Although the tools can be used for different types of buildings and for different phases of building processes, it is still a problem to adapt the underlying system of the pre-defined sets of criteria (something all above mentioned tools have in common) for making a case base specific design evaluation.
- The tools have problems to contribute to design stages since they are not succeeded to make comparative assessment of design alternatives.
- Most often the tools must be used with expert facilitators, or are at least assumed to, which make assessment process tough considering total numbers of stakeholders and time needed.
- A big concern for all the tools reviewed is their weighting systems and their methodologies which they use for assessment. All the tools reviewed use a Likert/rating scale system, some of which use verbal judgments while the others use point system for scaling(HQI also uses Yes/No questions). Outcomes of the surveys related to assessment contain heterogeneous data since using this methodology it is not clearly known what the relative importance is of the each criteria and sub-criteria to each other.
- Another problem is the lack of consistency measurement. Consistency cannot be checked until a certain amount of participants exist. As the tools intend to get also non-expert stakeholders' ideas, consistency should be considered and inconsistent surveys should be avoided.

Considering the above mentioned weak sides of the currently used tools, multi criteria decision making methodologies will be introduced and evaluated on their ability to cope with them. After the review of methodologies, a comparative chart of the most used methodologies will be introduced to cope with the weak sides of the current tools for further developments.

PROBLEMS OF LIKERT/RATED SCALE

It is hard to find a holistic way of an assessment approach of architectural design quality. Architectural design quality consists of tangible and intangible criteria which may be evaluated from different perspectives of the stakeholders. Who is going to assess the quality? For who are they going to do this and how are the solid questions to be answered? To point out problems of Likert/rated scaling which is used by most of the current tools related to assessment of design quality; rather than stating problems in theoretical ways, it should be better to make a short illustration to analyze problems in practice. Since architectural design is a one off attempt, keeping in mind that criteria may vary for each design problem, let us consider 20 criteria consisting of both tangible and intangible factors for assessment of architectural design quality for an existing building. (Table 2)

Criteria
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20

Table 2: *Criteria List*

Having defined the criteria, in the second step, tangible and intangible criteria are grouped separately. (table 3)

Criteria	
Tangible	C1, C3, C5, C7, C9, C10,C11, C12, C15, C18,C19,C20
Intangible	C2,C4, C6, C8,C13,C14,C16,C17

Table 3: *Criteria List*

Based on Likert/rated scale, for the third step, criteria are listed for quality assessment. The respondents are asked to assign weighting to the importance of each feature; on a scale of Excellent/5/Strongly Agree to Poor/1/Strongly Disagree called "Likert /Rated Scaling" which most of the current tools use as a methodology for design quality assessment.

Criteria	**Excellent (5) Strongly agree**	**Very Good (4) Agree**	**Good (3) Undecided**	**Fair (2) Disagree**	**Poor (1) Strongly Disagree**	**No idea (0)**
C1	+					
C2		+				
C3						+
C4		+				
……						
…..						
C20			+			

AVERAGE	Average of the building is good/3/undecided

Table 4: *Likert/rated scale based assessment methodology*

During the evaluation problems may be stated as:

1) Although tangible criteria may be evaluated with numeric values, according to Saaty(2008) intangible criteria cannot be evaluated numerically.
2) Since there is no hierarchic formation, every criterion is evaluated at the same level.
3) The relative importance of the criteria each other is not clear.
4) The consistency of the evaluation cannot be measured until a certain amount of participants exist.

For the next step, to cope with these problems stated above a hierarchic formation can be made. And also using weighting factors for evaluation may be added.

Weighting Factor	**Main Criteria**	**Sub-Criteria**	**Excellent (5) Strongly agree**	**Very Good (4) Agree**	**Good (3) Undecided**	**Fair (2) Disagree**	**Poor (1) Strongly Disagree**	**No idea(0)**
3	C1		+					
2		C5				+		
3	C2							+
2		C4		+				
1		C6						
…..	……	……						
4	C3				+			
2		C20			+			
AVERAGE		Average of the building is good/3/undecided						

Table 5: *Likert/rated scale based assessment methodology-Hierarchy and weighting factors added*

Although Hierarchy is formed, weighting factors are defined, there are still problems which may be stated as:

1) Still tangible and intangible criteria are evaluated with numeric values.
2) The relative importance of the criteria although they are hierarchically formed is still not known.
3) To assign weighting factors for the importance of each criterion is problematic since humans can only evaluate 5-9 factors in one task depending on Miller's (1956) famous theorem.
4) The consistency of the evaluation cannot be measured until a certain amount of participants exist

Pair wise compared MCDM based methodology will be introduced to cope with the problems stated above in further chapters of this paper.

MULTI-CRITERIA DECISION MAKING

Multi-criteria decision making (MCDM) methods deal with the process of making decisions in the presence of multiple criteria. Decision-makers are required to choose among quantifiable or non-quantifiable and multiple criteria. The objectives are usually conflicting and therefore, the solution is highly dependent on the preferences of the decision-maker and must be a compromise (Pohekar and Ramachandran, 2004). Priority based, outranking, distance based and mixed methods are also applied to various problems. Each method has its own characteristics and the methods can also be classified as deterministic, stochastic and fuzzy. There may be combinations of the above methods. Depending upon the number of decision makers, the methods can be classified as single or group decision making methods. Most used MCDM methods are AHP, ANP, PROMETHEE SAW and TOPSIS. (Pohekar and Ramachandran, 2004) (Triantaphyllou et al., 1998) (Özcan et al., 2011)

Considering its internal and external stakeholders, architectural design can be defined as an affective decision making process which is dynamic: a complex search for information, full of detours, enriched by feedback from casting about in all directions, gathering and discarding information, fuelled by fluctuating uncertainty, indistinct and conflicting concepts (Zeleny, 1982). Although methodology of current quality assessment tools shall be notified as MCDM to some degree, MCDM methods will be reviewed to cope with their ability to assess architectural design quality while keeping in mind the weaknesses of current tools as stated above.

Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) (Saaty, 1980, 1990) is based on decomposing a complex MCDM problem into a system of hierarchies. The pairwise comparison matrix is constructed by using the relative importance of the alternatives in terms of each criterion. The vector (ai1, ai2, ai3, ..., aiN) for each i is the principal eigenvector of an N×N reciprocal matrix which is determined by pairwise comparisons of the impact of the M alternatives on the i-th criterion (Triantaphyllou et al..,1998). AHP is based on three main principles a) Forming Hierarchy b) Determining supremacies c) Numeric and logical consistency (Topçu, 1999). AHP is an effective method of dealing with complex problems.

Analytic Network Process (ANP)

The ANP, also introduced by Saaty, is a generalization of the AHP (Saaty, 1996). While the AHP represents a framework with a uni-directional hierarchical relationship, the ANP allows complex interrelationships among decision levels and attributes. Related to Yuksel and Dağdeviren (2007), Maede and Sarkis (1998) define that the ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominant or subordinate, direct or indirect. For instance, not only does the importance of the criteria determine the importance of the alternatives, as in a hierarchy, but the importance of the alternatives may also have an impact on the importance of the criteria. (Yüksel and Dağdeviren, 2007)

Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE)

PROMETHEE, proposed by Brans and Vincke (1985), builds outranking relations among alternative pairs. An outranking relation is defined in the set of alternatives such that alternative *a* outranks alternative *b* if there are enough arguments to decide that *a* is at least as good as *b*, while there is no essential reason to refute that statement. There are two extensions

of the method: PROMETHEE I yields partial rankings (incomparability is allowed), on the other hand PROMETHEE II yields complete rankings.

Simple Additive Weighting (SAW)
SAW method calculates a global (total) score for each alternative by adding contributions of alternative with respect to each attribute (Yoon & Hwang, 1995; Vincke, 1992). A common numerical scaling system such as normalization (instead of single dimensional value functions) is required to permit addition among attributed values. Then alternatives are ranked by using their global scores.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
TOPSIS method evaluates alternatives according to their distance to positive and negative ideal solutions (Yoon & Hwang, 1995; Hwang & Ming, 1987). An alternative that would be recommended to the decision maker(s) should have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution. Positive and negative ideal solutions are imaginary alternatives. A positive ideal alternative has the best performance value for each attribute while a negative ideal alternative has the worst.

ANALYSIS OF MCDM METHODS FOR POTENTIALS OF DESIGN QUALITY

	AHP	ANP	PROMETHEE	SAW	TOPSIS
Decision Making	Individual and group	Individual and Group	Individual and Group	Individual and Group	Individual and Group
Methodology	Creating hierarchical structure and pairwise comparison matrices	Creating network structure and pairwise comparison matrices	Creating matrix structure and comparing pairs of alternatives to form an outranking relation	Creating matrix structure and calculating a global (total) score for each alternative by adding contributions of alternative with respect to each attribute	Creating matrix structure and calculating distance to positive and negative ideal point
Areas of Usage	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity
Adaptability/Flexibility	+ easy to adapt case specific	+ easy to adapt case specific	- not easy to adapt	- not easy to adapt	- not easy to adapt
Consistency Measurement	+	+	No need	No need	No need
Weighting System	Pair Wise comparison	Pair Wise comparisons	No specific method.	No specific method.	No specific method. Linear or vector normalization
Criteria Evaluation	Tangible and intangible criteria	Tangible and intangible criteria	Tangible criteria	Tangible criteria	Tangible criteria

Pros	Can give consistent results for every decision making process	Easy to implement, expressive power of modeling	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)
Cons	Linear evaluation	Several pairwise comparison questions. Complex survey process for non-expert participants	Identifying thresholds, incomparable results	Very easy, can give unreliable results	Easy, can give unreliable results

Table 6: *Multi Criteria Decision Making Methods(MCDM) comparison*

MCDM tools as described above are not used for imposing solutions to the decision makers. They aid decision makers to make decisions under the consideration of evaluation criteria. Their methodologies vary in their ability to cope with problems of design quality assessment in case of multi stakeholder decision making. Related to review above it might be stated that MCDM methodologies, especially the ones using pair wise comparisons, have the potentials to cope with most weaknesses of the current tools stated in the previous chapters.

Design and architecture may be listed amongst the wide variety of domains which MCDM methods are used. Some of the researches and studies (Binnekamp, 2010; Loon and Wilms,2006; Heurkens, 2006, leeuwen and timmermans-editors-, 2006) may be notified as instances/models for usage of MCDM methods in the design domain related to urbanism and architecture. Although several approaches of usage of MCDM for design and design processes are reported, there is no architectural design quality assessment tool in the literature found which is widely used and broadly accepted using MCDM methods based on pairwise comparisons.

PAIRWISE COMPARISON

Saaty (2008) states that "Numerical measurement must be interpreted for meaning and usefulness according to its priority to serve our values in a particular decision. It does not have the same priority for all problems. Its importance is relative". To cope with the complexity of assessment of architectural design quality, a systematic approach based on Simon's idea may be formed. Simon(1969) in his famous book- Sciences of Artificial - defines the shape of design as a hierarchy. He believes that to design a complex structure, one powerful technique is to discover viable ways of decomposing it into semi-independent components corresponding to its many functional parts. Considering his statement as a base, to cope the complexity of assessment of architectural design quality, decomposing the quality in criteria and sub-criteria hierarchically may be a fruitful approach. Using pair wise

comparison based approaches instead of Likert/rated scale which as used by all the current tools discussed, may provide better results to cope with many of the weaknesses listed above.

Underlying factors to use pair-wise comparison rather than Likert/rated scale can be endorsed by Saaty's notifications as follows: "Long before measurement scales were invented, people had no direct way to measure because they had no scales and had to compare things with each other or against a standard to determine their relative order. People still have that ability, and it is still critically necessary to be able to make comparisons much of the time, especially when they cannot measure things. One reason may be that people do not have the instrument or scale to do it. Another reason is that they may believe that the outcome of comparisons using their judgment would be calibrated better to their values than using a scale of measurement that was not devised particularly for the use they are putting it to. A third reason may be that there is no way known to measure something like: political effectiveness, happiness, aesthetic appeal. Ancient people used their judgment to order things. The way they did it was to compare two things at a time to determine which was the larger or more preferred. By repeating the process they obtained a total ordering of the objects without assigning them numerical values. After being ordered they could rank them: first, second, and so on". (Saaty, 2008)

20 criteria set illustration which was implemented for Likert/rated scale in previous chapter of the paper can be adapted to pair wise comparison matrix. (table 8) Main criteria (c1,c2,c3) and sub-criteria (c4, c5, ….,c20) can be ordered hierarchically. Hierarchically structured criteria and sub-criteria regardless of whether they are tangible or intangible can be pair wise compared. If it is needed, it is also possible to evaluate the alternatives. By using MCDM methods, for instance AHP or ANP, consistency can also be measured.

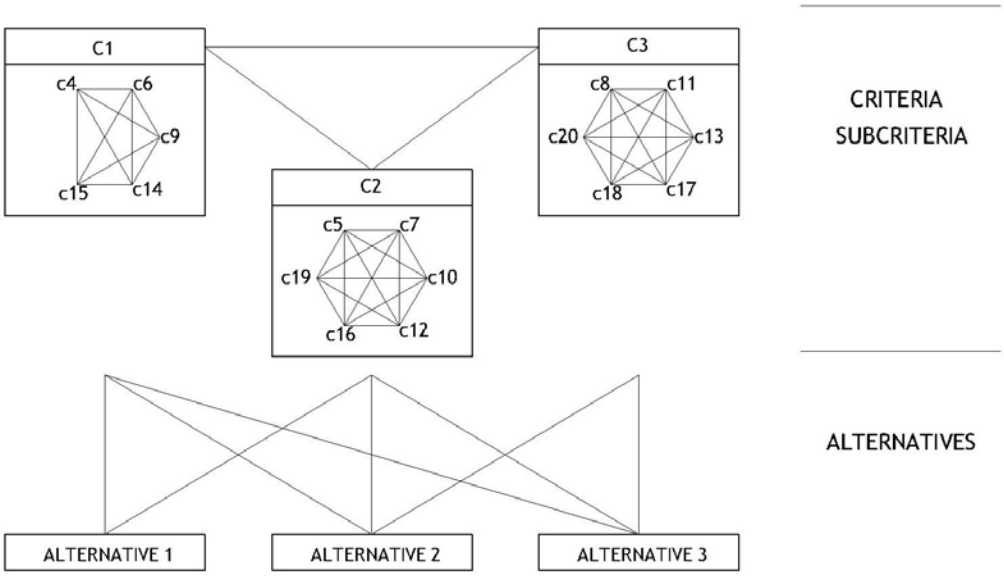


Table 7: *Pair wise comparison*

By using pair wise comparisons method:

- Criteria and sub-criteria can be grouped hierarchically. So related ones can be compared.
- Tangible and intangible criteria can be evaluated. (Saaty, 1980, 1990, 2008)
- Relative importance of the each criteria and sub-criteria to each other can be defined.

- If it is wished design alternatives can be evaluated.
- It is possible to add decision makers with weighting factors which makes group decision making available.
- Consistency levels of priorities of non-expert stakeholders can be measured with limited amount of participants.

MCDM methods, especially the ones using pair wise comparisons, may bring out relative importance of the criteria of preferences of stakeholders related to architectural design quality. They may be adapted easily for each step of building process mostly to design stages to evaluate alternatives within the design process.

CONCLUSION

This paper has begun by noticing significant problems of quality assessment tools in building processes mostly about architectural design quality assessment. Having remarked weaknesses of current assessment tools and major problems for their methodologies, outcomes to be used further about quality assessment can be listed as below:

- As there is not a universal definition for quality, tools to be created for architectural design quality assessment should consider a flexible/adaptable system for criteria selection. Criteria must be adapted for different building types, for the different phases of the building process and for different project teams.

- Reflection of the ideas of stakeholders to building processes is a big plus for integration. Tools to be designed for design quality should consider adapting stakeholders' preferences accurately into the building design process.

- As design is a complex decision making process, MCDM methods, especially the ones using pair wise comparisons, can be used/adapted for architectural design quality assessment to overcome the some of the weaknesses all current tools seems to have in common. To help designers to get stakeholders ideas into the design process, rather than using Likert/rated scaling system, pair wise comparisons can be used instead to evaluate criteria and sub-criteria. Otherwise the score of assessment will contain heterogeneous data which cannot be transferred to knowledge for design teams. Also consistency should be considered in case of data gathering.

- Assessment tools must put out not only assessment scores but must also provide methodologies about transferring the data to be used as knowledge within the design process by design teams.

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LIVING BUILDINGS AND THE ASSOCIATED R&D BASED MANUFACTURERS - *The Revolution towards Evolutionary Construction*

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Abstract
The construction industry is not sustainable. Expressed in percentages of the totals in the Netherlands and when calculated over the total lifecycle, from the early start to the processing of waste after demolition, energy consumption is more than 50%, CO2 emission is more than 50%, waste production is 35 %, road transport is 25 %, failure costs is more than 15 %, average profits of construction companies are less than 2% of the turnover. The contribution of the construction industry to the GNP is 11%. The global figures will probably be worse as cooling requires disproportional more energy than heating. Obviously, the construction industry should be changed fundamentally. In this paper a great design of a sustainable construction industry is presented. Using ”attribute listing” as method, the contours of a future Construction Industry are described in 50 typical characteristics and attributes each of them in full contrast to the current situation. The result can be considered as Evolutionary Construction with Living Buildings, which are able to survive in a faster and faster changing world. These sustainable buildings are created by variation, selection and reproduction. Like car producers, building producers will develop new buildings from existing buildings. All properties, attributes and features with respect to architecture, quality, quantity and costs of these buildings should be described in a Parametric Knowledge Model which is continuously fed by each realization. Hence, each new or adapted building will contain the experience and knowledge accumulated during a long series of already realized buildings. A main condition is that each building of the family of buildings should have the same structure, which is the set of architectural, structural, mechanical and physical relations between the elements. But at the same time each building is unique by a large variation of elements. These buildings are fully (de) mountable and composed of standardized industrial elements in order to cope with changing environmental circumstances. As the lifetime of most elements and components are longer than the expected lifetime of buildings as a whole, a major part of buildings can thus be reused after dismantling. This Darwinism for construction industry manifests itself in adaptability not only over generations of buildings but also in each building that should survive in its own lifetime. In result, the Big Picture of the future culture and structure of the construction sector can give us some hypothetical benefits. An estimate: The value of buildings will be at least twice as much, the prices at least 50 % lower and the delivery time at least 50 % shorter. Moreover the energy consumption and CO2 emissions will be halved. In this paper the basic principles and thoughts, which have been used for this design work and the 10 most important changes out of 50 are presented. In 2012 a book will be published on Evolutionary Construction.

Keywords: Living Buildings, Sustainable IFD Buildings, R&D based Buildings, Parametric Design, Integrated Supply Chain

INTRODUCTION

Practitioners and scientists all over the world agree that the construction industry shows systemic failings resulting in disappointing production, effectiveness and efficiency. The first movements aimed at substantial changes date from the early nineties of the last century and was initiated in the UK by the Latham commission (Latham,1994), followed by Rethinking Construction (Egan ,1998). After Australia and Finland also in Holland started an initiative after the big fraud affair (Tweede Kamer, 2002 and PSIB,2004). Measures were mainly aimed at change of the adversarial culture of the construction industry which manifest itself in lack of respect of its employees and uncapability of delivering for its custumers. During the last decades improvements were achieved by creating more openness, cooperation, trust, honesty, commitment and teamwork in projects (Egan,2002).

In the late nineties of the last century, the notion of sustainability emerged in the world when facing the climate problems. Here, the construction sector plays a critical role, as its contribution is rather bad (Dubois &Gaddle,2002; Nam & Tatum, 1988). Expressed in percentages of the totals in the Netherlands the energy consumption during the utilization phase is 35 %, the CO2 emission during the utilization phase is also 35 %, the consumption of energy and the CO2 emission due to the production of materials is 35 %, the waste production is 35 %, road transport is 25 %, failure costs is more than 15 %, which is about 10 billion Euros per year. Moreover the average profits of construction companies are less than 2% of the turnover. These figures are rather bad when compared with the 11% contribution of the construction industry to the GNP (Lichtenberg, 2006). The global figures will probably be worse because cooling requires more energy than heating.

The reason behind this bad performance is that every building is treated as a unique product. The world is covered with billions of unique buildings and unique structures. Each of them is not only the result of a unique project, but it is also developed by a unique combination of people, built under unique circumstances, delivered to a unique client, to be used by unique users, erected at a unique location, surrounded by a unique environment and constructed for a unique long lifetime. For each building the wheel is invented again and again (London & Kenley, 1999). For buildings as a whole neither learning curves, nor repetition effects can be observed throughout the supply chain (Vrijhoef & Koskela; Woudhuysen & Abley; Lansley,1994; Koskela,2003). In all, buildings and structures have an artisan character and show suboptimal performance).

With the current credit crunch, the coming energy crisis and the booming construction activities in Asia, it is perhaps time for the international community in and around the construction industry to make a very fundamental change of the whole system with its associated cultural and structural aspects. In this paper a Big Picture of a sustainable construction sector is presented.

METHODOLOGY

The method used in this paper is called ”Attribute Listing” and developed in design theory for innovation. Attribute listing, as used and adapted for this special purpose (the change of a complex and complicated system), contains 8 subsequent steps:

Step 1: Take for granted that the construction industry is not a good system. Based on the figures as presented in the introduction, this starting point can easily be defended.

Step 2: Make a list of typical characteristics and attributes associated with the present construction industry. This is rather difficult because this step requires a generalization of the construction industry. It is generally accepted that ”the construction industry” as a whole does not exist. Therefore this step is quite debatable and can only be based on general reports of governments (see paragraph 2). Nevertheless this step suffers to personal interpretation.

Step 3: Provide each characteristic with theoretical and practical objections. These comments are essential for the directing the possible changes. These objections can be found in the general reports (see step1)

Step 4: Develop, using the objections of step 3, an idea about a new system, that is not only understandable for everyone but also imaginable for everyone. Obviously the first idea used is the normal industrial market for consumer products. It fulfills the two requirements and it is far more sustainable than construction industry. A problem is that buildings should be tailor made and should also have a large lifetime. Therefore a second idea was added. That is the analogy of the termitarium. All information of the termitarium is contained in the combination building/builder. It is stored in the DNA of the termites. Each building is slightly different in shape but totally similar in structure. The structure is the most important factor, where the final shape depends on local environmental circumstances. It seems to be that termites have the disposal of build-in learning curves and build-in repetition effects. That is exactly what lacks in the construction industry.

Step 5: Change the characteristics and attributes of the old system as much as possible towards associated characteristics and attributes of the newly to developed system. This is a difficult step because the construction industry has some specific characterics that are totally different frojm the normal consumer’s articles. For instance, buildings are fixed on the ground, have low value per kg material and a long lifetime.

Step 6: Cluster the characteristics and attributes on mutual relations. The reason behind is that the relations imply a combined approach for change

Step 7: Try to arrange the clusters of step 7 in a causal order. This is important because some changes have to be started first before other changes make a chance.

Step 8: Provide the characteristics and attributes of the new system with individual examples that show those characteristics and attributes already or in a certain rate. This is an important step, because people only want to change a system when they clearly see not only advantages and benefits but also working examples (not presented in this paper).

The main 10 changes

The basic topic of the construction industry is to develop a building frictionless in its environment (Alexander, 1961). The fit between building and environment is given in al large set of conflicting variables like capacity, costs, safety, reliability, etc. This is sketched in figure 0, that is the main reference of the description of the present construction industry at one side and the prescription of a future construction industry at the other side.

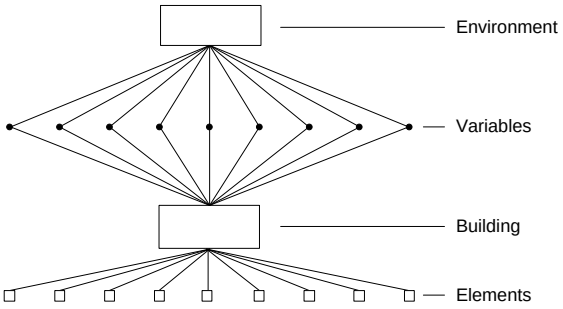


Figure 0: *Fit between building and environment*

1. The present practice to fix all variables in a set of output specifications for the building should be changed into the creation of a solution space (see figure 1).

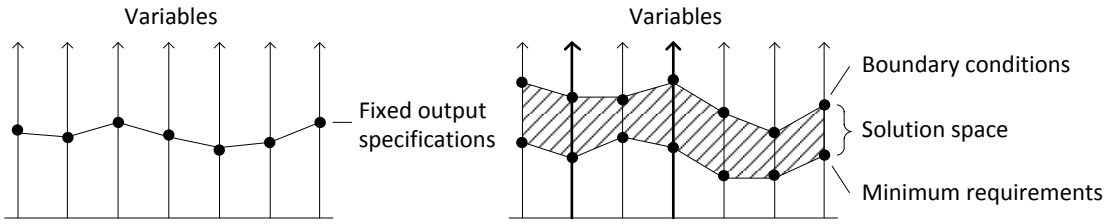


Figure 1: *Change in specification*

All variables are wishes (as much/less/large as possible), provides with weighting factors, minimum requirements (internal) and boundary conditions (external). This was applied for the €400 million Storm Surge Barrier in Rotterdam in The Netherlands (de Ridder,1994).

2. The present price competition should be changed into a competition on value price ratio (see figure 2).

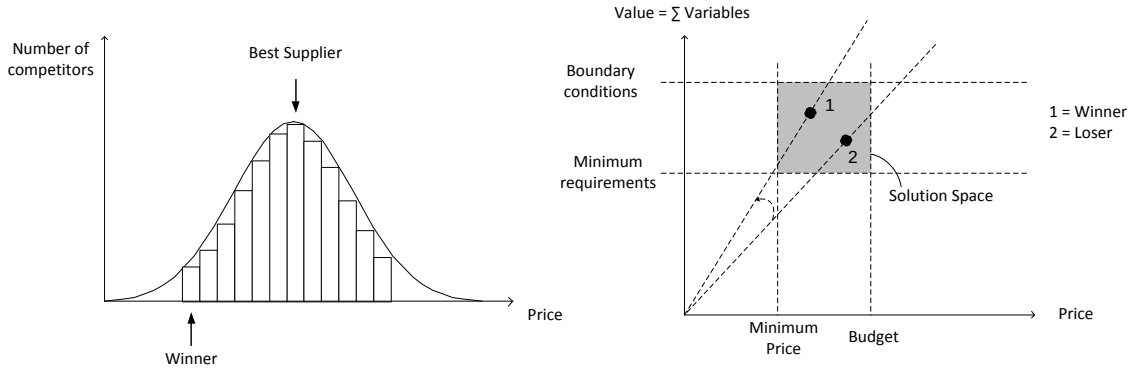


Figure 2: *Change in competition*

The lowest price bidder is in most cases not the best builder. When considering the weighted scores on the variables and checking whether the bids are inside the solution space (specific validation) , it is easy to select the bidder with best value price ratio. This was applied for the Storm Surge Barrier in Rotterdam.

3. The present focus on the building of all players in the supply chain should be changed in a focus on the solution space (context) at the demand side and the building at the supply side (see figure 3).

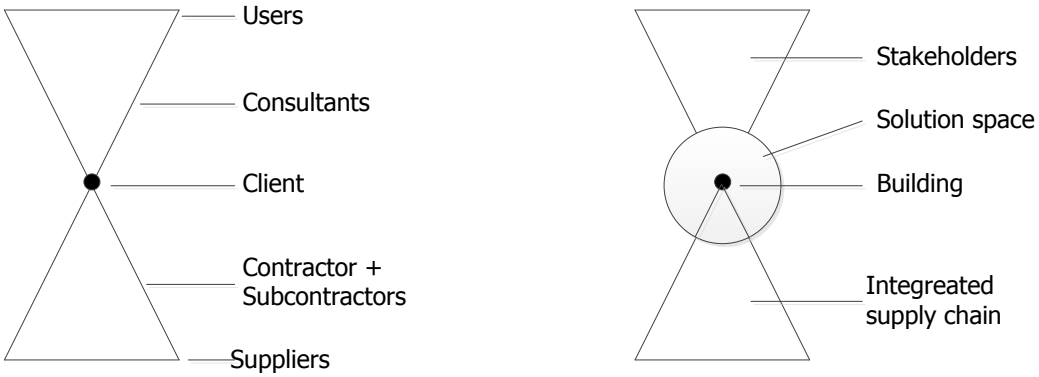


Figure 3: *Change in supply chain*

The main consequence is that the demand side and the supply side have their own responsibility. In result building companies are able to develop their own specific buildings and will be specialized. It also allows for creation of learning curves and repetition effects.

4. The present practice of the client to ask a series of consultants to make a complex design with associated output specifications should be changed into a situation in which the client asks consultants to define the complicated solution space (see figure 4).

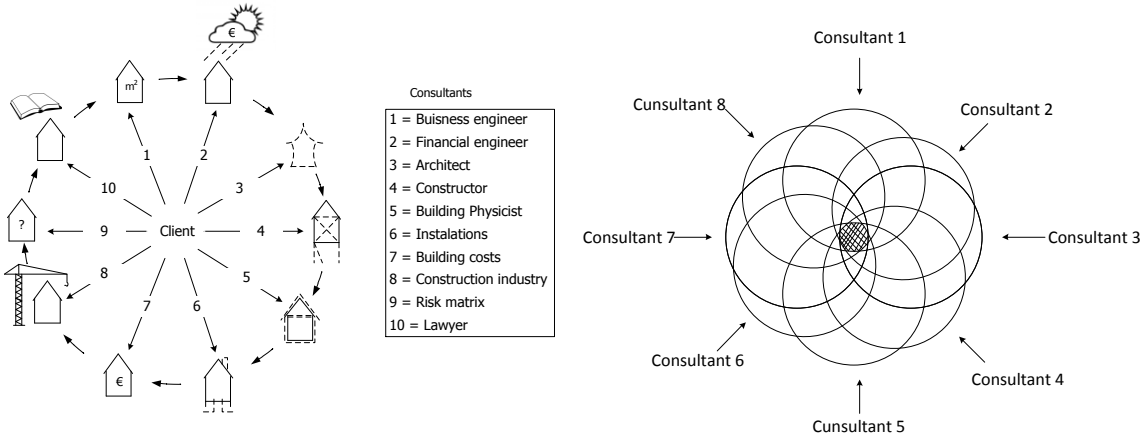


Figure 4: *Change in consultants' work*

Because complexity can't be decomposed the serial design work of consultants without obligations for the final result is not advisable. The building will not be specified correctly. It is better for the client to stay out design work because it attracts responsibility. This was applied for the demand specification for a Living Building Concept hospital in Den Helder in The Netherlands (Gemini).

5. The present practice to focus design work on disciplinary interfaces, clenched in between fixed requirements and fixed industrial elements, should be changed into a focus on fixed relations between all variables (see figure 5)

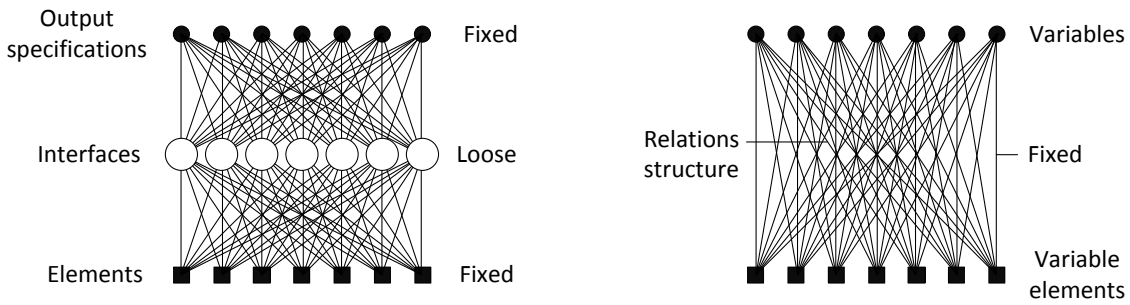


Figure 5: *Change in system approach*

When fixing the relations, the designer fixes the internal structure of the building. Design work then becomes adaption. Design work becomes research and development. This is applied by Burggraaff in Leeuwarden,The Netherlands (Burggraaff).

6. The present practice to fit the building in between the fixed demand (output specifications) and the fixed elements from suppliers, should be changed into tuning the demand with its complicated context and the supply with its complex building (see figure 6)

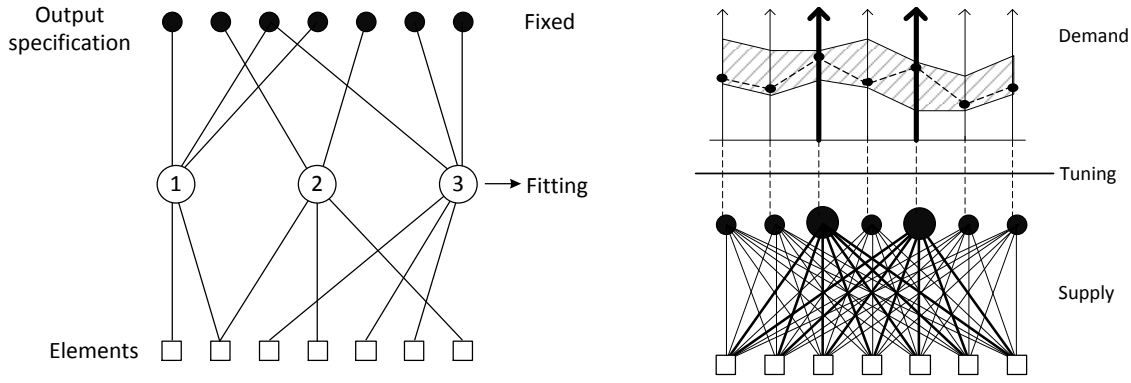


Figure 6: *Change in design work*

As can be seen in figure 6, the supplier can easy choose a magnitude for a variable in order to get a good score. Because the internal structure is fixed, the consequences for all elements are known. The tuning operation is in fact playing with elements. Due to the fast changing demand in relation to the long lifetime of buildings this leads automatically to industrialized flexible (de)mountable (IFD) buildings. The range however is limited. Exotic one shot realizations, which require specific internal structures, can't be offered. No examples in the construction industry yet.

7. The present organization of the supply chain based on outsourcing should be changed into a supply chain based on collaboration (see figure 7)

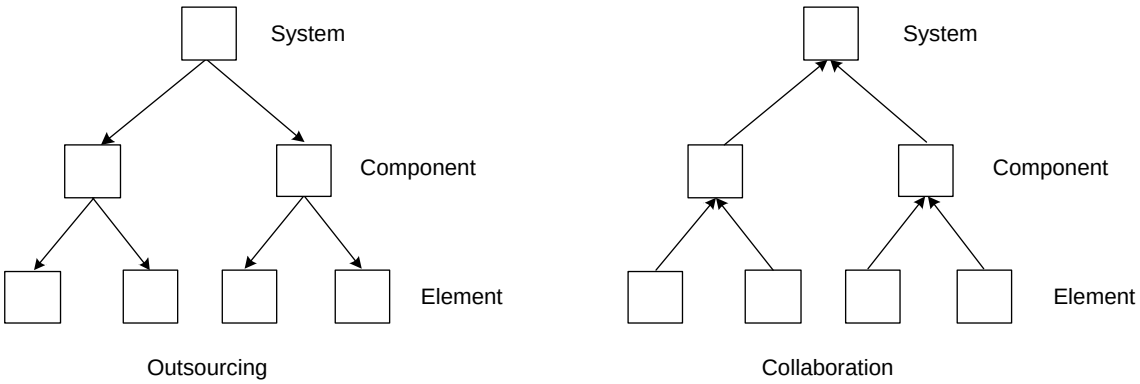


Figure 7: *Change in supply chain organization*

The major change is from an ad hoc project based supply chain towards a project independent supply chain. Outsourcing is top down specification and neglecting relations between parts. Collaboration is bottom up and making the whole more than the sum of the parts. No examples in the construction industry yet.

8. The present practice to produce and build on site should be changed into prefabrication in factories and assembly on site (see figure 8)

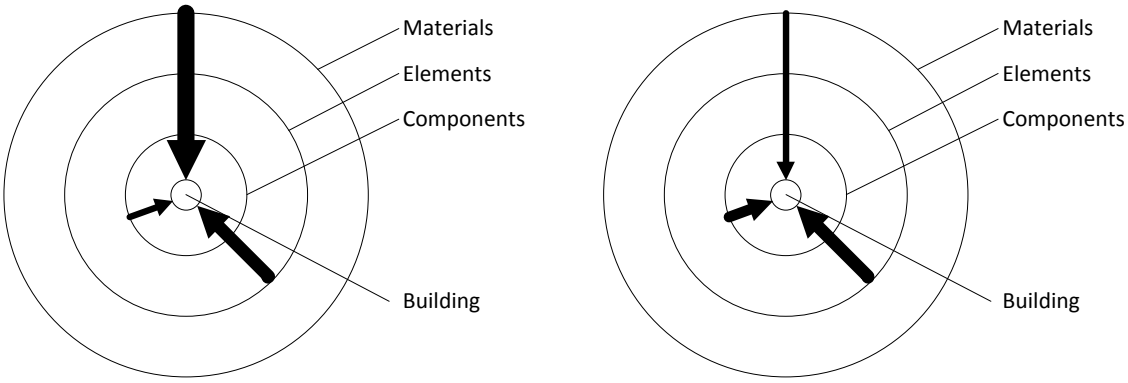


Figure 8: *Change in logistics*

The change into prefabrication is not only beneficial for the quality of buildings, but also for the speed in construction and mainly for the transport efforts in time, money, resources and emissions. This was applied for the 100 meter height Millenium Tower in Amsterdam without construction yard (Wessels Zeist) .

9. The present practice to downcycle all elements and components of a building after dismantling should be changed into a practice where elements and components with longer lifetime than the building itself will be reused (see figure 9). No examples yet.

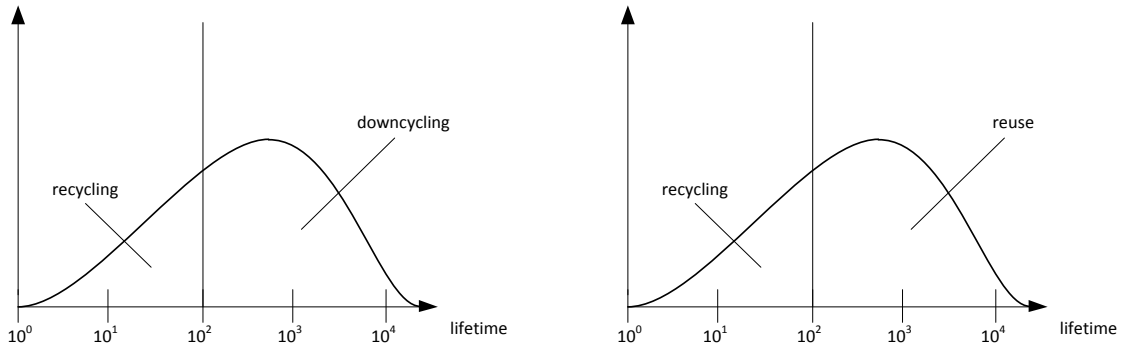


Figure 9: *Change in recylcing*

10. The present Design & Construct practice should be changed into a Research & Development practice (see figure 10)

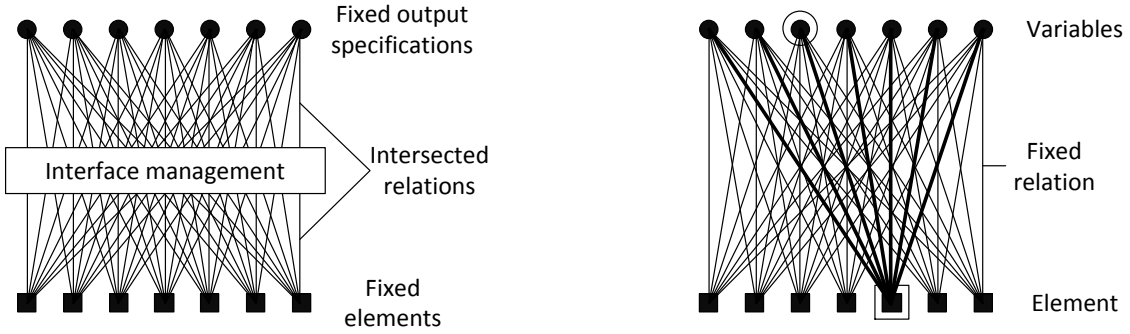


Figure 10: *Change in knowledge*

Inventing the wheel again and again with Design & construct of one shot, unique realizations should be replaced by a sound R&D supported with a Parametric Knowledge Model of Supplier specific Buildings. New buildings can easily be developed from existing buildings by researching the consequence for the elements when changing a variable or, reversely, researching the consequence for the variables when changing an element. This is applied with Burggraaff (Burggraaff).

CONCLUSIONS

When the construction industry is able to change itself in the description of the right sides of the columns, then producers and buildings together form living buildings. They belong to the set of living man-made systems. These buildings will be developed from a long series of already realized buildings. The buildings obey to Darwin's principle of the survival of the fittest. Producers experiment with variations on existing buildings and select the best variations for multiplication. A crucial condition is that producers fill their Parametric Knowledge Models of their buildings with each delivery, inducing continuous improvement. Each building has more or less the same structure but the final form is totally different as result of the interaction with the environment. The buildings are flexible and adaptable, keeping them up to date en fit for changing purposes provided with state of the art technology. This is very important as the world inside and outside buildings changes faster then the buildings itself. Living buildings and

structures are sustainable in any imaginable respect and at least doubles the lifecycle value, halves the lifecycle cost, doubles the profit of construction companies and halves the energy consumption and emissions. This will be achieved by increasing effectiveness by learning curves and increasing efficiency by repetitiveness. It is comparable with automotive and computer R&D. Each newly developed type contains all experience and knowledge of a long series of earlier types.

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SELECTION CRITERIA AND TENDER EVALUATION: THE EQUIVALENT TENDER PRICE MODEL (ETPM)

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Abstract
Several research studies have identified critical success factors and their impact on project success. Central to both success and failure is the issue of selection criteria, and the importance of incorporating qualitative factors when contracting for complex design and construction projects. Empirical findings suggest that price is still commonly used criterion for selecting a winner, even though tendering documents indicate that quality factors are part of the evaluation. In this paper we argue that tender competitions with high focus on price in complex design and construction projects deteriorate both incentives for collaboration and project outcome in terms of cost and quality. Thus, the lowest bid may paradoxically result in the most expensive project from both an investment and a life cycle cost perspective. We offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. Simulation tests of the model demonstrate that evaluation of tenders through an Equivalent Tender Price model makes selection criteria more transparent and quantifiable and therefore less at risk of manipulation.

Keywords: Equivalent Tender Price, selection criteria, evaluation models, LCC, PDCS

INTRODUCTION

Several research studies have identified critical success factors and their impact on project success (see e.g. Belassi and Tukel, 1996; Fortune and White, 2006; Park, 2009; Pinto and Slevin, 1988; Zwikael and Globerson, 2006). Central to success is the factor of quality, operationalized as e.g. availability of required technology and expertise, technical background of contractor's personnel, and communication skills. Empirical research also identifies central determinants of project failure (Meland, 2000). These *failure factors* include the use of price competition on complex design services, poor communication and information logistics, as well as lack of competence. Common to both failure and success

factors in construction projects is the importance of quality-based selection criteria when contracting for complex design and construction projects. The problem is that tender competitions with high focus on price in complex design and construction projects deteriorate both incentives for collaboration and project outcome in terms of cost and quality. Thus, the lowest bid may paradoxically result in the most expensive project from both an investment and a life cycle perspective. An increasing focus on environmental sustainability and life cycle costs in construction projects necessitates a new form of competence in the planning and management of construction projects, which in turn needs to be reflected and incorporated into the selection model. Recent practices of project management, however, emphasize qualitative aspects in the selection of contractors such as key personnel, past project performance, company standing (reputation), and technical expertise (Watt, Kayis and Willey, 2010). But the emphasis on soft factors increases the complexity of evaluation due to subjectivity and lack of transparency in the selection process.

Despite numerous efforts to establish a universal set of selection criteria, the issue continues to plague both theory and practice (Holt, 2010; Watt et al., 2009). The failure to develop such universal methods and criteria can be attributed to the complex circumstances of project contracting; the combination of soft and hard objectives, coupled with a large doze of uncertainty and risk. Even though mainstream literature is turning focus in criteria selection from "lowest price" to "value enhancement", anecdotal evidence suggest that price is still a commonly used criterion for selecting the winner. The gap between theoretical ideal and industry practice on criteria selection places a "credit crunch" (Holt, 2010, p. 305) on the "value literature". We offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase value enhancement for the client, by increasing the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. In this paper we present and test the ETP model through simulation and compare the results to traditional selection models. The results demonstrate that evaluation of tenders through an Equivalent Tender Price model yields a result less at risk of manipulation in the selection process, because the selection criteria are transparent and quantifiable. The Equivalent Tender Price model is able to absorb and reflect the market price for qualitative elements such as competence and experience of key personnel, and should thus enable clients to make more correct decisions regarding price and quality in tender competitions.

CRITERIA FOR SELECTION

For any given project, it is essential to establish objectives and assess them according to how they influence the choice of project delivery and contract strategy (PDCS). This may include cost and schedule restrictions, as well as quality and business requirements (CII 2003; Lædre 2006). It is a crucial phase of the project process and encourages the client to focus on the critical success and failure factors for the project under consideration. Another central part of the PDCS is the selection of compensation forms, qualification criteria, selection criteria and the selection model itself. All these elements should represent choices that increase the probability of "best-value" for the client. Best-value contracting strategy aims at combining the use of price and qualitative factors in the qualification and selection process to enhance the long-term performance of the project. Among these are the criteria of reasonable whole life costing principles (WLC/LCC) and sustainability.

The importance of tender evaluation and selection criteria is well established in the project management and purchasing literature (Holt, 2010; Watt et al., 2010). Selection criteria and processes are directly related to project success and achievement of project objectives (Alsugair, 1999; Holt, Olomolaiye and Harris, 1994; Lopes and Flavell, 1998; Meland, 2000).

The success factors commonly focus on objectives such as availability of required technology, key personnel, expertise, technical background, and communication skills (Belassi and Tukel, 1996; Fortune and White, 2006; Park, 2009; Pinto and Slevin, 1988; Zwikael and Globerson, 2006). These are all indicators of "competence". Furthermore is past project performance, financial and technical capabilities, as well as tender price elements that are normally taken into the selection model. However, critical determinants in selection models have varied over time. Previous research point to price and cost as critical determinants of selection criteria (Hatush and Skitmore, 1997; Holt et al., 1994; Proverbs, Holt and Olomolaiye, 1997), whereas recent reviews contradict the findings from a decade earlier (see e.g. Holt, 2010). One study concludes that amongst 16 categories of selection criteria, price was found as the third lowest reported occurrence (Watt et al., 2009), even though anecdotal evidence and actual practice may point in a different direction. The increased value focus in tendering may partly be explained by the tendency of focusing more on life cycle cost and environmental sustainability, which in itself require a selection model that assess long term value rather than just the investments costs. Furthermore, the use of partnering models as well as collaborative contracting, necessitate more qualitative elements in the evaluation of tenders in order to reflect the participating parties' ability and incentives to cooperate, and to avoid sub-optimalization processes during the project.

Some of the traditional factors in tender evaluation should be taken care of outside the selection model itself, partly because they should not be exposed to competition, and partly because they are not acceptable criteria according to EU directives on public procurement (2004/18/EC 2004). The latter is a much debated issue within public procurement, because public clients commonly confuse qualification criteria with selection criteria. Even though they are closely related, there is a distinction between company capabilities in general and a company's bidding of specific personnel for a specific project. In the evaluation process it is therefore important to distinguish between qualitative factors that directly reflect value for a specific project, and qualitative factors that are merely an expression of the company's technological and financial capability.

Previous research on tendering competition of design services reveals two factors that should be avoided to circumvent project failure (Meland, 2000):

- too short time available for an adequate design process
- price competition on design services

To contest on time schedule in tender competition for design services jeopardizes the quality aspect of the design process itself, because a competition on the number of man hours and time factor in the design process represents a high risk for poor quality and costly changes in the construction phase. Unless time is an extremely important success criterion, it should be set up by the client as part of the project strategy aims and objectives. Due to economic incentives and EU procurement regulations, there should however be an element of price competition for design services. But in order to avoid the risk of inadequate design, these contracts should be reimbursable, and the tender price should focus on man-hour rates, which then is included in the selection model (Meland, 2000).

As previously pointed out competence is commonly viewed as a success factor for construction projects, and should therefore be an important criterion in any selection model for complex design and construction projects. Competence, however, is a typical proxy measure of quality which includes several indicators such as technical expertise and capability of key personnel. In the construction industry the problem with 'value enhancement' criteria is often that the qualitative elements either become too "costly" during

the decision process, or they are not properly appreciated by the client, because the selection model can not absorb the quality differences between tenders. Suppliers of construction projects, who offer higher quality at the cost of higher price, run the risk of being discriminated *and* loose the bid, because the client is unable to assess the market price of quality in the selection model. The market price for competence is reflected in the average salaries for various levels of formal education and years of experience. Salary data may thus be used to estimate the price differences between different qualifications. Hence, in order to increase the markets' offering of higher competence levels in tenders, the client must be willing to pay for it. The suppliers must also be ensured that offering increased quality, through higher levels of competence, will be appreciated in terms of fair comparison of tenders. Finally, the "equivalent price" of each tender, on which comparisons are made, must reflect the value of quality in transparent and objective ways.
To establish incentives for offering increased quality at the cost of higher price, two factors must be attended:

1) The value of quality must be reflected and valued in the selection model
2) The selection model must have capacity to absorb differences in quality in a consistent way

The above factors are central elements in the ETP model as will be demonstrated in the following sections.

THE ETP MODEL VERSUS TRADITIONAL SELECTION MODELS

From an economic point of view, the theoretical problem in all selection models is the potential for adverse selection. This is especially a problem when the tender process involves qualitative elements, such as for instance supplier capability and competence. If hidden information exists about the suppliers' competence and no information is available for the client, price will be the only decision criteria. The risk of low price and low quality will be significant, and the client risks a suboptimal procurement situation. The issue of selection processes is to reveal relevant and trustworthy information about the supplier's and competencies. There may be two ways of acquiring such information. One is obviously to do the necessary research and gather relevant information about the different suppliers. But this may be both costly and possibly not very reliable data. The other way is through screening, by using relevant market information. Suppliers pay a market price for the staff employed. The price, as reflected in average market salaries, is based upon different employee characteristics. The salary can be interpreted as a hedonistic price function, because it is decomposed as a sum of values for the different characteristics; for instance formal education and years of relevant experience. By using the values for the different employee characteristics, observations can be made on how the market values these characteristics. This market information is valuable to reduce the risk of adverse selection and increase the probability of selecting the supplier offering the best combination of price and quality. In the following section we will illustrate this point by using the "equivalent tender price" (ETP) model. For comparison, we will first illustrate how a traditional selection model fails on three important issues. First of all a traditional model is usually linear, which delimits the model's mathematical capacity to absorb the variety of tender scores on selection criteria. Second, a linear model does not "act" in the interest of the client, and thirdly it does not reflect the marked pricing of competence. These weaknesses are illustrated in the sections below.

Selection criteria and corresponding measures

Common selection criteria for construction projects include a price element and one or more qualitative elements. Normally the client assigns weights to each element to reflect the client's emphasis on the different criteria in the model. Each tender receives a score per criterion, based on the client's evaluation of each tender. The final value for each bid in a linear selection model will be a sum of the weighted scores per criterion, where the winner has highest sum.

For illustration purposes, we first simulate results of a tender competition with a linear selection model. We then use the same simulation data in the ETP model and compare the results. The following selection criteria are used throughout the testing of the two models:

- Price
- Competence
- Other (project related criteria of importance)

In the model simulation our specific focus is on the price and competence criteria. However, we have included a third criterion, "Other", to illustrate the model's rest capacity to include other criteria in addition to price and competence. Each criterion is assigned an individual weight summarized to 1,0 (100 %). The weights are labeled as follows:

- V_1 = Price
- V_2 = Competence
- V_3 = Other

Each criterion can be divided into several indexes that are relevant and measurable. In this simulation we limit the use of indexes to the competence criterion, which is measured by following:

- V_{21}= Level of formal education (master, bachelor etc)
- V_{22}= Relevance of education compared to the actual project position and project
- V_{23}= Time of experience
- V_{24}= Relevance of experience compared to the actual project position and project

An individual score per tender will be assigned to each of the four indexes. The individual scores will range between 0,0 and 5,0 and is labeled as follows:

- m_{21} = Score on formal education, where Master of Science =5,0,
  Bachelor of Science =4,0, No formal education beyond high school=2,0.
  Scale interpolation is used for additional studies/courses etc.
- m_{22} = Score on relevance of education, where for instance a degree in architectural science yields top score (5,0) while a computer science degree yields a low score (1,0) in an architectural design competition
- m_{23} = Score on experience, where > 30 years of experience =5,0 and
  no experience = 0. Values are to be interpolated linearly between 0 and 5.
- m_{24} = Score on relevance of experience, where 3 relevant projects in the CV =5,0 and less relevancy is to be linearly interpolated towards 0.

Each candidate offered in the individual tender is rated according to the above indexes, and a weighted average score is calculated to reflect each tender's total score on V_2 Competence.
Normally the market price for competence can be measured by the average salaries according to employee characteristics such as level of education and relevant experience. The

association of chartered engineers in Norway (RIF) yearly presents statistics of salaries, invoicing level, different cost elements etc for their members. We use RIF statistics (2009/2010) to compare the marked value of three competence indicators:

- Formal education (V_{21}),
- Time of experience (V_{23}),
- Relevance of education and experience (V_{22} and V_{24} summarized).

Based on statistics from RIF (2010), table 1 presents simulated examples of yearly salaries for engineers. The other items included in the table are various costs and parameters associated with the corresponding salary level for engineers in Norway. From table 1 we find that an average salary for a Master of Science in engineering is priced to €85625 per year, and a Bachelor of Science degree is priced to €72875, which gives a difference of €12750. When controlling for all other parameters but formal degree, the equivalent market price of a Master of Science candidate is €111 per man-hour (mhr), whereas the man-hour rate for a Bachelor of Science candidate is €98. The difference in a company's bid price for these two candidates is €13 which represents the difference in marked price between the score 4,0 and 5,0 for the factor formal education (V_{21}) in our model.

			MSc candidate		BSc candidate		
Yearly salary	100 000	87 500	**85 625**	75 000	**72 875**	62 500	56 125
Manhour salary	57	50	49	43	42	36	32
Social costs (25%)	14	12	12	11	10	9	8
Company's salary cost	71	62	61	53	52	44	40
Invoicing level	73 %	73 %	73 %	73 %	73 %	73 %	73 %
Company's real cost	98	86	84	73	71	61	55
Overhead per manhour	18	18	18	18	18	18	18
Profit	9 %	9 %	9 %	9 %	9 %	9 %	9 %
Company's bid price	126	113	**111**	100	**98**	86	80

Table 1: *Salary and cost statistics for employment of different engineering candidates. All figures in € (based on statistics from RIF, 2010)*

According to the RIF statistics (2010) a yearly salary for a Master of Science degree varies on average from €59625 for a non-experienced master candidate, to €124125 for an employee with 30 years experience on top of her master degree. Corresponding figures for Bachelor degrees are €53375 and €81625, respectively. Thus on average for both categories this indicates that the marked price of one additional year of experience for an average engineer is close to €1,25 per man-hour. The scale interval for V_{23} (time of experience) represents 7,5 years. This corresponds to a market price difference of €9,12 per interval, which, all else equal, indicates the price difference between a candidate with 30 years and a candidate 22,5 years of experience. Finally, according to RIF, the salary gap between the group of highest paid engineers (measured as 90 % percentile) and the lowest paid engineers (measured as 25 % percentile, since 10 % not available), is on average for both masters and bachelors €18,75. This figure represents the full range of the scale for V_{24} and V_{22}, with a marginal change value of €4,75.

The salary data for Norwegian technical personnel is reliable for the characteristics V_{21} (Level of education) and V_{23} (Years of experience). There is, however, no salary information available for criteria V_{22} and V_{24}, which both relates to work-specific relevance of education

and experience. As an approximation we have used a measure of the variation in salaries for these criteria. We assume that salary variation for engineers across all education and experience levels is partly explained by differences in relevant skills. This assumption is, however, highly debatable. The variation may also reflect different scarcities in different marked segments for technical personnel.

In the following illustrations he figures above are assumed to be the market price for the value of formal education (V_{21}), time of experience (V_{23}), relevance of education and experience (V_{22} and V_{24}). In the next section we test the general linear model and the ETP model, using estimated market values to demonstrate the difference in capacity and transparency between the two models.

Testing selection criteria in a linear model

A traditional way of calculating for the price score for a tender is to give the score 2,5 for the average priced bid, 0 for the highest bid and the score 5,0 for the lowest bid (score scale 0-5). The other bids' score are calculated linearly. Five bids with the illustrated man-hour rates and tender price in table 2 should then be given the following price scores:

Bids	A	B	C	D	F
Manhour rate and tender price (€)	100	106	113	119	125
Price score (m_1)	5,00	3,75	2,50	1,25	0,00

Table 2: *Five illustrated bids with linear score on price*

As illustrated in table 1, the marked price for an average master candidate is €111 and €98 for a bachelor candidate. All other factors equal, tenders based on these man-hour rates should be given equal score in any selection model, given that market value of competence is of importance for the client. We add these two "bids" to the 5 other bids in table 3 and start the selection process based on a linear selection model. Price is given the weight 25 % of total.

	BSc candidate			MSc candidate			
Manhour rate and tender price (€)	**98**	100	106	**111**	113	119	125
v_1 Price	0,25	0,25	0,25	0,25	0,25	0,25	0,25
m_1 Price score	5	4,57	3,43	2,54	2,29	1,38	0,00
v_{21} Formal degree	**0,62**	0,62	0,62	**0,62**	0,62	0,62	0,62
m_2 Degree score	**4**	4	4	**5**	5	5	5
v_3 Other criterion	0,13	0,13	0,13	0,13	0,13	0,13	0,13
m_3 Score other	5	5	5	5	5	5	5
Score total	**4,38**	4,27	3,99	**4,38**	4,32	4,09	3,75

Table 3: *Traditional linear selection model (Score= v1* m1 + v2* m2 + v3* m3)*

Table 3 demonstrates that by weighting the formal degree (V_{21}) criteria 0,62, the two candidates (master and bachelor) obtain the same total score (4,38) as they should, according to the pricing of formal degree. All the other tenders are overpriced relative to the type of candidate offered. Their price score in combination with formal degree score is causing their tender loss. As shown, price (V_1) and formal degree (V_{21}) constitute a total of 87 % (0,62+0,25) out of the total model capacity. Thus the model is inadequate to absorb the full value competence as V_{22}, V_{23} and V_{24} are not included. Hence the linear model does not "act"

in the interest of the client, because it does not reflect the marked pricing of competence in its full scope, but reflects competence only through formal degree. Capacity constraints is one of the major weaknesses in traditional, linear selection models, and it jeopardizes possibilities for a more thorough and objective differentiation of qualitative aspects in bids.
We also observe another capacity weakness of the traditional model. By comparing table 2 and 3, we observe that the price score (m_1) given for the original five bids have changed as a consequence of adding the two new "bids". This indicates that the model is neither predictable nor robust. Linear selection models usually assign the price weight to be between 40 to 80 % of total criteria. This means that in practice the competition is almost solely based on price, even though the client may indicate otherwise in the tender documents. Furthermore, it is commonly observed that the full scale range for price is fully used (e.g. 0-5), but the scale range for other criteria is often used between 2 and 4. The real evaluation is thus even more price focused than exemplified above.

We have demonstrated that a linear selection model is very sensitive to the tender evaluation structure and in fact also to the numbers of tenders. This affects the model's robustness in an undesirable way. We suggest a solution to the problem by constructing a more robust and universal applicable model.

Testing selection criteria in the ETP Model
A main purpose in the ETP-model is to establish a useful and operational balance between the consideration of price and qualitative elements in selection models. Formally this is done by choosing one single parameter, k, in the ETP-model. The model is constructed in such a way that the value of k influences the client's choice of focus; from pure price competition to hardly any weight on price at all. A very large value of k represents pure price competition, whereas when k is reduced towards zero, more and more emphasis is placed on qualitative elements.
As the intention is to use market price information, the model has to be aligned to the observable market prices (salaries). We will demonstrate one way of doing this, and at the same time discuss various design of the model. We have argued that a linear selection model for projects where quality elements play a critical role is more or less useless. Instead we propose a quadratic model, and demonstrates its usefulness by simulate different values of the parameters for scores and weights. In these simulations we will be using market information for the salaries for technical skilled personnel in Norway (RIF, 2010).

The general formula for the ETP model we are going to use is (note its quadratic form):

$$ETP = P\frac{M^2 + k}{(\sum_i v_i m_i)^2 + k}$$

where:

ETP = Equivalent tender price
P = Estimated price inclusive of the suppliers profit
M = Maximum score on a selected scale (e.g. 5)
k = A selected constant as a number $[0,\infty)$
v_i = Weight of the quality factor i ($\sum v_i = 1$)
m_i = Score of the quality factor i (e.g. [1,5])

The sensitivity of ETP with respect to the choice of k, may be illustrated as the derivative of ETP with respect to k:

$$\frac{\partial ETP}{\partial k} = P\frac{\left(\left(\sum_i v_i m_i\right)^2 + k\right) - \left(M^2 + k\right)}{\left(\sum_i v_i m_i\right)^2 + k\right)^2} \leq 0$$

If k is increased the ETP is reduced, so a higher k means less weight on the quality factors described by $\sum_i v_i m_i$. Furthermore as $k \to \infty$ $\frac{\partial ETP}{\partial k} \to 0$, which means that ETP is an asymptotic downward sloping function towards P. A simulation of ETP with different levels of scores on $\sum_i v_i m_i$ is shown in figure 1. In the figure, k varies between 0 and 100, and the maximum score is 5 so $M^2 = 25$. The figure illustrates the ETP when the estimated price =1 for suppliers scoring a $\left(\sum_i v_i m_i\right)^2$ of 5, 10, 15, 20 or 25.

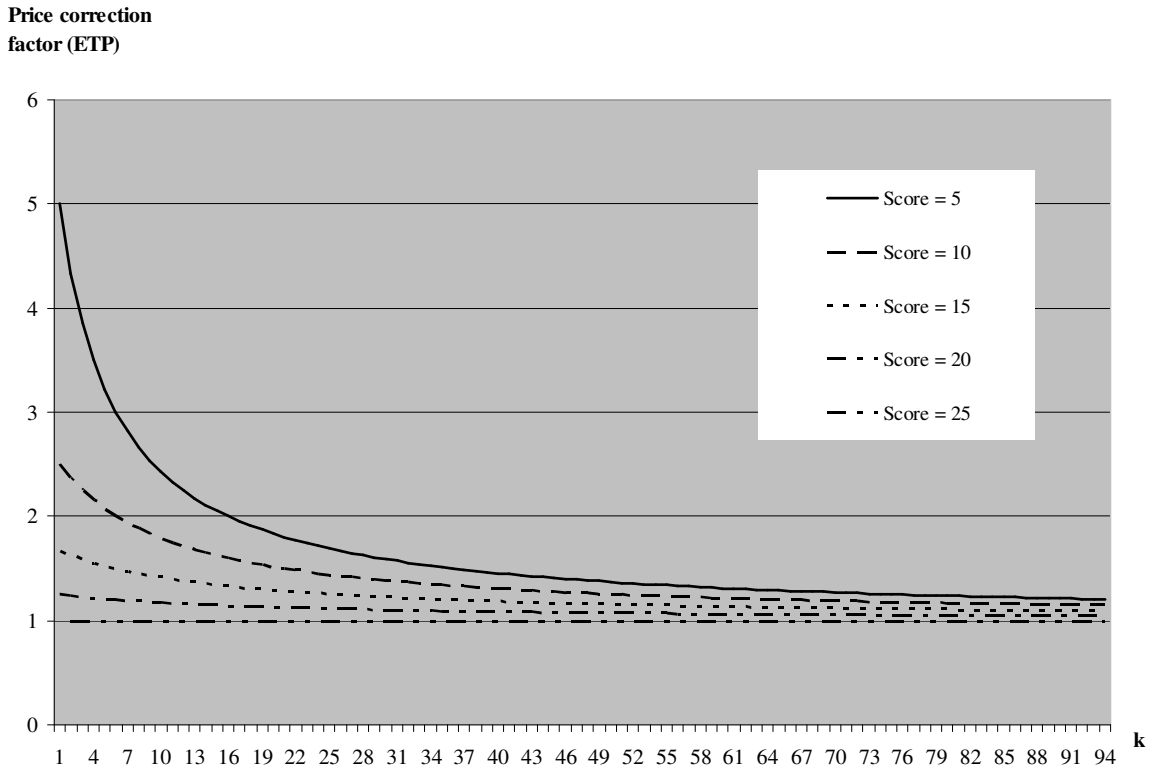


Figure 1: *Price correction factor (ETP) for different values of k*

Figure 1 shows the importance of selecting a low k if quality is the dominant selection parameter of a tender. Furthermore if there is a variety of selection parameters, a low k must be chosen to "make room" for aligning the model to market information, as will be demonstrated in the simulations in the next section. The quadratic model has the potential to discriminate between different suppliers more efficiently than a linear model as one can reduce k towards zero to exponentially increase the weight on quality. This will also be illustrated in the simulations in table 3 and 4. Figure 1 also demonstrates that by choosing a

low k one harshly punishes law quality tenders as the difference between the ETPs increases progressively when the scores on $(\sum_i v_i m_i)^2$ declines.

The model incorporates both a price element and qualitative elements, as the aim is to give high score (yielding a low ETP) to tenders offering factors that increases the probability of avoiding project failure related to cost overrun, pure quality and lack of functionality. We aim for a model with few and simple quality factors, but with build-in capacity to open for use of supplementing factors. Furthermore, the ETP selection model will be able to incorporate relevant success-factors at their marked price, and balance price and qualitative elements in a way that reveals the best tender. Finally the ETP model allows the individual bids score to be independent of each other so every criterion in the model – even price – can be evaluated in a transparent way. Of course, to ensure transparency, the score scale and the individual weight for the selection criterions must be clearly defined in the tender papers and meticulously used in the evaluation process.

In the following we present a numerical example of using a non-linear ETP model. As demonstrated in table 4, the model is capable of absorbing 34 % of the total weighting for other criterion than competence (V_3) by using k=0.

Offered tender candidates	MSc candidate	BSc candidate	BSc candidate, w/less experience	BSc candidate, w/less experience and low relevance
Manhour rate and tender price (€)	**111**	**98**	**88**	**84**
M = Max score	5	5	5	5
k = constant [0,?)	**0**	**0**	**0**	**0**
v_{21} Formal degree	**0,32**	**0,32**	0,32	0,32
m_{21} Degree score	5	**4**	4	4
v_{22} Relevance of degree	0,00	0,00	0,00	0,00
m_{22} Relevant degree score	5	5	5	5
v_{23} Experience	0,23	0,23	**0,23**	0,23
m_{23} Experience score	5	5	**4**	4
v_{24} Project relevant experience	0,12	0,12	0,12	**0,12**
m_{24} Relevant experience score	5	5	5	**4**
v_3 Other criterion	0,34	0,34	0,34	0,34
m_3 Other criterion score	5	5	5	5
Equivalent Tender Price (ETP)	**111**	**111**	**111**	**111**

Table 4: *Examples of tenders evaluated by the ETP model with k=0*

In table 4 we present four tenders with different man-hour rates and different competencies of the candidates offered. A fully experienced (30 years or more) MSc candidate with relevant project experience (3 or more) has a tender price of €111. A fully experienced BSc candidate with relevant project experience is offered at €98. However, a BSc candidate with only 22,5 years of experience, but with full relevant project experience is offered at €88. Finally a BSc with 22,5 years of experience, and less relevant project experience is priced to €84. All these tenders should be evaluated equally valuable for the client, given equal score on parameter V_3 (other criterion). They are all priced according to marked value for the individual competence factors $V_{21} – V_{24}$. Thus the equivalent tender price illustrates how a high priced tender with a

fully experienced and qualified master is valued equal to a low priced tender offering a bachelor candidate with 22,5 years of experience and less relevant project experience.

In table 5 we present the same tenders as in table 4, but k=5 is used instead of k=0. As illustrated in the table, the model capacity is reduced by increasing the value of k. There is only about 20% left for other criteria than competence. This demonstrates that for tenders of design and design build contracts, where competence is an important economic factor, k should be set low in order to fully take advantage of what the market can offer.

Offered tender candidates	MSc candidate	BSc candidate	BSc candidate, w/less experience	BSc candidate, w/less experience and low relevance
Manhour rate and tender price (€)	111	98	88	84
M = Max score	5	5	5	5
k = constant [0,?)	**5**	**5**	**5**	**5**
v_{21} Formal degree	**0,38**	**0,38**	0,38	0,38
m_{21} Degree score	5	**4**	4	4
v_{22} Relevance of degree	0,00	0,00	0,00	0,00
m_{22} Relevant degree score	5	5	5	5
v_{23} Experience	0,28	0,28	**0,28**	0,28
m_{23} Experience score	5	5	**4**	4
v_{24} Project relevant experience	0,15	0,15	0,15	**0,15**
m_{24} Relevant experience score	5	5	5	**4**
v_3 Other criterion	0,20	0,20	0,20	**0,20**
m_3 Other criterion score	5	5	5	5
Equivalent Tender Price (ETP)	**111**	**111**	**111**	**111**

Table 5: *Examples of tenders evaluated by the ETP model with k=5*

We recommend k=0 for tenders of complex to middle complex design services. More simulations, however, are needed in order to qualify for recommendations in pure construction contracts.

CONCLUSION

The ETP-model has, with different values of the *k* factor, been used in proximately 20 tender competitions in Norway. For every competition the score scale and the individual weights of the chosen selection criteria have been defined in details and strongly adhered to in the evaluation process. The evaluation of competence has thus been fairly simple and transparent. The use of other criteria, such as process understanding, project manning plans, and team management with client and users etc., have been given a wide range of scores, which is an indication of measurement problems and low predictability.

Commonly used models and criteria for selection of tenders are still highly focused on price, even though literature indicates a turn of focus from lowest cost to value enhancement in complex construction projects. The important issue, however, is how traditional selection

models are capable of including the value of qualitative elements, of for instance competence, as reflected by the market price.
We have demonstrated that traditional linear selection models do not have the capacity to absorb the market's pricing of competence in tender competition for consultancy services and complex construction projects. We therefore offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. Simulation tests of the model demonstrate that evaluation of tenders through an Equivalent Tender Price model makes selection criteria more transparent and quantifiable, and therefore less at risk of manipulation. Furthermore the ETP model demonstrates more robustness with respect to adding more qualitative elements into the model. The model is also capable of reflecting marked prices for services irrespective of other tenders, as well as encountering new bids without having to alter the pre-assigned weights.
Our simulations of the ETP model conclude that competence should be given a weight of 66 – 81 % of total weighing in the model, depending on the value of k (0-5). How competence should be weighted for pure construction contracts is dependent upon the specific contract strategy, further studies of the market's pricing of the competence profile in construction companies, and the fact that engineers are representing approximately 10-20 % of total construction costs. A tender competition for a design-built contract should yield higher competence weighting than a pure built (design-bid-built) contract, and the uncertainty and complexity should be taken into consideration. The choice of the constant k in the ETP model will balance these considerations.

LIMITATIONS AND FURTHER RESEARCH

We have argued that the ETP-model is more robust and universal applicable than e.g. a linear selection model. This does not however mean that the weights and scores used in our example are applicable in every situation. For different purposes and especially for different countries, it may be useful to align the scores and weights according to for example the country specific conditions. For the competence criterion, different countries may have different educational systems which may justify other grades of the scores.
Future research should seek to remedy these limitations by providing greater empirical evidence of the robustness of the model.

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PARADOXES OF INNOVATION AND ARCHITECTURAL DESIGN: A MODEL OF DESIGN KNOWLEDGE GENERATION IN ARCHITECTURAL PRACTICES

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Abstract

What are the organisational paradoxes that beset the design process in architectural firms? As innovative knowledge workers and system integrators architects are often called upon to produce innovative and custom designed buildings. Architects can be characterized as knowledge intensive professionals who help to lead innovation. However, most of the research conducted in design innovation and organisational paradoxes has had a product portfolio focus. For example, it has been claimed that product innovation relies on two seemingly contradictory and paradoxical processes in product development organisations: the exploitative and the exploratory. How might these concepts be related to architectural firms and design teams? Using the above concepts an initial model was developed and then tested in order to understand the paradoxical processes that architects employ when designing. How might design processes in service firms differ from either linear or dichotomous models of innovation with their origins in product development? An initial model is proposed which is then tested and refined. These questions are tested in a broader survey of 73 Australian architectural practices. The survey aimed to identify the links between exploitative and exploratory design processes in the firms and the organisational paradoxes which surround these. A survey framework was developed which defined and highlighted to what degree architects instigate Radical or Incremental design changes in projects. The survey identified the extent to which Australian architects generate new design solutions after a particular design has been mandated. It concludes that these architects deliberately sought to foster highly paradoxical processes within their firms in the early stages of a project in order to create new design knowledge. Highly paradoxical processes, which oppose exploitative and exploratory design activities, tend to diminish as the project proceeds. Further research is needed to clarify if design processes with a high degree of paradox are where project innovation occurs. The paper concludes by outlining a model of exploitative and exploratory innovation and organisational paradox in knowledge intensive design firms.

Keywords: Architecture, Design, Organizational Paradoxes, Innovation.

INTRODUCTION

Design architects are often accused of changing their minds once decisions have been made during the project development and delivery process. Design changes are often seen as being unwelcome and at odds with sequential project development milestones. Some have argued that this contributes to rework during the construction process and adds to project risks. On the other hand creative and generative design is seen to foster innovation. This paper explores the paradoxes evident within the architectural design process. For the purposes of this paper a paradox is defined as "the simultaneous presence of contradictory even mutually exclusive elements" (Cameron and Quinn 1988:2 in Clegg, Cunha and Cunha et al 2010). In

construction management very little is known about how organizational paradoxes might play themselves out within design teams. This may be because design is an activity which 'poses difficult managerial problems' which requires interdependent decision-making. (Tzortzopolous and Cooper 2007, 17). The need to understand the interdependencies and paradoxes between an initial design concept and its implementation and delivery as a constructed project is important. One way to understand these interdependencies is to investigate the paradoxical modes of design that architects appear to employ.

The paper proposes and then tests a theoretical model of how design oriented organisational paradoxes are created and resolved within architectural practices. Tushman and Benner's concepts of exploitative and exploratory innovation are adapted to the architectural design context (Benner and Tushman 2003). It will be seen to what extent these different modes exist simultaneously when creating design knowledge and that this process should not be characterised as being either strictly binary or linear. The model developed in this paper suggests that Architects might blur sequential distinctions between exploitative and exploratory design by pursuing both at the same time. Specifically, the model suggests that both types of design take place simultaneously and that the pathway to an innovative project outcome is not linear. The model suggests that during the design process exploitative innovations are purposefully destroyed in order to create exploratory outcomes; and conversely, exploratory outcomes are destroyed in order to create exploitative innovations. Moreover, it will be suggested that design paradoxes are resolved through processes of improvisation.

Design Knowledge Creation and Organisational Paradox

Linear and binary descriptions of the design process abound in design literature. However, these concepts have not often been developed as paradoxical concepts. For example, Winch theorises that designing can either be characterized as a conjectural model or a linear model (Winch, 2008). He claims that the linear model is a problem solving approach which involves analysis, synthesis and evaluation. He argues that the conjectural model, a model which is arguably linked to design, is 'much closer to scientific method' and more discontinuous or disruptive. This model is not unlike Tushman's concept of exploratory innovation. Winch argues that in a conjectural design approach, an initial hunch or conjecture is formulated and following this the process then proceeds through a number of iterations. It is through these paradoxical iterations that design knowledge is created; in each iteration conjectures are proposed and then abandoned. Lawson argues that architectural design processes are complex and need to be distinguished from engineering definitions of optimised design. He argues that many of the maps or descriptions of the design process tend to be overly theoretical or prescriptive and that these tend to place a value on those linear descriptions of the design process sometimes ignoring the iterative design process that takes place within a particular design exercise. (Lawson, 1980, 29).

Architects have also been seen as Systems Integrators who are able to create innovations. However, System Integration has not been developed further or conceptualized in terms of organizational paradoxes. Obviously, the systems integration concept could easily be seen as the means by which paradoxes, for example, related to different innovation pathways or requirements, might be reconciled. In a study of 10 architectural firms Renier, Volker and Wamelink test Winch's idea that architects are System Integrators (Renier et al 2010). They conclude that architects are indeed System Integrators who will strive to attain a particular level of innovation in order to maintain the firm's competitive advantage. Referring to

Winch's two-moment model of innovation they assert architects have two primary modes of idea generation: The first is based on problem solving dynamics centered on the project, often as the result of the need to develop new solutions. The second dynamic is the generation of new ideas as a result of changes in broader market conditions. In this model Winch contextualizes innovation with reference to the way in which a firm and a project are linked to its broader environments: "new ideas can either be adopted by firms and implemented on projects, or result from problem-solving on projects or be learned by firms" (Renier et al. 2010). This model is based on a binary top down and bottom up model. But it does not explore or suggest how these two different modes of innovation might generate paradoxes either in the organization or within the project.

Another more complex model that has been advanced is the idea that architectural designers can be characterised as Knowledge Intensive Professionals Firms who 'have a pivotal role of the knowledge worker in leading the co-production of innovation with clients' (Lu and Sexton, 2006). Despite the fact that architects and clients are often in conflict this model does not see co-production as having a paradoxical potential. Shu-Ling and Sexton have adapted and developed Nonaka and Takeuchi's spiral model of Knowledge Capital creation in order to explain how knowledge is created in, what they call, KIPFCS. Interestingly, this is a model which does not describe the role of paradoxical processes in the creation of design knowledge. It is an interaction model which posits that knowledge - for example, design knowledge - is created via individuals in project organizations. This knowledge then becomes more explicit, rather than tacit, through collaborative interaction between individuals, teams and organizations. The model presumes that knowledge is created in a continuous or linear fashion in which knowledge capital is increased as these interactions increase. The model is linear, despite its spiraling nature, because it does not allow for the paradoxical processes that might take place in the interactions between individuals, teams and organisations.

In attempting to adapt ideas of organizational paradox to construction Price and Newson argue that strategic management in organizations has been portrayed as a linear process, that is, a process which privileges notions of rationality and logic over those of creativity and the imagination. Price and Newson adopt a top down strategic management approach to describe paradoxes in relation to strategy formulation in construction organizations. They argue that construction organisations should pursue an optimal balance between organizational paradoxes when planning long term strategies. They conceive of, from a construction viewpoint, a taxonomy of paradoxes, which they categorise in binary terms as: Logical (rational) versus creative (generative) strategies; Intended (deliberate) versus realized (emergent) strategies; Revolutionary versus Transformational strategies; Strategic fit versus strategic stretch; and Strategy versus organizational effectiveness (Price and Newsom 2003).

Of the paradoxes identified by Price and Newsom the terms Logical and Creative are characterized as signifying a paradox between "structured decision-making" that leads to incremental change and a "more creative approach" that may lead to greater innovation and "Radical step changes." This distinction echoes the work of Tushman and Benner who have made the distinction between exploitative and exploratory innovation. Exploitative actions utilize existing organizational resources in order to generate short term competitive advantage. Exploratory innovation employs new organizational resources in order to generate "sustainable long term competitive advantage. Clegg, Cunha and Cunha suggest that some of the above binary dichotomies and distinction can be reconciled using a bilateral relational model of organizational paradoxes. In this model they employ the concept of improvisation and claim that this is the process by which organizations resolve paradoxes. They highlight

the paradoxes that exist between exploration and exploitation in organizations. They state that "exploration and exploitation enter a mutually supportive relationship when existing resources are used to look for and take advantage of new opportunities." (Clegg, Cunha and Cunha et al 2010).

Each of the above models or concepts is conceived to explain a different aspect of organisations' approach to innovation. All of the above models are built on a range of expressions that signify binary oppositions: external and internal, top down and bottom up, logical versus creative, rational versus generative, linear versus iterative and exploitative and exploratory. Remarkably, these terms seem to exist in isolation. Very little discussion is noted about the process by which these paradoxes are held apart, consciously encouraged or resolved. If these concepts are regarded as paradoxes then it is possible that more dynamic models may emerge that better relate design processes to construction innovation. Improvisation by way of generative problem solving or designing is not conceptualised in the above models. Seeing architects as systems integrators suggest that they can easily reconcile conflicting and contradictory elements within different project contexts. But this says little about how this is done.

Methodology

The above concepts were examined in a way that attempted to illuminate the paradoxes between rational and exploitative design process and generative design. Underlying the approach in this context is the idea that organizational paradoxes should be examined at the level of project and team business processes and not exclusively from a top down strategic management approach. As suggested above, this survey presumes that generative or exploratory actions are a key driver of innovation. This research aims to understand if simultaneous occurrence of design paradoxes in a project organization may be related to

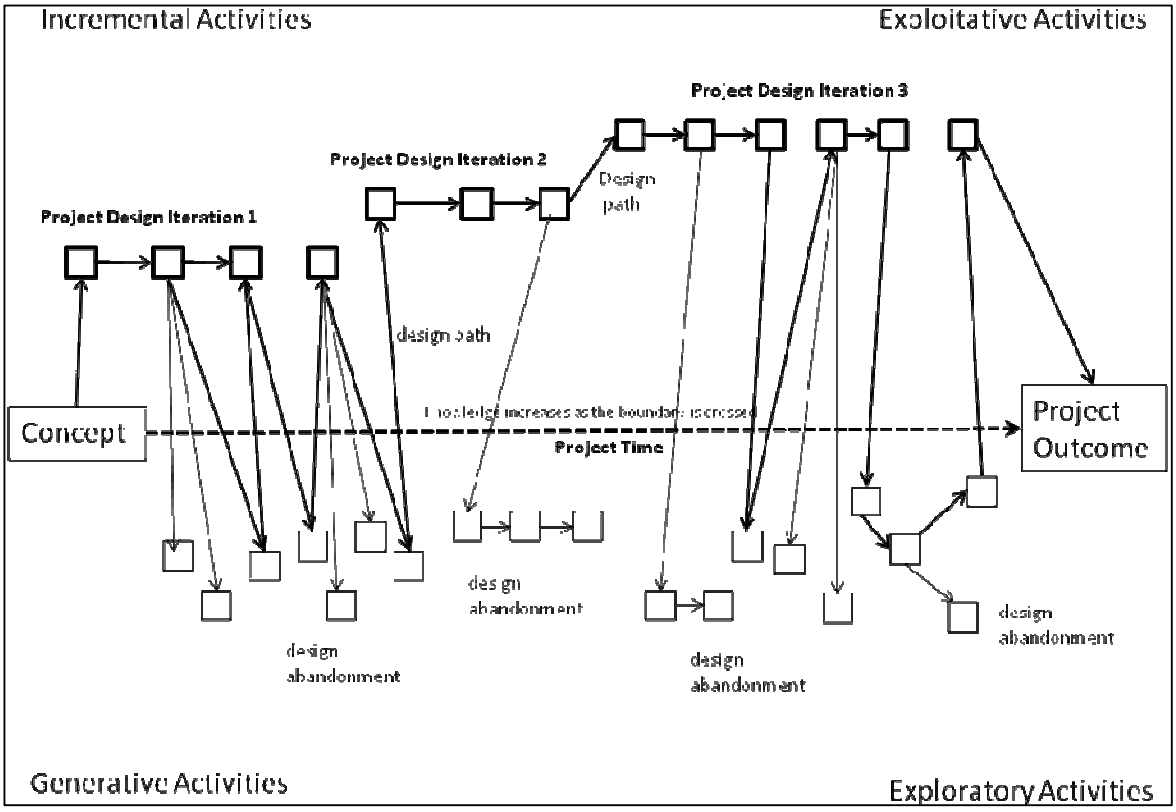


Fig 1: *Design Paradox Systems Integration Model*

innovative outcomes. This research is a first step in approaching this aim. An initial model of how Incremental and Exploitative activities might take place during the design process is set out in Figure. 1. A paradox occurs when generative or exploratory activities occur at the same time as Incremental or Exploitative activities. The survey was designed to ascertain to what degree architects paradoxically pursue both Radical or Incremental design solutions in a given project context. The term Incremental is a signifier for exploitative, logical, and rational design versus Radical which signifies exploratory, generative and creative design. In the survey in order to begin to define these terms, Radical and Incremental were also equated with the kinds of design changes that might take place in a project context. The survey respondents were also asked to define how they themselves defined these terms in a project context.

Using the above definitions the hypothesis employed was the proposition that architects deliberately seek to foster highly paradoxical processes within their firms in order to create new design knowledge. To achieve this the research questions of this paper are aimed to discover to what degree architects are *continuing to simultaneously generate both radical and incremental design solutions throughout the design process.* In order to test this hypothesis a survey was developed that would begin to investigate how architects approached concepts of incremental and radical design during the sketch design, design development and construction stages of the project process. In other words as the design proceeds, to what degree do architects continually question and reconsider design knowledge that has already been created? To what degree will architects consider making radical design changes after a particular design stage has been decided upon? It is important to also understand if architects pursue both Radical and Incremental design solutions at the same time.

In the survey the underlying structure is that exploratory actions are designated as Radical design solutions. These are generative and conjectural in nature. Likewise, incremental design solutions are translated from the concept of exploitative actions. These are linear and incremental in nature. The survey was sent to 1145 architects around Australia all of whom were members of the Australian Institute of Architects. There were 63 responses.

Survey Questions

Given that most architectural practices are SMEs and work on a range of projects in size and financial value it was decided to develop the survey by identifying each practice's largest project, the number of staff in the practice and the type of work they did. The survey also identifies the predominant project type in the firm as well as the monetary value of this project in order to ascertain the complexity of the project. Alongside this project context the number of staff in the practice was identified together with the role, experience and involvement of survey respondent.

Having asked questions about the architectural firm the survey then included questions about how the firm might define Radical and Incremental design changes. Respondents were then asked why such changes take place during the project delivery process. Following this a number of questions were asked about the extent to which Design teams or designers within the practice have the freedom to continue to generate Radical design solutions even if a design or design stage has been agreed on. Finally, the respondents were asked to respond to

a number of statements which gauged to what degree they felt Radical or Incremental design solutions coexisted within a particular project context or design process.

Results

There were 73 responses to the survey out of 1145 invitations. 95% of respondents were architectural directors and 70% of these had over twenty years experience. Most practices were small with 43% having between 2 and 5 staff and 18% having up to 10 staff. 8% of respondents came from practices that were larger than 50 staff. 48% of respondents stated that the largest project in their office was between $AUD1M and $AUD5M. Notably, 78% of respondents stated that they spent at least 25% of their time managing design and design teams.

The respondents strongly agreed that Radical design changes were most related to: the functionality of the project as a result of briefing changes 69%, the overall floor area or building heights 59%, the projects siting or orientation 54%. Radical design changes were seen to encompass a wide range of activites such as: "the inclusion or removal of significant functions", "significant change in the floor area", "changes in leadership within the briefing team", "planning or design changes required due to significant program or delivery timing parameters/budget amount/funding source/ legislative changes." Many respondents were less specific in their definitions and stated that Radical design changes were design changes that: "lead to fundamental rethinking of elements of the project", "affect the form or conceptual origin", "change the design concept" or "A change that affects the fundamental design - so great that the concept must be re-assessed or thrown out."

In response to the question of why Architect initiated Radical design changes are instigated, the respondents agreed that such changes were neccesary in order to: respond to a cost cutting or value management exercise 82%, better co-ordinate services and systems within the project 55%, improve the quality of the projects aesthetic or spatial qualities 50%. Finally, 58% of respondents agreed or strongly agreed that such changes were often made to deliberately explore innovative aesthetic and spatial solutions.

Once a Conceptual or Sketch Design has been signed off, to what extent will the designer and project team be allowed to:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	greatly Encouraged
Continue to test the Conceptual Design or Sketch Design solutions by creating alternatives to it.	5 7%	17 23%	24 33%	25 34%	2 3%
Pursue new design solutions at the risk of creating a new Conceptual or Sketch Design.	8 11%	30 42%	23 32%	11 15%	0 0%

Play with the design in order to see what new concepts or solutions may emerge.	6 8%	25 34%	25 34%	15 21%	2 3%
Use the Conceptual Design or Sketch Design as a basis for generating new subsidiary design solutions in order to advance the design to the next stage.	2 3%	10 14%	11 15%	41 56%	9 12%
Advance the design to the next stage using the practice's processes and resources.	1 1%	5 7%	8 11%	45 62%	14 19%

Table 1: *% of firms that continue to generate creative design solutions after sketch and concept design stage.*

The responses seemed to indicate that most exploratory or generative design activities take place in the early stages of the project design process. At this stage, as can be seen in table 1, even though a sketch design or concept design had been mandated, 38% of firms either encouraged or greatly encouraged a generative design process in order to create alternative solutions to the mandated design. Most firms or directors encouraged their teams to use the Conceptual Design or Sketch Design as a basis for generating new subsidiary design solutions in order to advance the design to the next stage. However, a significant percentage actively pursued and encouraged new design solutions or explored the design in order to seek new concepts and solutions. However, it can be seen in tables two and three that once the sketch design stage has passed, architects are reluctant to pursue alternative design solutions.

Once a project has been signed off at Design Development stage to what degree will the designer and project team be allowed to:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	Greatly Encouraged
Continue to test the Design Development solution by creating alternatives to it.	13 18%	27 38%	23 32%	7 10%	2 3%
Pursue new design solutions at the risk of creating a new Design Development solution.	19 27%	27 38%	19 27%	5 7%	1 1%

Play with the design in order to see what new concepts or solutions may emerge.	21 29%	24 33%	18 25%	9 12%	0 0%
Use the Design Development stage as a basis for generating new subsidiary design solutions in order to advance the design to the next stage.	13 18%	12 17%	23 32%	23 32%	1 1%
Advance the design to the next stage using the practice's processes and resources.	7 10%	6 8%	11 15%	39 54%	9 12%

Table 2: *% of firms that continue to generate creative design solutions after design development stage.*

It can be seen in Table 2 above and Table 3 below that once the sketch design stage has passed that architects are reluctant to pursue alternative design solutions for their own sake. They will, however, pursue any design solution that will advance the design to the next stage. Obviously in some circumstances, if there is a change of brief of example, this would mean employing Radical design soultions to do this. However, the results suggest that architects are more likely to pursue incremental or exploitative changes at these stages through the generation of subsidiary design solutions and the exploitation of the firm's normative processes and resources.

Once a project has been signed off after Tender stage and is in Construction to what degree will the designer and project team simultaneously:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	Greatly Encouraged
Continue to test the Sketch, Design Development and Documentation solutions by creating alternatives.	49 67%	16 22%	7 10%	1 1%	0 0%
Pursue new design solutions at the risk of creating a new conceptual or Sketch Design.	51 71%	16 22%	5 7%	0 0%	0 0%

Play with the Design in order to see what new concepts or solutions may emerge.	48 67%	16 22%	5 7%	3 4%	0 0%
Use the Construction stage as a basis for generating new subsidiary design solutions in order to improve the design.	30 41%	16 22%	13 18%	11 15%	3 4%

Table 3: % of firms that continue to generate creative design solutions after design development stage.

Table 3 above indicates that architects are very reluctant to pursue alternative design solutions once a project is under construction. No firms indicated a willingness to pursue new design solutions at the risk of creating a new sketch or conceptual design. A very few respondents did appear to encourage playing with the design in order to see what new concepts would emerge. However, 19% of respondents did see the construction phase as an opportunity for generating new subsidiary design solutions in order to improve the design as it neared completion.

To what extent do you agree or disagree with the following statment	
Pursing Radical design changes is a part of the practice's normal design process.	28%
In our practice any project the principal designer, designer teams and design architects have the time to pursue new design solutions throughout the project.	29%
Design teams or designers within the practice have the freedom to continue to generate Radical design solutions even if a design has been agreed on.	17%
Continuing to generate both Incremental and Radical design solutions throughout the process helps to identify and highlight new design issues and problems as the design progresses.	42%
Continuing to generate both Radical and Incremental design solutions throughout the process outweighs impacts on project delivery time or cost.	21%
Implementing Radical design solutions throughout the process outweighs impacts on project delivery time or cost.	21%
Sometimes it is necessary to discard a design solution or sketch design and start the design process again in order to achieve a better project outcome.	72%
It is difficult to manage designers and design teams who pursue both radical and incremental design changes in a project simultaneously.	57%
Creating and then culling both Radical and Incremental successive design solutions in a given project helps to achieve high quality and innovative design.	65%

Table 4: % of firms that agree or strongly agree with the question.

Discussion

The survey appears to indicate that a significant proportion of architects foster paradoxical design processes in their firms. The initial model proposed here posited that architectural designers and design teams will undertake exploratory and exploitative activities simultaneously. The hypothesis tested was the proposition: that many architects deliberately seek to foster highly paradoxical processes within their firms in order to create new design knowledge. It would appear that this is the case even though an initial sketch design has been mandated. In the early design stages of a project 37% of architects will continue to pursue alternative design solutions and 15% of architect respondents will continue to test a design solution at the risk of creating a new design solution. Architects will continue to play with the design solution in order to see what new concepts emerge through sketch design, 24%; design development 12% and even into the construction phase 4%.

The results indicate that architects continue to*, simultaneously generate radical and incremental solutions throughout the design process;* this only holds true for the early stages of the project prior to design development. It would appear that the sketch design stage is the stage that appears to be the most paradoxical. This is because it is the primary stage where both exploratory and exploitative activities take place during the project. This is described in Figure 2 which is a revision of the initial model as set out in figure 1. This model, which would be tested by further future research, indicates that in the early stages of a project architects freely generate design solutions which create design paradoxes with other project elements and systems. Some of these solutions are abandoned, or destroyed, and others are then integrated into the project and developed in an exploitative fashion. As the project advances fewer paradoxes are created. This is because fewer generative design solutions are created and the focus in the project is on developing subsidiary solutions and systems integration as the project approaches construction delivery. Those paradoxes that are created

One limitation of this research has been the initial necessity to establish the definitions of what architects regard as radical and incremental design changes. In the survey Radical and Incremental were also equated with the kinds of design changes as well as the solutions that might take place in a project context. These changes are regarded as Radical if they require a substantial change to the brief or a significant change to the original design concept or strategy. Future research would better align definitions of what architects regard as Radical design changes with what they regard as Radical design solutions. Future research could also look at the design processes within a small range of architectural practices, or projects, over time in longitudinal detail. This might require a close observation of architectural design processes particularly in the early design stages. A key aim of future research would be to establish to what degree construction or design innovation is achieved in the early design stages of a project. Creating both exploratory and exploitative design solutions simultaneously may not necessarily lead to innovation.

It would appear that once a design concept is produced Architects deliberately pursue generative solutions which tend to create paradoxes with other more rational project constraints. But this appears to take place primarily in the early stages of a project where architects have more freedom to explore and are not as constrained by time and cost

Deadlines. Through a process of systems integration these solutions are developed and advanced though exploitative means. In the later stages of a project, as can be seen from the results generative, a lesser number of generative, or exploratory, solutions are pursued at the

same time that earlier generative solutions are being integrated, by exploitative means into the project process. On the basis of thesis results it could be argued that for architects the creation of design paradoxes, using generative and exploratory means, diminish as the project proceeds. Nevertheless, the model suggests how architects act as systems integrators and that both types of design take place simultaneously and that the pathway to an innovative project outcome is not linear.

Theories of organisational paradox should allow for the fact that paradoxes are often nested. One paradox may appear one reside within another Paradox. Examining one paradox may often reveal another paradox at a different level or scale. For example For example, 57% of respondents cited the difficulty of managing design teams that pursue both incremental and radical design changes simultaneously. However, they still agreed that creating and destroying both Radical and Incremental design solutions was at least one way to achieve design innovation. If any overarching paradox exists within construction project processes it is that many project systems favour sequential linearity, in other words exploitative processes, alongside actual project processes which are never linear and often complex and chaotic.

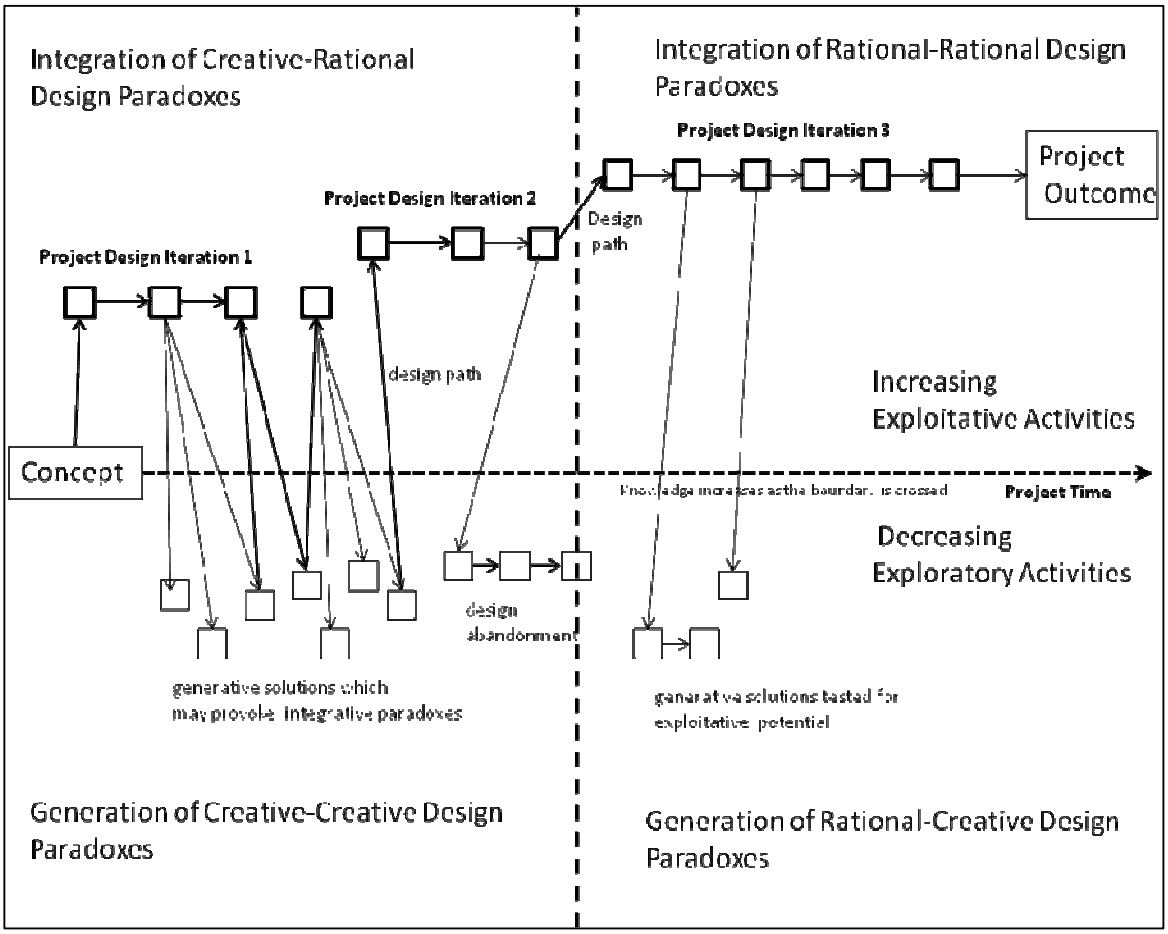


Figure 2: *Revised Paradox Systems Integration Model*

Conclusion

Future research would also examine in detail those firms that continued to engender design paradoxes by pursuing exploratory design solutions throughout the entire process. Whilst only a very small minority of firms were willing to do this after the tender or bid stage it would be interesting to know more about the characteristics of these firms. Are they firms with a good reputation for design? More importantly do paradoxical processes create high quality design knowledge that drives innovation? Much of the literature suggests that in theory so called creative, non linear and conjectural processes create innovation. However, these assertions need to be tested in project organisations and teams. Organisational paradoxes should not be seen as existing only in the domain of high level strategic management. Paradoxically, this research itself raises a number of paradoxes that should be the focus of future research.

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AN OVERVIEW OF GREEN BUILDING PRACTICE IN TURKEY

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Abstract
The building industry is responsible for a large part of the world's environmental degradation as buildings converge in themselves major indexes of energy and water consumption, raw material employment and usage of land. Thus, green buildings, which are defined as resource-efficient and ecosystem-conscious structures designed with a holistic understanding of social and environmental responsibility, have become the flagship of sustainable development. Today, in several countries, there is a well developed green building practice that is used to improve and assess diverse aspects of a building such as site selection, energy, water, material consumption, waste production and pollution. Ongoing development of the sustainability phenomenon, as well as some pioneer green projects in Turkey, has brought on awareness and discussions regarding the green building practice in the Turkish architectural, engineering and construction (AEC) industry recently. In this paper, current green building practice, legislative framework and policies regarding green buildings have been analyzed and deficiencies in policies and statutory regulation in Turkey are determined to bring forward suggestions towards a more institutionalized development of green building practice. On the other hand, Singapore's Green Building Masterplan and its key aspects have been overviewed as a best practice in terms of a planned and holistic approach in the quest for constituting a model for countries looking for a widespread adoption of green building practice in the near future like Turkey.

Keywords: green buildings, building assessment, sustainable design and construction, Turkey.

INTRODUCTION

The debate about sustainability of buildings is becoming more and more intense with the increasing awareness of the impact that buildings have on the environment both in terms of their construction and use. The building industry, indeed, is responsible for a large part of the world's environmental degradation as buildings converge in themselves major indexes of energy and water consumption, raw material employment and usage of land (Melchert, 2007). Buildings account for nearly 40% of energy consumption, 70% of electricity consumption, 40% of carbon dioxide emissions, 12% of water and 40% of raw material use in the developed countries (Retzlaff, 2008). Thus, also variously designated as "ecological", "environment-friendly" or "sustainable" buildings, the green buildings have become one of the most important elements in the issue of sustainability, an issue inevitably highlighted by climate change and depletion of natural resources. Green buildings are defined by the

Turkish Green Building Association (2009) as resource-efficient and ecosystem-conscious structures designed with a holistic understanding of social and environmental responsibility, harmonious with local conditions, built with proper materials and systems so as to minimize energy consumption, where renewable energy sources are given priority and waste production held under control.

This paradigm shift also generated the need to develop norms and regulations for sustainable building design and construction. Today there is a well developed green building practice and a diverse array of regulations and policies regarding green buildings and sustainability in several countries. However, the results of research by Akbiyikli et al. (2009) show that the current level of sustainability understanding and hence its implementation is still unstructured, piecemeal and insufficient in the Turkish AEC industry.

Since the preparation of relevant legislation and adoption of appropriate and resolute policies constitute an indispensable part of the development of the green building practice, current deficiencies in green building legislation and policies in Turkey are determined and Singapore's Green Building Masterplan is analysed as a best practice in this paper in the quest for constituting a model and putting forward suggestions for countries looking for a widespread adoption of green building practice in the near future like Turkey.

GREEN BUILDING PRACTICE IN TURKEY

Green Building Certification Systems

Green Building Certification is the core and most tangible part of the green building practice for the stakeholders of the AEC industry. Today, in several countries, there is a well developed green building certification practice that is used to assess diverse aspects of a building such as site selection, energy, water, material consumption, waste production and pollution. Despite the debate and efforts, there is a consensus that a global standardization (and certification) of green buildings seems not possible due to the regional differences in climate, supply of energy, water, raw materials and land, availability of "green" materials (EMS certified materials etc), environmental conditions, economic conditions, legal framework, culture and way of conducting business in the AEC industry. On the contrary, recently more and more national certification systems are being developed or global systems are being adapted to local conditions. Leadership in Energy and Environmental Design of the US (LEED), Building Research Establishment Environmental Assessment Method (BREEAM) of the UK, Sustainable Building Tool (SBTool) of Canada, German Sustainable Building Certificate (DGNB), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) of Japan, GreenStar of Australia and BCA Green Mark of Singapore are some of the green building certification systems that are widely adopted around the world.

The concepts of green buildings and sustainable design have gained recognition in the AEC industry within the past decade in Turkey. However, green building practice is still entirely voluntary and generally limited to foreign investment projects, buildings designed for global corporations, new residential developments and educational buildings. BREEAM and LEED are the two certification systems used and supported institutionally by the Turkish Green Building Association (TGBA). However, TGBA is recently working on an adaptation of BREEAM to develop "BREEAM Turkey". BREEAM was chosen over LEED for adaptation since most of the UK's and Turkey's regulations and standards are common or compatible due to Turkey's adoption of the acquis communitaire within the accession process to the EU.

Despite these recent efforts, green building practice is very limited and piecemeal and the total number of projects certified is still very low. This can be explained with the "context" the green building practice is operating in, namely the *legislation* regarding green building issues and green building *policies* adopted by the central or local administrations. These two are analysed in detail below and suggestions are brought forward for a wider adoption and a more institutionalized development of green building practice in Turkey.

Green Building Legislation

Turkey is one of the few countries which included environmental protection in its Constitution. According to the Constitution, "everyone has the right to live in a healthy, balanced environment and it is the duty of the state and citizens to improve the natural environment and to prevent environmental pollution". Despite this provision, no specific legislation exists in Turkey currently on the green buildings. Therefore, in this section, current legal situation is analyzed under common themes relevant to green buildings such as energy, water, building materials, land use and waste.

Legal regulation has recently been made in Turkey with the purpose of stimulating energy conservation in buildings, rendering some practices compulsory and enabling inspection of obtained results. These legal measures are assembled in Regulation on Energy Performance of Buildings (BEP-Y) dated December 5th. This regulation covers the computational rules for the assessment of all energy uses in a building, and its classification with respect to primary energy use and carbon dioxide emission, the specification of minimum energy performance requirements for new or substantially renovated buildings, guidelines for the evaluation of the practicability of renewable energy sources, inspection of heating and cooling systems, abatement of greenhouse gas emissions, and the performance criteria and the implementation guidelines that apply to the buildings. This regulation is promulgated on the EC Directive on the Energy Performance of Buildings, which lays down requirements as regards the general framework for a methodology of calculation of the integrated energy performance of buildings, the application of minimum requirements on the energy performance of new buildings and large existing buildings that are subject to major renovation as well as the energy certification and regular inspection of buildings and its systems. Regulation on Energy Performance of Buildings requires the evaluation of the energy performance of buildings including determination of energy consumption, CO_2 emission, benchmarking these values to a reference building and classification of the building according to the benchmark results. Building Energy Performance Calculation Methodology (BEP-HY) defines the assumptions and methods used in the calculation of energy consumption of heating, cooling, ventilation, lighting and hot-water systems in a building. BEP-HY can be used for comparing the energy performance of alternatives in the design phase, comparing the cases of using and not using energy efficiency measures, developing foresights for the need of energy in future by calculating typical buildings that can represent the building stock in an area and developing a national database of energy performance of various building elements and materials (Ministry of Public Works and Settlement, 2009).

Although one of the most serious problems that Turkey may face in parallel with global warming is water shortage, currently no legislation exists in Turkey regarding water efficiency in buildings. Use of efficient water equipment, rainwater harvesting systems, surface water harvesting systems, efficient irrigation systems, plant types that consume less water in landscaping, recycling of the treated effluent for appropriate reuse in buildings and water efficiency awareness-building programs for the public could be addressed by such a legislation. Building materials, on the other hand, are regulated by Regulation on Building

Material, which requires the materials used in buildings to be mechanically resistant, non-toxic, safe to use, energy efficient and have a CE or G marking. This regulation could be amended to include limits and/or incentives regarding the environmental impact of the production process of materials in order to render the buildings "greener" in Turkey. Furthermore, additional legislation could be prepared to encourage the use of "green materials" in buildings such as recycled, recyclable, local and renewable material. Such legislation might be supported with training of designers and professionals dealing with material selection in construction projects (Ilter, 2011).

Development plans are the main source of restrictive regulations in land use for buildings. Planning areas are divided into zones such as residential, commercial, industrial etc and some development restrictions such as the maximum number of floors and the usable area to land area ratio are included in these development plans. Ercoskun (2005) argues that current development plans do not consider urban identity and ecological values such as climate, spaces between buildings, direction, natural lighting, and air circulation etc resulting in the Turkish cities to be unsustainable. Furthermore, the reality of illegal settlements and brutal development interests has a damaging effect on both natural and built environment in big cities. However limited to big scale projects, a key piece of legislation regarding environmental concerns in site selection is the Regulation on Environmental Impact Assessment, requiring an independent assessment report evaluating the positive and negative impacts of a project on the environment and appropriateness of the site selected for the project. The scope of this regulation covers energy production and distribution plants, industrial and agricultural buildings, as well as hotels with 100 rooms or more, public and private housing projects with 200 units or more, educational and sports complexes.

As for waste, Regulation on the Control of Excavation, Construction and Demolition Wastes, promulgated on 13 March 2004, sets the rules for the collection, accumulation, recycling and disposal of wastes generated in the excavation, construction and demolition phases. According to the regulation, wastes should be minimized at the source, the persons or organisations who are responsible for the management of the wastes should take the necessary precautions to minimise the harmful impacts of the wastes to the environment, the wastes should be recycled and used as building materials where possible, excavation soil and construction / demolition wastes should be processed separately, wastes should be classified at the source for a healthy recycling process, the producers of the unrecyclable excavation, construction and demolition wastes should pay for the disposal of such wastes. Regarding the recycling of excavation soil, the regulation requires the vegetative soil to be used in parks etc and the rest to be used in filling, as a cover material in solid waste storage areas and as clay in cement industry where the chemical properties of the soil allow. Collection, treatment, disposal and recycling of wastewaters and solid wastes produced during the utilization of buildings, i.e. wastewater and solid waste management are also well established fields covered by separate special legislation and institutional agencies (Ilter, 2011).

Green Building Policies

Apart from the ones supporting the well developed legislation stimulating energy conservation in buildings, holistic policies regarding green buildings or sustainable built environments do not exist and seriously needed in Turkey. There are diverse aspects ranging from macro to micro scales in this approach and thus we need to ensure that we learn from best practise on a global level. Singapore is one of the few countries that introduced a resolute policy regarding green buildings and has tackled the issue of green buildings within a Masterplan prepared with a holistic approach. Therefore, in the next section, "Singapore

Green Building Masterplan" and its key aspects are analyzed in the quest for constituting a model for other countries looking for a widespread adoption of green building practice in the near future, such as Turkey.

A Best Practice: Singapore Green Building Masterplan

According to Building Construction Authority - BCA (2009) and Seng (2011), Singapore Inter-Ministerial Committee on Sustainable Development (IMCSD) has set itself an ambitious target of having "at least 80% of the buildings in Singapore to be greened by 2030", which means 80% of the buildings in Singapore must be certified by Building Construction Authority (BCA)'s Green Mark Scheme by 2030. BCA Green Mark was launched in 2005 as a green building rating system to evaluate buildings in terms of environmental impact and performance in Singapore. The key assessment criteria are energy efficiency, water efficiency, environmental protection, indoor environmental quality and some other green features. There are platinum, gold-plus, and gold certificates available for projects with higher scores and projects that achieve mediocre scores are only "certified" without any further classifications. BCA Green Mark Scheme is only a part of Singapore's Green Building Masterplan which has been designed with a holistic approach and has diverse aspects.

The legislation in Singapore require all new buildings to meet the minimum Green Mark standards, and the public sector demonstrate even stronger commitment by targeting the highest Green Mark certificate (Platinum) award for all new projects and existing buildings undergoing major retrofitting works with an air conditioned floor area larger than 5,000 m2. Other existing government buildings with more than 10,000 m2 air conditioned floor area are required to achieve Green Mark Gold Plus certificate by 2020. On the other hand, higher tier Green Mark standards have been set as land sales condition by the government in new growth areas to ensure that they are truly green. This is expected to result in at least 25% reduction in energy use. This represents an estimated project value of $500 million from the government over the next ten years to upgrade all existing buildings owned by government agencies. When all these are done, Singapore is expected to achieve substantial energy savings of $120 million per year.

As for incentivizing the private sector, 102 projects have been funded with a budget up to S$3 million in cash per project. S$20 million incentive resulted in 26 platinum, 14 gold-plus and 62 gold certified buildings, 56 of which were residential and the rest being commercial projects. On the other hand, to encourage private developers to construct new buildings that attain higher tier Green Mark ratings (i.e. Green Mark Platinum or Green Mark Gold-Plus), BCA and Urban Redevelopment Authority (URA) are introducing the Green Mark Bonus GFA Scheme in the form of additional Gross Floor Area (GFA) for higher-tier Green Mark projects. The Green Mark Bonus GFA incentive is extended to all new private developments, redevelopments and reconstruction developments. The quantum of bonus GFA is up to 1% for Green Mark Gold-Plus and up to 2% for Green Mark Platinum. This is expected to help to accelerate the adoption of environmentally-friendly green building technologies and building design practices to enable the development of green buildings to be even more economically viable in the longer term. To date, 46 applications have been received by BCA and URA, 33 applications were approved and 13 applications were given approval in principle.

As for retrofitting the existing buildings to improve energy efficiency, BCA is introducing a bold S$100 million Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) to jumpstart the 'greening' of existing buildings in the private sector. This will probably be

another successful incentive since financial considerations is one of the key barriers for building owners in upgrading the energy performance of their buildings. This scheme will operate in two parts; first being the cash incentive that co-funds up to 35% of the costs of the energy efficient equipment installed. The second part is the 'health check' scheme; this is an energy audit which determines the efficiency of the air-conditioning plants. BCA will also co-fund 50% of the cost for conducting this Health Check. To date, 13 applications were given approval in principle amounting to S$3 million.

BCA has also raised a S$50 million fund for research in green buildings and supported 48 projects. In this context, a Zero Energy Building (ZEB) has been planned as a show-case to encourage the building industry and show that greening existing buildings to meet the highest Green Mark standards is possible. Apart from being a zero energy retrofitted building, ZEB is also a platform for academicians and researchers to analyse green building technologies and their performances in a real setting so as to bring new knowledge to the technical community and explore areas for further research. It also gives BCA a platform where industry stakeholders, local and foreign government officers, building professionals and students learn about green building technologies by physically seeing them in action.

Beside ZEB, there are many large-scale integrated living labs in Singapore. These offer testing of intelligent energy systems, off-grid energy solutions and applications, sustainable public housing solutions, green business park solutions, trialling of EVs & charging solutions and solar capability building on public housing. There is also innovation and R&D centres, centres of excellence and incubation centres established in Singapore dealing with different aspects of sustainable urbanisation such as urban transport management, connected cars, green ICT, green building and infrastructure, integrated water management systems, smart grid and integrated security management.

BCA also committed to building industry capabilities through training. In this regard, in order to meet the challenging target of greening 80% of all buildings by 2030, BCA has estimated that a total of 18,000 - 20,000 green specialists would be needed over the next 10 years. These specialists include personnel across the entire value chain, covering upstream activities of development and design to the downstream activities of construction and operation & maintenance. With the aim of training these specialists, BCA Academy has been established where a comprehensive suite of green related training courses have been put in place. These include Executive Development Programmes targeting at the senior management of firms, as well as the Academic Programmes, Specialist Certification Programmes and Niche Competency Programme targeting at the professionals. To date, 1563 professionals have been trained as Green Mark Manager, 115 as Green Mark Professional and 133 as Green Mark Facilities Manager. BCA is planning to continue to enable the industry to raise its capability to develop more Green Buildings by providing a comprehensive training and educational framework ranging from Master degree, specialist diploma to certificate courses to ensure adequate supply of green building professionals and sub-professionals to meet the expected strong demand for green buildings.

For international recognition and awareness raising purposes, BCA has established the Singapore Green Building Council with an international panel of experts and BCA was connected to global sustainable building community such as the World Green Building Council through Singapore Green Building Council. After this BCA Green Mark Scheme was adopted by many other countries, such as Malaysia, Vietnam, Thailand, China, India and some Middle Eastern countries.

As a statutory obligation, the Code for Environmental Sustainability of Buildings were incorporated into the building control act as a form of legislation that set out the minimum standard for new buildings to meet the minimum green mark certified level.
Over the years, there has been a steady increase in the number of green buildings. By end of FY2010, it is projected we will have 650 green buildings, occupying 20 million m2 of floor space (Figure 1). This is about 9% of the total GFA in Singapore.

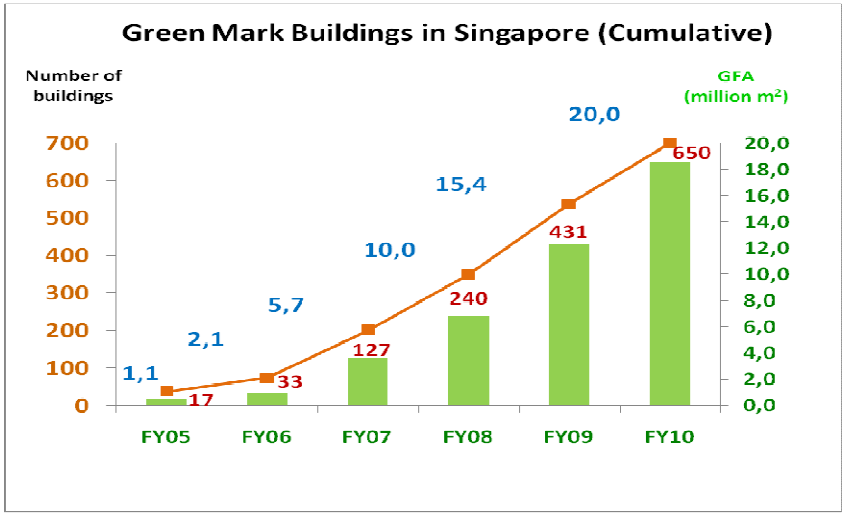


Figure 1: *Green Mark Buildings in Singapore (Seng, 2011).*

BCA Green Mark Scheme was recently revised and Version 4 for new buildings had taken effect from 1st Dec 2010. This new revised rating system placed emphasis on passive design (natural ventilation, day lighting etc), sustainable construction, greenery system as well as enhancement to building energy efficiency standard.

Lessons Learned
Analyzing the best practice of Singapore reveals important lessons for countries aiming a widespread adoption of green building practice in their AEC industry. First of all, as seen in Singapore, government itself has to take the lead and apply green building standards to public buildings (both existing and new) to set a good example for the community. All public sector buildings should meet minimum standards of environmental sustainability. By doing this, government will also be creating a green building industry and business in all levels in terms of production and commerce. On the other hand, government policies for incentivizing the private sector are needed since initial investment is one of the most important barriers to building green in terms of both new developments and retrofits. Resolute policies should be set up ranging from supporting a house owner for retrofitting to tax exemptions for developer companies building green. This can be formulated as direct monetary incentives to developers that achieve a green building rating above a certified level as seen in the Masterplan of Singapore. To further encourage private developers to achieve outstanding design, quality, and sustainability objectives in their projects, policies should set higher standards as land sales conditions for selected new growth areas.

Policies should be formulated to step up developmental and collaborative efforts to build up capabilities and expertise in green building design and technologies. As seen in the Singapore example, this will eventually lead the way to more viable and cost effective applications of

green building designs and technologies. Showcase buildings, laboratories, innovation and excellence centers, incubations hubs are all useful platforms to test bed and showcase new technologies and designs for the built environment. Supporting R&D projects should also be an indispensible part of the policies on furthering the development of green building technologies. Besides supporting the institutions and facilities, human resources should also be created and supported. To meet the increasing demand for green building professionals, it is important to develop the industry's capabilities and ensure an adequate supply of trained professionals. For this purpose, a comprehensive training framework should be prepared to train the specialists in the development, design, construction, operation and maintenance of green buildings. Also, existing personnel will need to be upgraded and new entrants recruited in order to create a highly skilled green collar workforce.

Awareness raising among public and industry stakeholders is an important part of the green building policies. It is important to elevate awareness of green buildings, energy efficiency, and the need for a sustainable built environment within the industry and the community. Green building councils and associations should be supported in this regard for preparing showcase projects, conferences, and workshops etc which are among efficient tools in terms of awareness raising activities.

As for imposing minimum standards on the industry, there certainly is a need for regulations as seen in the Singapore example as well as in Germany, Denmark and the UK. Many countries including Turkey has adopted legislation regulating the energy performance of buildings, however, this should be expanded to include water, raw material efficiency, waste and pollution control etc.

Last but not least, continuous development of the certification systems are needed with different set of measures for new and existing buildings since green building is a relatively new and constantly evolving concept. Serious amount of scientific research and R&D activity is being undertaken and efforts should be made to both support and use the results of these in green building practice in the AEC industry.

CONCLUSIONS

The building industry is responsible for a large part of the world's environmental degradation as buildings converge in themselves major indexes of energy and water consumption, raw material employment and usage of land. Thus, also variously designated as "ecological", "environment-friendly" or "sustainable" buildings, the green buildings have become one of the most important elements in the issue of sustainability, an issue inevitably highlighted by climate change and depletion of natural resources. This paradigm shift also generated the need to develop norms and regulations for sustainable building design and construction. Today there is a well developed green building practice and a diverse array of regulations and policies regarding green buildings and sustainability in several countries. However, the results of research by Akbiyikli et al. (2009) show that the current level of sustainability understanding and hence its implementation is still unstructured, piecemeal and insufficient in the Turkish AEC industry.

Since the preparation of relevant legislation and adoption of appropriate and resolute policies constitute an indispensable part of the development of the green building practice, current deficiencies in green building legislation and policies in Turkey have been determined and Singapore's Green Building Masterplan analysed as a best practice in this paper in the quest

for constituting a model and putting forward suggestions for countries looking for a widespread adoption of green building practice in the near future like Turkey.

Analysis of the current legislation regarding green buildings in Turkey revealed that,

- Energy efficiency is the most advanced theme and there is well established legislation in this area
- Currently no legislation exists in Turkey regarding water efficiency although one of the most serious problems that Turkey may face in parallel with global warming is water shortage
- The Regulation on Building Materials should be amended to include limits and/or incentives regarding the environmental impact of the building materials' production process
- Site selection is the most complex theme requiring regulations and resolute policies on various scales. Besides restoring and implementing development plans with an ecological concern, the problem of illegal settlements in big cities needs to be solved in order to set forth a realistic approach to the issue of sustainable buildings and cities in Turkey
- Regulation on the Control of Excavation, Construction and Demolition Wastes sets the rules for the collection, accumulation, recycling and disposal of wastes generated in the excavation, construction and demolition phases. Collection, treatment, disposal and recycling of wastewaters and solid wastes produced during the utilization of buildings are also well established fields covered by separate special legislation and institutional agencies.

It has been argued in the paper that resolute policies are needed besides the legislative framework for a widespread adoption of green building practice. It has been found that, apart from the ones supporting the well developed legislation stimulating energy conservation in buildings, holistic policies regarding green buildings or sustainable built environments do not exist and seriously needed in Turkey. Analysis of Singapore's Green Building Masterplan as a best practice in this regard constituted a good example for countries looking for a more institutionalized development of green building practice such as Turkey. This analysis revealed that,

- Minimum standards should be imposed in the form of a legislative framework
- Public sector should be taking the lead in terms of greening the public buildings to set up a good example for the community and create a "green building industry"
- Incentive policies should be set up for the private sector in terms of both new developments and retrofitting the existing buildings
- Funds should be raised to support research and technology development projects as well as building up the necessary facilities such as laboratories, innovation and excellence centers, incubations hubs etc.
- Industry capabilities should be improved through training in order to meet the increasing demand for green building professionals
- Awareness raising should be an indispensible part of the policy in order to expand the green building practice to the whole community
- Policies should be set up to provide continuous development of the certification systems to catch up the state of the art in the ever-developing green building technology.

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COLLABORATIVE NETWORKS SUPPORT SUSTAINABLE BUSINESS SETTINGS REGARDING INTEGRATION OF DESIGN AND CONSTRUCTION.

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Abstract
Integration of design, engineering and construction (D-E-C) aligned to collaborative networks (CN's) is about overcoming traditional barriers. Collaborative Network systems are submitted to economic, social and environmental circumstances. D-E-C integration linked to CPFR and submitted to CN's could bridge traditional barriers, when aligned to an agreement and a joint business plan. CPFR contains four levels and eight collaborative tasks and was initiated and co-led as CFAR by Wal-Mart in 1995. CPFR offers entrance to a synchronized process and identified partners submitted to a joint workflow management system. Limits to arrive at D-E-C integration are indicated by defining ontology (a theoretical model) on interdisciplinary activities.

Keywords: collaborative networks, D-E-C integration, CPFR, ontology, identified.

INTRODUCTION
Collaborative networks (CN's) are systems of legally independent partners in industries and services to cooperate on shared economic sense. Partners coordinate and communicate in changed business paradigms that use systems supported by Service Oriented Architecture (SOA) often aligned to web-based services. Collaboration structured through CN's offer the opportunity to enlarge capacity, reinforcement of capabilities and market strength. Due to traditional business settings the barriers are high to enter CN's such as virtual enterprises [Worst, 2009]. According to PwC [2005] firms participating in collaborative networks consider their investments in ERP environments crucial and cherish traditional ICT configurations. Following Sterman [2000] single-loop learning models such as the construction process will use one existing mental model to reach their goal. For instance: The Constructon case [Project Pact, 2004] indicates that unchanged mental models block collaboration. Constructon [2004] was initiated as a pilot project to find a solution on the construction industries' supply chain mismatch. The project was introduced by Constructon to establish virtual enterprises. Constructon initiated a link to ConstrucNed Technologies, which provided web-based services. The main goal was to reinforce integrated co-operation cross the construction supply chain by embedding web-based services. Adoption of e-commerce in combination with business process reengineering (BPR) was addressed as the key to new business settings to arrive at competition on quality instead on price. The key to success was focused on synchronizing business processes within and across project partners to elevate efficiency and effectiveness. The initiative was supported by earlier studies on virtual enterprises of CSTB France [Zarli et al. 2002] and European platforms such as RoadCon, Manubuild, and the OSMOS project [Worst 2004, 2009]. Hosted databases and data warehousing connected to web-based services were introduced in 2006 by ConstrucNed Technologies [2006]. The pilot project ended in 2008 due to lack of support. Although virtual business settings reinforce concurrency in the construction process, it is difficult to arrive at a synchronized process. In particular new roles, functions, and transparency block change of traditional business settings. Integration of design, engineering, and construction requires change of mental models and operational management.

PROBLEM

Considering collaborative networks and D-E-C integration, the following questions are of importance to find a solution:

- How do the construction industry and its adjacent markets cope with collaborative networks to regulate competition and transparency?
- How do partners in a construction project organize collaborative assessment of partners in networks?
- Are collaborative networks adopted by governments, industries, supportive industries, public services and private services? Are they legally supported by current national and international law?

Objective of this paper is:

- To identify ontology of collaborative networks focused on integration of design, engineering, and construction.
- To describe a CPFR model aligned to collaborative networks focused on integration of design, engineering and construction.

Collaborative Networks (CN's): CN's operate legally almost as real firms. CN's represent connected participants opting for one goal. For instance they represent a virtual enterprise, when partners are legally bound, and share economic sense and ideas about economics, environment and social responsibility. Participants are legally independent firms underwriting a contract that settles a code of conduct and rules of engagement. Architects, engineers, contractors, suppliers and subcontractors aligned to a CPFR-model have to accept new roles in the construction process. Do CN's have legal foundation according to domestic law of member states, when looking at the EU? Yes, for instance assets of CN's are e.g. concessions to build, which indicates liability to contracts. Economic, Social and Environmental factors regarding the opportunities CN's offer are currently not an issue of business strategy in the West European construction industry, although the many opportunities CN's offer.

Integration of design and engineering requires a network organization that links investment decisions, marketing, object design, engineering, and execution of processes. CN's submitted to a synchronized process contribute to increase efficiency in mobilization and allocation of design, logistics and engineering. CN's contribute also to reduction of inventory, transportation, and logistic costs. CPFR is a business model to enhance collaboration. To start collaboration, Leeman [2010] indicates CPFR (collaboration, planning, forecasting, and replenishment) as a business solution. It provides guidelines to start up collaboration. The CPFR-model encompasses an opportunity to start up synchronized processes to arrive at design D-E-C integration. It means that investor, marketers, architects, engineers, contractors and suppliers have a legal understanding based on an agreement and a joint business plan.

CPFR began in 1995 [Wikipedia, 2011] as an initiative co-led by Wal-Mart. Originally it started as a model on collaboration, forecasting and replenishment named CFAR-model. CFAR was presented to the Voluntary Interindustry Commerce Standards Committee (VICS). CPFR was [Leeman 2010] developed by the VICS organization since 1998 and is similar to the ideas about the virtual enterprise described by Worst [2009]. In 1998 VICS initiated a roll-out of CFAR as an international standard, which was published in 1998 as CPFR voluntary guidelines and followed by CPFR Technical Specification in 1999. At first CPFR was a 9 data flow process. CPFR was seen by VICS [1999] as a "platform- and vendor independent environment, where multiple parties can operate". "Partners of different sizes

and technical levels can collaborate through accessible technologies, including Internet, and the Web, private Value Added Networks, or transport networks".

Since 2005 VICS describe CPFR as a model that exists of four levels encompassing eight collaborative tasks. CPFR is a licensed tool managed and registered by VICS [Overview May 2004]. Following Prasad [2002] CPFR was initiated to reduce inventory and save on organization of material distribution (time to consumer). However, the projected benefits were not realized due to badly shared information between suppliers and retailers. Induced by lack of visibility replenishment programmes were not realized. CPFR could be disruptive to traditional business paradigms. For instance, collaborative networks such as virtual enterprises [Worst 2009] adopt according to their definition the CPFR-model. Of utmost importance for individual partners is to overcome a cultural lack and ICT time-lag. CPFR is according to Prasad adopted in varying degrees by other industries, although it is assumed best working in consumer good's industries. The following matrix diagram (figure 1) indicates the relation between efficiency and effectiveness when opting to arrive at CPFR level..

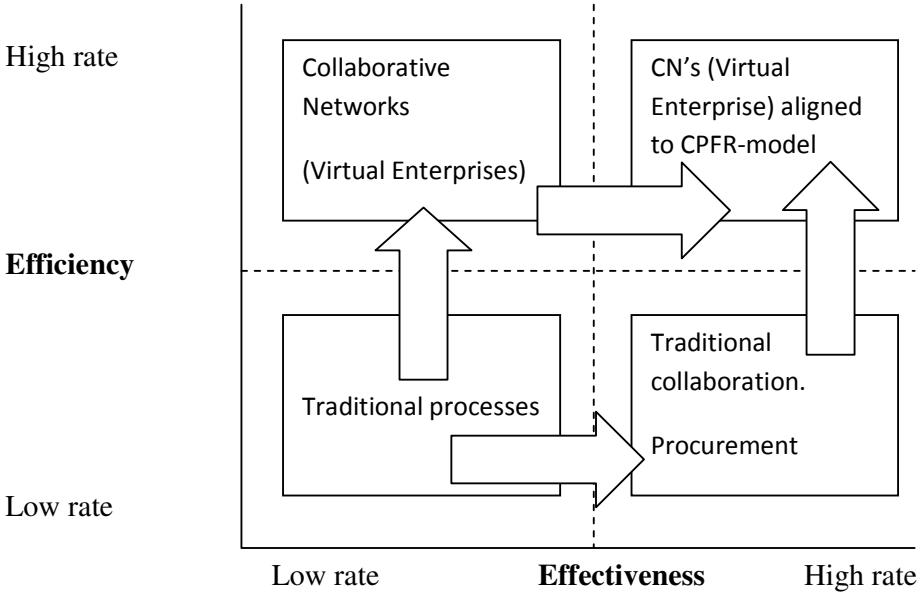


Figure 1: Matrix diagram indicating arrival at CPFR-level.

Arrival at CPFR level is possible by opting for collaborative networks encompassing the CPFR-model, or breaking with traditional procurement policies. Investors, architects, engineers and contracting engineers have an agreement containing: (1) a joint project focused business plan, (2) forecasting objects'exploitation, (3) planning of design, (4) engineering, and construction, (5) delivery plan, (6) guarantee and maintenance, (7) construction monitoring and (8) performance assessment. By developing and implementation of exception management as part of performance management, strengths and weaknesses of the partnership are identified. Following the previous steps, efficiency will be enhanced, because the process is based on transparent and synchronized operations supported by WorkFlowManagementSystems (WFMS). A common catalog eliminates inconsistencies in trading partners and product/service identifiers. CFPR, when aligned to web-based services offers an opportunity to a synchronized process. Effectiveness will increase due to transparency to all trading partners including design and engineering. In fact, it is a meta-

market focused business model, which increase capacity and clear product and service identifiers to all partners. Access to on line procurement of selected and identified partners. Access to a large community of selected and identified partners. Table 1 point at the benefits of CPFR, when D-E-C integration is involved.

Table 1: Benefits, when opting for CPFR to support D-E-C integration

Participant:	**Product demand:**	**Economic:**	**Process:**
Investor/Buyer	Clear point of buying. Clear point for rental.	One price; Fixed DBMOT guarantee.	Synchronized. WFMS.
Architect/Engineer	Clear objective. Approved theme.	Identified products and services.	Synchronized. WFMS
Suppliers	Clear specifications.	Stable work flow. Stable cost-benefit.	Synchronized. WFMS

Looking at the three basic factors [Worst, 2009; pp. 17 to 29] of collaborative networks tables 2, 3 and 4 indicate general strengths and weaknesses. Although the opportunities (including strengths and weaknesses) of the supply chain are known, integration of design, engineering and construction is only possible, when an agreement on collaboration is created and interfaces between all participants are submitted to Service Oriented Architecture (SOA) aligned to web-based services.

Table 2: Economic factors in the context of domestic economic situation.

Economic factors.	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
Enlargement of capacity on Skilled Labor Force	Domestically diminishing enforced by East European labor force.	Domestically diminishing, because of high payment in Western Europe.	Travelling labor force over the continent.	Training and import from abroad.	Not available. Training programmes are required.
Enlargement of manufacturing capacity on prefabricated elements.	Limited capacity regionally controlled by MNE's.	Limited capacity controlled by domestic suppliers and MNE's.	Limited and controlled by large firms such as MNE's.	Limited and controlled by domestic suppliers.	Small, traditional and domestic.
Doubling of Equipment capacity	Limited and controlled by large suppliers.	Limited and controlled by large suppliers and MNE's.	Limited and controlled by (MNE's)large suppliers.	Limited and controlled by large suppliers.	Import.
Enlargement of Building materials' resources.	Resources controlled by large suppliers.	Resources controlled by large suppliers and MNE's.	Resources controlled by (MNE's)large suppliers.	Resources controlled by domestic suppliers.	Domestic and import.
Double capacity of web-based services.	Partially explored.	Partially explored.	Partially explored.	Partially explored.	Partially explored.

Double D & E capacity.	Export of methods and knowledge.	Domestic plus import.	Architects are often leading consultants.	Domestic plus import of leading consultants.	Import of methods and knowledge.
Double Financial capacity.	PFI and PPP require solvent partners.	PFI and PPP require solvent partners.	PFI in cooperation with private sponsors.	Private, PPP and FDI	FDI
Increased transparency	Tenders on Capacity and Concessions.	Tenders on Capacity and Concessions	Tenders and concessions.	Tenders and concessions.	Tenders and concessions.

Table 3: **Social factors in the context of domestic situation**.

Social factors	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
PPP and PFI's	Political instruments.	Cutting budgets?	Cutting budgets is necessary	Economic growth offers budget growth	Depend on FDI initiatives
Cross cultures	Industrialized states.	Partly industrialized.	Multi-cultural	Industrializing.	Natural resources.
Responsibility and Accountability	Accept PFI's and PPP's	Proper use of PPP's and PFI's	Private funding	PPP and FDI instrument	UN i.c.w. FDI
Reinforce Equity	Current low profit margin.	Current low profit margin.	Current low profit margin.	Economic growth boosts local margins.	No margin to realize trade-offs.
Social security	Pension plans burden.	Pension plans burden.	Health care insurance.	New regulation required.	No insurance.

Table 4: Environmental aspects in the context of domestic situation.

Environmental factors	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
Stable Natural resources	Import by MNE's	Import by MNE's	Controlled by MNE's.	Domestically controlled	Controlled through FDI
Pollution	Kyoto	Kyoto	Non Kyoto	Kyoto?	Kyoto?
Ecosystems and sustainability	EU regulation?	EU regulation?	Dispersed regulation?	Dispersed regulation?	Regulation at all?
Collaborative Logistics	Civil law is different between domestic markets.	Civil law is different between domestic markets.	Civil law is different between states.	Civil law is not equal to Western Europe.	Civil law is often absent.

CN's are confronted with legal and cultural constraints. Therefore CN's could be of importance, when investors initiate new projects and are operating on different domestic

markets submitted to different regulation and business culture. The tables 2, 3 and 4 indicate also aspects, that influence not only design, engineering, and construction, but investment, marketing, procurement and financial engineering too.

Crucial in communication between partners is the intention and rationale of architecture. Electronic-concurrent engineering [Mesquita et al. 2002] provides a solution to cope with information sharing to arrive at integration of design, engineering and construction. In line with Love [1997] Mesquita et al. mention the fundamentals of concurrent engineering such as multidisciplinary teams and execution of concurrent product development during different stages of the process. It affects integration of roles of different players during the process. By briefing [Caballero, 2001] of all partners during the design stage, it is possible to initiate a creative learning, which affects interfaces such as: client - architect; client – engineers; architect – engineers; engineers – suppliers; and engineers - contractors. Poor adoption of concurrent engineering by participants of collaborative networks in the construction industry is one reason for low correlation between firms' strategy and operational management (see attachment). Low correlation occurs, because the engineers use communication technology in a unstructured way and without any ranking of data and relationship with workflow management systems (WFMS). To all partners involved in the supply chain adjusting information is crucial (see attachment).

How do you transmit information in the form of single data, meta-data and documents? Not only during the kick-off of a project, but during the whole process. Considering the fragmentation of the industry Caballero et al. [2001] defined an information model, which is similar to portal models supported by web-EDI.

Strategy focused on entrance of CN's is informal, but when aligned to CPFR formally guided. According to Menardi [2010] strategies became relatively formal since the 1960's for two reasons: "(1) The increasing amount of available data on business costs and operational performance; and (2) The uncertainty and anxiety that available data cause. No company could be sure it went on top." Actually, analysis has a retrospective effect and not a pro-active. So the insights of successful strategies are not known. Since the 19-nineties strategy of construction firms [Worst, 2001] was based on acquisition to reinforce construction capacity and being best cost provider.

ICT Strategy focused on replacement of existing system architectures was low. However, according to the Economist (issue dated 18th March 2011) firms have to focus on vertical integration, which means integration of IT hardware, operating systems and applications such as ERP aligned to web-based services aligned to SOA, and applications. In particular computer giants such as Dell and HP are currently competing on the previous mentioned vertical integration due to the overwhelming success of Apple's iPad.

Business strategy, when aligned to collaboration, has no significant correlation with connectivity through the web. Following Worst [2009] the reason is and was that top management considers investments in web-based solutions not in line with the investments in their ERP environment. The pay-off of investment in a virtual environment takes a long time. Currently the effects of the economic crisis and slow economic growth reinforced thinking about the benefits of collaborative networks.

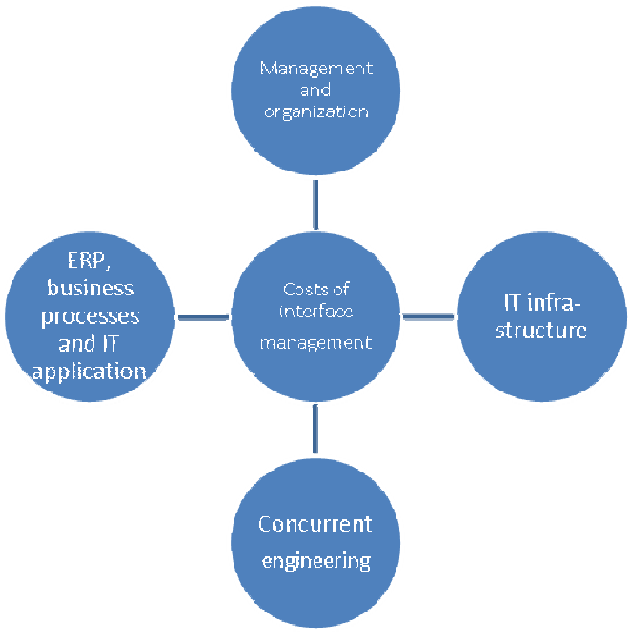


Figure 2: Sustainability and stability considering the cost of controlling interfaces.

Information, communication and integration: Integration of design, engineering and construction will be accelerated, when use of structured exchange of information and communication is organized through use of web-based solutions and SOA. Current development of technology to control interfaces and data exchange, offers support of high quality to systems supporting CN's. It is of utmost importance according to Derksen et al. [2009] to measure the stability of current IT infrastructure, the number of interfaces and the costs of communication and sharing information. Figure 2 indicates costs of interface management given the level of stability between management and organization, business processes, ICT configuration, and acceptance of concurrent engineering. The main question is: What investments need to be made to arrive at a level that firms can fully participate in CPFR driven CN's?

Partners of CN's are considered to be aware of business model stability. So, establishing CN's requires adoption of web-based services aligned to SOA. SOA is also aligned to integration of dispersed installed software such as Planning, CRM, HRCC, Accounting, logistics, and CAD. Firms have to look in the future. In particular to achieve balance (figure 3) between strategy, IT-infrastructure, management and organization and business performance. Partners must be able to respond to CPFR guidelines encompassed in the collaboration agreement next to exception management, which is aligned to performance assessment.

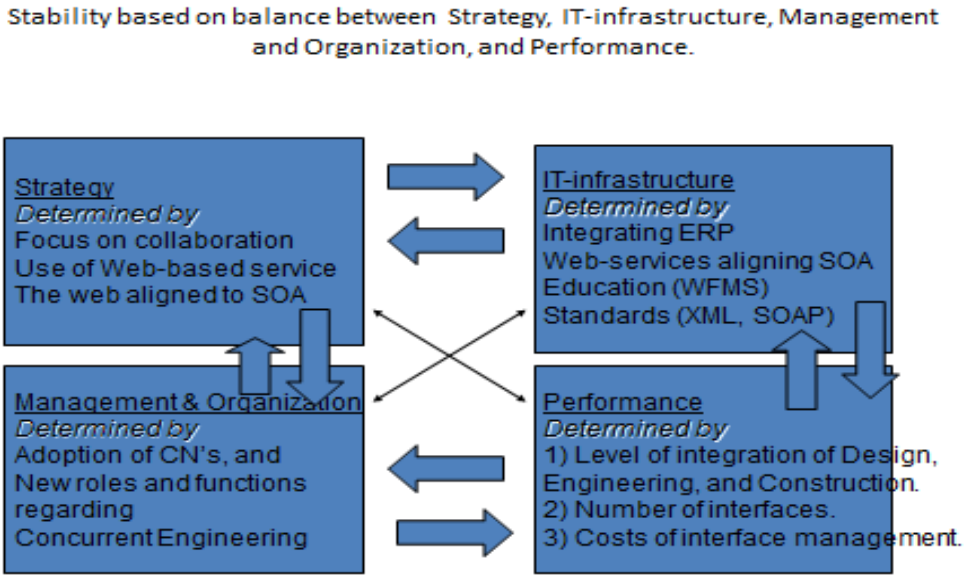


Figure 3: IT Investment focused on balance between strategy, IT-infrastructure, Management & Organization and Performance [source Worst, 2009].

Ontology defining the logical theory of models regarding CN's requires a set of relevant relations. These relations consider aspects of strategy and planning; forecasting; execution; and performance and analysis. Contracts such as BOT; DBOT; DFBOT; DFMBOT and LBC are based on prognosis of project performance and often [Mesquita et al. 2002] subject of incomplete forecasting, because of unbalanced briefing on rationale of design. D-E-C integration of design is subject of research since the 19-sixties. Love et al [1998, 2002] described the barrier between design and construction as an important constraint. Love

suggested cross discipline briefing in the construction industries' supply chain. Not only in the construction vertical (supply chain), but also in the construction horizontal (value chain).

Transparency is required to involve the customer, the user, the investor, contractor, sub-contractors and suppliers in construction supply chain management. To arrive at such point, the following principles are known and set to all partners:

- Synergy due to collocation of economies of scope and economies of scale.
- Openness in sharing information.
- Transparent workflow management systems (WFMS).
- Definition of the layers of communication such as: Chat, telephone call, conference, web-sphere communication, and or web-services?

Using the Internet to reinforce communication between managers requires a stable endogenous business environment when it concerns Web driven Electronic Data Interchange. Exogenous: the quality of the provider, claim of the CN's domain and hosting of web-based service are crucial to arrive at collaboration between client, architect, engineers, suppliers and contractors. As shown in table 5. Structuring collaboration and cooperation starts with alignment of all partners to the intent of design and its rationale. If not, disturbances between partners will occur during the process.

Table 5: Communication and sharing information through use of World Wide Web.

The web	How is openness of entrance to infrastructures and sources?
Provider(s)	Are they offering web-services to support collaborative networks?
Domain	Which domain-owners offer legal solutions to collaborative networks in construction or otherwise?
Hosting	How is hosting organized? By suppliers of web-based services, providers, domain owners?

Ontology: D-E-C integration and the assumption about reduction of cost of failure and low cost of interface management requires a philosophy, or a theoretical model (ontology). In computer science ontology is a technical term for an artifact designed for an objective such as modeling knowledge about a specific business. According to Liu and Özsu [2008] ontology comes from the field of philosophy concerning the study of existence. Their definition is as follows: "ontology defines (specifies) the concepts, relationships, and other distinctions that are relevant for modeling a domain". Osterwalder and Pigneur [2002] base their definition of ontology on four pillars. The first denoted as "product and services", the second as "infrastructure and the network of partners" necessary to create value. The third notation is "relationship capital", which refers to the sustainable contacts with the customer and the fourth refer to "financial aspects" such as cost and revenues. The virtual enterprise is according to its definition [Worst; page 11, 2009] an ontology, which has to fit with all participants' ICT capabilities.

A collaborative network encompassing CPFR aligned to a construction project could be defined as: a legally guided collaboration between legally independent partners in the construction process, to cooperate on shared economic sense, and to coordinate a construction exercise to build a single design, a combination of designs, or a concept using the Internet to

communicate. This definition is broader than the ontology of the virtual enterprise (VE), which was based on coherence between strategies, culture (operational management), information technology and web performance of business models.

Each VE-model has the ability to be adopted by a participant in the construction process. Considering the ideas of Guarino (table 6), conceptualization of CN's has to be seen as a domain of D-E-C integration < I >. Collaboration through guidelines concerning CPFR is related to < P, C >. Given the limits of < P, C > conceptualization of a set of relevant relations affect the current state of affairs encompassing construction industry's fragmentation, and transparency. The engineering artifact is related to the consequences of fragmentation [Caballero, 2001] such as inadequate capture, structuring, prioritization, and implementation of clients' needs. Life-cycle aspects are absent and not subject of collaboration, integration, and coordination. Therefore data about design, engineering, prefabrication and construction of a project are not brought downstream to be readily reused.

Design intent and rationale are according to Caballero et al. [2001] poorly communicated. Such an attitude by all partners involved leads to unwarranted design changes, unnecessary liability claims, and increase of design time and inadequate pre- and post- design specifications. The conclusions about communication flaws during the construction process as shown in the Project Pact report [2004] adjust the conclusion of Caballero et al. Considering the analysis of Guarino [2008] we may in philosophical sense refer to ontology as a particular system accounting for a certain vision on the world. Guarino refers to Gruber [Guarino 2008], who defines ontology as a specification of conceptualization. Table 6 and figure 4 indicate ontology.

Table 6: definition of ontology regarding D-E-C integration (adapted from Guarino 1998)

Category:	Specification:
D-E-C Integration	CN's does not depend on particular relations regarding D-E-C integration.
Artificial Intelligence	Ontology is geared at an engineering artifact. This artifact is constituted by specific CPFR guidelines to describe D-E-C integration.
Relations	Explicit assumptions regarding the intended meaning of the relations, which have the form of a logical theory on managing interfaces.
Intended meaning	Depends on the relations plus the set of assumptions.
CN concepts regarding CPFR driven D-E-C integration.	I is a domain of projects' D-E-C integration C is a set of CPFR guidelines on P D-E-C integration is a concept, which defines domain I structure <P,C>. A domain is collocated with projects (P). Collaboration (C) aligned to integration requires an object and specifications (o); guidelines (g); a synchronized process (s); and a workflow management system (s). So C = {o, g, s, w}.

Ontology [Guarino, 2008] is a logical theory accounting for the intended meaning of a formal CPFR driven relationship, e.g. ontological commitment to D-E-C integration. The intended models of D-E-C integration using CPFR, which are a constraint by its ontological commitment. Ontology indirectly reflects CPFR and the underlying conceptualization by approximating these intended models. In figure 4 the intended models are restricted to formal definition of ontology. O is a prediction within limits of D-E-C integration.

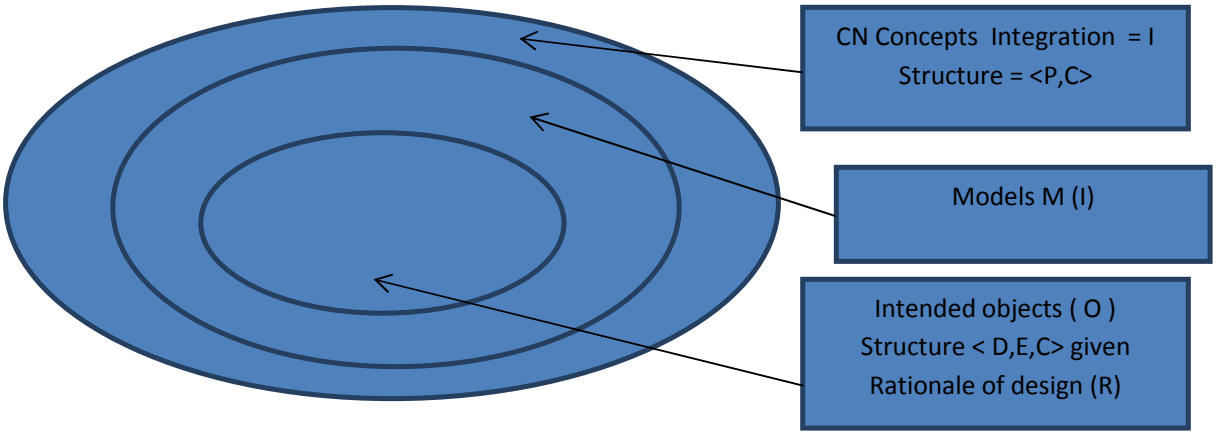


Figure 4 indicates the definition adapted from Guarino [2008]

Regarding business intelligence (BI) there is a lag. According to van Beek [2010] the BI lag increases, because of increasing availability of data and reduction of time to evaluate stages. Decision making is supposed to be done in a very short time. Complexity and dynamics of the business environment increased during the postindustrial era. Liautaud [2004] mentioned that decisions are made by knowledge workers (e.g. architects, technical and financial engineers) and operators (e.g. foreman and craftsmen). However, currently managers (e.g. project managers and construction site managers) are collecting data in a traditional way and neglect the opportunities CN's offer.

Interpreting Guarino [2008] (table 6) the D-E-C integration points at the following: (1) Traditional business settings are no longer accepted. [Love et al. 2000; Caballero et al. 2001]; (2) All partners agree upon intent and rationale of design and engineering [Caballero et al. 2001]; (3) Web-based services related to SOA are open to all participants of a project; (4) Web-based services are required to integrate individual ERP environments (web parts) containing crucial documents [Worst, 2009] Following the language the domain and its admit table extensions can be defined (see figure 4) to D-E-C integration is a concept, which defines domain I structure <P,C>. A domain is collocated with projects (P). Collaboration (C) aligned to integration requires an object and specifications (o); guidelines (g); a synchronized process (s); and a workflow management system (s). So C = {o, g, s, w}.

The D-E-C integration model M is part of I equal to the domain of the integration language. Notation: M is partly a collection of I. The intended models denoted as building Object (O) structured according to <D,E,C> and the architecture's rationale (R) (I) K = <P,C>. Given the DEC integration it is possible to define the models M(I) and the intended models O given the CPFR concept <C,P> and the architecture's intent and rationale (R).

In particular "exception management" and "performance assessment" are crucial parts of CN's CPFR model. CPFR guidelines encompassed in the CN's agreement, assess integration

of different but coherent disciplines. Given the organization of a project, partners are submitted to collaboration guidelines, a joint business plan, forecasting of user's needs, specific construction elements planning; logistics and task fulfillment, exception management and performance assessment. Table 7 indicates the process identifiers, qualifiers, functions and roles of partners and activities involved in the projects' supply chain.

Table 7: CPFR supporting D-E-C integration

Partners:	**Synchronized process:**	**Role in WFMS:**	**Object:**	**Activities:**
Investor/Buyer	Investment and contract partner of CPFR driven collaborative network.	Final approval.	Property investment.	Point of exploitation. Contracting collaborative network.
Leading consultant engineer.	Selection and identification of partners according to investors' and CPFR driven CN's guidelines.	First approval. Knowledge center. Delivery schedule.	One lump sum according to budget.	Planning delivery schedule, mobilization and controlling workflow management.
Architect	Design and identification of design according to investors' specification(s).	Feasibility, design and final design.	Materialization. Detailing design.	Identification of materialization. Identification of details.
Engineer(s)	Identification of design and engineering according to investors' specification(s) and construction method	Calculations. Construction method.	Construction elements split in construction tasks.	Identification and calculation of construction elements split in construction tasks.
Supplier(s)	Allocation of identified services, products and equipment.	Labor. Materials Equipment	Identified and classified products and services.	Allocation and application of labor, materials and services.

To establish a CN such as a virtual enterprise (an almost real business environment) adopting CPFR requires the fulfillment of:

- Ability to support ICT systems supporting collaborative networks (e.g. Web-EDI).
- Quality and solidity of organization, management and staff. Commitment to intentions and rationale of the investor and architect.
- Trust and Organization of Leadership, which means more leaders and less management. Responsibility and accountability are organized at the lowest level of the networks' organization. Commitment to guidelines of the CPFR-model

- Quality of construction capacity, and technical capacity, when looking at construction methods, engineering methods, and equipment.

Table 8: definition of ontology focused on D-E-C integration aligned to the CPFR model

Category:	Specification:
D-E-C Integration	CN's does not depend on particular D-E-C integration. Every partner could enter with own ERP and ICT environment.
Artificial Intelligence	Ontology refers to an engineering artifact. This artifact is constituted by CPFR to describe a certain reality. For instance virtual collaboration.
Relations	Explicit assumptions regarding the intended meaning of CPFR, which have the form of a logical theory. Intensions and rationale of architecture are the main determinants for trust and cooperation.
Intended meaning	Depends on CPFR plus the set of assumptions.
CN concepts regarding D-E-C integration.	I is a domain of projects' D-E-C integration C is a set of CPFR guidelines on P D-E-C integration is a concept, which defines domain I structure <P,C>.
Domain space	I is a set of maximal states of success considering CPFR. I is formulated according to table 7 and aligned to CN's.
Ontology [Guarino, 2008] (CN concepts) regarding integration of design, engineering and construction committed to CPFR, which is aligned to Collaborative Networks such as virtual enterprises.	Ontology is a logical theory accounting for the intended meaning of a formal CN, e.g. its ontological commitment to a particular CN concept. ***For instance a construction project.*** The intended models of collaboration using such a CN concept are constraint by its ontological commitment: ***CPFR guidelines.*** Ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models. ***CPFR guidelines aligned to CN's.***

Conclusion: Ontology concerning D-E-C integration is crucial to cope with interfaces and CPFR adoption. Especially, when it concerns CN's aligned to a joint business plan and ICT guidelines. According to Guarino and Gruber [2008] this leads to ontology driven information systems. It is not an accidental type casting indicating the result of familiar activities, which are crucial when adopting interdisciplinary activities. In fact, it is an engineering artifact focused on managing interfaces in the context of D-E-C integration and structured by CPFR-model guidelines. An artifact using D-E-C integration to describe CN's given the reality of the construction industry's horizontal (value chain) and the construction industry's vertical (supply chain). The intended model represents the CN aligned to the CPFR principles shown in table 9.

Table 9 The intended CPFR-model determinants for construction projects

1. Strategy and planning focused on D-E-C Integration.	• Collaboration • Joint business plan per project
2. Forecasting	• End user's needs • Specific planning
3. Execution (Planning)	• Planning logistics and construction tasks • Planning construction tasks and segments
4. Performance and Analysis	• Execution Management • Performance Assessment

The construction industry has to deal with specific IT hardware configurations, information systems and development of CPFR aligned to web-based services (Web-EDI). According to Guarino [2008] building ontology's will help to shorten development time and building a CPFR web-based service open for CN's focused on D-E-C integration. Ontology enables reducing the number of interfaces and shorting run time of virtual project analysis. Although ontology is based on theory it will contribute to focused strategy and planning, forecasting, execution (planning) and performance assessment linked to exception management. CN's aligned to CPFR represent promising business paradigms to cope with the current turbulence on markets. Considering D-E-C integration, collaborative networks encompass opportunities like enlargement of capacity, cost effectiveness, avoidance of doubles, and cost reduction on interface management. Collaborative networks (CN's) adopting CPFR and aligned to D-E-C integration indicate total integrated transfers of total spatial solutions identified according to investors' specifications. They provide the best back-up of contracts encompassing offers meeting the "cost of ownership" standard e.g. LBC contracts. CN's aligned to CPFR modeling underpin synergy between "economies of scope" and "economies of scale". Collaboration means cooperation with identified partners. Fully deployed exception management supports performance assessment and contributes to sustainable and competitive collaborative networks.

CPFR indicates working according to strict collaborative guidelines and joint business plans. Supply chain management (SCM) is focused on forecasting "time to market" and "time to volume" set by guidelines to all partners involved in the construction process. In current practice often deployed as Continuous Process Monitoring. Strategy and planning of the CN's containing design, engineering and construction are clearly focused on the investor and user. Logistics and the building process are submitted to fulfillment of the contract.

Participation in CN's provide an opportunity to start a new economic life cycle. The adoption of Internet and alignment to web-based solutions indicate speed in work flow management and exchange of information. Participants such as architects, engineers, contractors, suppliers and subcontractors submitted to CPFR driven D-E-C integration have to accept new roles. In particular when ontology regarding a CN's domain and its interfaces aligned to CPFR guidelines is involved in construction supply chain management.

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Attachement (Source Worst 2009 «The Virtual Enterprise » published by MsM)

Model test concerning 125 W-E firms with a strong domestic market and web orientation.
Given the ECVI of 0.630 this model is stable, which indicates a perfect fit.

Table: The covariance relationship matrix of model

Constructs:		**Strategy**	**Culture**	**Technology**	**Performance**
Strategy	Nature of numbers:	1			
Culture	Correlation/Covariance coefficient	0.15	1		
Technology	Correlation/Covariance coefficient	0.07	0.642	1	
Performance	Correlation/Covariance coefficient	0.488	0.631	0.893	1

Strategy is determined by the investments in ICT enabling the adoption of web-based solutions. Strategy is very poorly correlated with Technology and Culture. Culture is based on gaining a strong domestic market position, and adoption of concurrent engineering. The correlation (table) between culture and technology is moderate. Performance is determined by familiarity with web-based solutions and the adoption of e-business. The correlation between performance and strategy is poor, which is moderate for the correlation between performance and culture. Technology is correlated with performance.

Model represents a strong domestic market position and a focus on e-business.

Fit indicators	**Model**	**Values**	**Fit**
N	108	> CN 134.25	Close to fit
Df	14		
Chi-square	23.358	Small	Excellent fit
Chi-square/Df	1,7	- < 2	Excellent fit
P	0.0547	> 0.05	Perfect fit
GFI	0.991	Close to perfect > 0.95	Perfect fit
AGFI	0.978	0.9 – 1	Good fit
PGFI	0.386	0 – 1 Sensitive to model size	Moderate fit
CFI	0.995	0.9 – 1 almost perfect	Perfect fit
NFI	0.988	0.9 – 1	Perfect fit
RMSEA	0.185	Poor > 0.1	Poor fit
RMR	0.124	Close to fit 0.1	Close to fit

Hypotheses testing of Model

Hypotheses	The chi-square indicates excellent fit. The GFI; AGFI; NFI, and PGFI indicate an almost perfect fit.
Hypothesis 1 General Contractors' and project related participants' business strategies are positively related to the e-business setting of virtual enterprises.	The hypothesis is true
Hypothesis 2 General Contractors' and project related participants' business culture is positively related to the e-business setting of virtual enterprises.	The hypothesis is true
Hypothesis 3 Contractors' and project related participants' adoption of ICT is positively related to the e-business setting of virtual enterprises.	The hypothesis is true

Conclusion

There is a gap between ICT strategy and the current options to arrive at entering virtual enterprises. However, there is distance between operational management and ICT management given the moderate correlation between culture and technology. Strategy is not correlated at all with culture and technology. The model indicates, that D-E-C participants do not opt for a strategy primarily focused on business models adopting web-based solutions. In fact, the power of business intelligence to arrive at virtual collaboration is completely ignored. Sharing information to control the interfaces between participants of the construction process to benefit from efficiency is not an issue.

DEVELOPING AND MARKETING SUSTAINABLE CONSTRUCTION SERVICES

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ABSTRACT

Increasing calls for action on addressing the negative impact of human activities on the natural environment have lead to the growth of new markets for sustainable solutions. At a more macro level, the role of construction and marketing in economic development has been well established. In striving towards economic growth, a balance between marketing and construction should be considered to achieve sustainability. Engineering consultancies and other businesses have been developing the provision of 'sustainability services' to a diverse range of sectors including construction, energy and transportation, corporate and others. This has also been stimulated by policies enshrined in governmental legislation. Market growth in developed countries such as the UK and Singapore has been fast due to the implementation of more stringent regulations. This paper considers how the principles and practice of marketing may be applied to the promotion of sustainability services offered by engineering and construction consultancies and contractors. It will also consider the constraints and barriers, together with the opportunities for sustainability service markets in developed and developing countries.

Keywords: sustainability, services, marketing, construction, economic development

INTRODUCTION

This paper will set out to define sustainability and the development of markets and services associated with sustainable construction. It will consider the applicability of services

marketing, in particular "green" marketing, to the promotion of sustainability services by consultants and contractors in the built environment sectors.

Awareness of the importance of sustainable development has been growing around the globe for the last few decades. 'Agenda 21', the closing document of the UN 'Earth Summit' in 1992 in Rio de Janerio , the Kyoto protocol for reduction in greenhouse gas emissions, and many other international and national initiatives show the growing concern for protecting the environment for the future generations by introducing sustainable development concepts (Parkin, 2000). Recently, nearly 100 world leaders accepted UN Secretary-General Ban Ki-moon's invitation to participate in an historic Summit on Climate Change to mobilize political will and strengthen momentum for a fair, effective, and ambitious climate deal in Copenhagen in December 2009.

There are many definitions for sustainable development. The World Commission on Environment and Development (WCED) has defined sustainable development as development which meets the needs of the present without compromising the ability of future generation to meet their own needs (Bourdeau, 2000).

The construction industry has a huge contribution to fulfill our quality of life. Construction, building materials and associated professional services together account for some 10% of Gross Domestic Product and provide employment for around 1.5 million people (Raynsford, 2000). Buildings and structures change the nature, function, and appearance of cities, towns and rural areas.

Building has a significant impact on the environment, accounting for one-sixth of the world fresh water, one-quarter of the wood harvest and two-fifth of its material and energy flows (Gottfried, 1996). All the resources are needed to create, operate, and replenish, so to remain competitive and continue to expand and produce profits in the future, the built environment sectors must address the environmental and economic consequences of its actions. Moreover, that recognition is leading to changes in the way the building and building owners/developers approach the design, construction, and operation of the structures which is seen as implementing sustainable construction.

According to Sage (1998), sustainable development refers to fulfill the needs through the improvement of environment, social, economics, culture and technological.

Other researchers define sustainable development, through different perspectives. According to Chaharbaghi and Willis, (1999), every single professional they have their own perspectives of sustainable development such as politicians define as sustainable development a rhetorical device, environmentalists define sustainable development as avoiding a catastrophe, and technologists define sustainable development as a problem they can solve and others.

By referring to Malik et al. (2002), the Department of Environment, Transport and Regions (DETR) argue that sustainable development is all about ensuring a better quality of life for everyone, now and for generation to come through social progress that recognizes the needs of everyone, effective protection of the environment, prudent use of natural resources and maintenance the level of economics and employment.

Sustainable development comprises the three broad themes of social, environmental, and economic accountability. According to Malik et al. (2002) these themes were called 'triple bottom line'. The summary of this themes are outlined in Table 1.

***Table 1**: Themes of Sustainable Development*

Theme	Social	Environmental	Economic
Sub-theme	Equity Community	Global Local and site Internal	Constructions Materials Infrastructure
Issues	Poverty Minorities Inner cities Transport Communications	Climate changes Resources Construction Internal environments Wildlife	Profitability Employment Productivity Transport and Utilities Building stock values

Sustainable is an opportunity to use natural resources efficiently while creating healthier buildings that improve human health, build a better environment and provide cost savings. A green building is a structure that is designed, built, renovated, operated, or reuse in an ecological and resources efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health, improving employee productivity, using energy, water and other resources more efficiently and reducing the overall impact to the environment (Aysin Sev,2000).

Sustainable Construction

Sustainable construction has different approaches and different priorities in various countries. Some of them identify economic, social and cultural aspects as part of their sustainable construction framework, but it is raised as a major issue only in a few countries (Md Zin Dang Anom, 1998).

According to Charles J. Kibert, sustainable construction could be best defined as the creation and responsible management of a healthy built environment based on resource efficiency and ecological principles (Malik et al., 2002). Sustainable construction is generally used to describe the application of sustainable development to the construction industry. Therefore, sustainable construction also is describe as a subset of sustainable development, which includes design, tendering, site planning, and organization, material selection, recycling, and waste minimization (Langston and Ding, 2001).

There are six main principles for sustainable construction, presented by Charles J. Kibert, University of Florida (Y. Miyatake, 1996). The principles are:

i. Minimization of resource consumption
ii. Maximization of resource reuse

iii. Use renewable and recyclable resources
iv. Protect the natural environment
v. Create a healthy and non-toxic environment

Pursue quality in creating the built environment

APPLYING MARKETING AND "GREEN MARKETING PRINCIPLES

Marketing means different things to different people. Typically, people perceive marketing as advertising, which is only a part of the marketing activities. Marketing is also frequently simplified to selling. Marketing is also adversely associated with such distorted phrases as 'marketing tricks' and 'marketing ploys'. In the field of marketing, however, marketing is seen as a business function, an orientation, and business philosophy.

According to Drucker (1968), the fundamental purpose of business is 'to create customers'. This provides first piece of evidence that marketing is concerned with customer orientation. Furthermore, Drucker (1968) believed that marketing is the basic function of any business. He stated that 'because it is its purpose to create a customer, any business enterprise has two – and only these two – basic functions: marketing and innovation' (Drucker, 1968). Additionally, he maintained that marketing aims to satisfy the needs of today's customers whereas innovation aims to satisfy the needs of tomorrow's customers (citied by Rickards, 1999). This concept of 'marketing as a business function' is important because it demonstrates the importance of marketing in any business environment.

Kotler (2003) has classified his definition of marketing into two categories, as social and managerial definitions. For a social definition, marketing is the societal process by which individuals and groups obtain what their wants through marketing activities. A managerial definition, on the other hand, places the emphasis on marketing as a business function, a concept or business philosophy that governs the direction of any business. The concepts of 'marketing as customer orientation' and 'marketing as business function' are important because they shape the perceptions of academics in interpreting marketing. Recent marketing literature has been focusing on marketing as customer orientation, and some sources offer broader viewpoints by suggesting competitor orientation and interfunctional coordination (Narver and Slater, 1990).

Marketing scholars acknowledge that service is a special kind of offering in business environment. Service is 'intangible' and 'variable' (Baker, 1996; Jobber, 2001; Kotler *et al.* 1999; Kotler, 2003). Such service as consulting has a few tangible elements. Therefore it brings difficulties to service providers to display or demonstrate what kind of service is being offered. At the same time, it is also difficult for customers to measure the standard or quality of the service before buying (Baker, 1996; Jobber, 2001; Kotler *et al.* 1999; Kotler, 2003). On the other hand, because of its variable nature, it is difficult to standardize the quality of service delivery. Because of this, it requires extra care and attention in formulating strategic marketing activities for service industry.

Furthermore, according to Donelly and George (1981), services marketing is marketing based on relationship and value. It may be used to market a service or a product. Marketing a service-base business is different from marketing a goods-base business. There are several major differences, including:

i. The buyer purchases are intangible
ii. The service may be based on the reputation of a single person
iii. It's more difficult to compare the quality of similar services
iv. The buyer cannot return the service

The major difference in the education of services marketing versus regular marketing is that apart from the traditional "4 P's," Product, Price, Place, Promotion, there are three additional "P's" consisting of People, Physical evidence, and Process (Donelly and George, 1981). Service Marketing has been relatively gaining ground in the overall spectrum of educational marketing as developed economies move farther away from industrial importance to service oriented economies.

Green Marketing

Green marketing is defined as"The process of selling products and/or services based on their environmental benefits" (http://sbinfocanada.about.com).

"Green marketing incorporates a broad range of activities, including product modification, changes to the production process, packaging changes, as well as modifying advertising" (Polonsky, 1994).

The American Marketing Association (2010) defined the green marketing as: The marketing of products that are presumed to be environmentally safe. This definition has three key components:

- It is a subset of the overall marketing activity;
- It examines both the positive and negative activities; and
- A narrow range of environmental issues are examined. It ensures that the interests of the organization and all its consumers are protected, as voluntary exchange will not take place unless both the buyer and seller mutually benefit.

As the above definitions illustrate, green marketing encompasses a broad range of activities from product design to writing advertising copy. It is increasingly important because consumers are paying more attention to a product's or service's sustainability features as well as the practices of the provider organization.

Nowadays, a concept of "green marketing" is becoming more and more popular. Li and Cai (2008) mentioned that, it began in Europe in the early 1980s when specific products were identified as being harmful to the earth's atmosphere. Terms like Phosphate Free, Recyclable, Refillable, Ozone Friendly, and environmentally friendly are some of the things consumers most often associate with green marketing. While these terms are green marketing claims, in general green marketing is a much broader concept, one that can be applied to consumer goods, industrial goods and even services. For example, around the world there are resorts that are beginning to promote themselves as "ecotourism" facilities, i.e., facilities that "specialize" in experiencing nature or operating in a fashion that minimizes their environmental impact. Thus green marketing incorporates a broad range of activities, including product modification, changes to the production process, packaging changes, as well as modifying advertising.

Mankind has unlimited wants while limited recourses on the earth. Green marketing looks at how marketing activities utilize these limited resources, while satisfying consumers wants, both of individuals and industry, as well as achieving the selling organization's objectives.

SUSTAINABLE CONSTRUCTION AND MARKETING IN ECONOMIC DEVELOPMENT

The role of construction in economic development has already been well established for many years. The relationship between construction and economic development is especially crucial in the developing countries where infrastructures and buildings play an important role for economic growth. The construction industry is also an important sector in the developed countries even though the rates of growth of the construction industry in the developed countries might be less than those of the developing countries following the formative years of the former (Turin, 1978; Edmonds, 1979; Drewer, 1980; Ofori, 1990; Low and Leong, 1992; Hillebrandt, 2000).

The role of marketing in economic development has likewise been well established for many years. As far back as the 1950s, Drucker (1958) urged that attention should be paid to marketing for countries to achieve economic growth. Marketing inputs at both the domestic and international platforms were seen to contribute to economic development (Dixon, 1981; Cundiff and Hilger, 1982; Etemad, 1984; Kaynak, 1986; Kaynak and Hudanah, 1987). In this context, marketing has been defined as the management function of identifying, anticipating and satisfying client needs at a profit (Kotler, 1967, 1988).

Given that both construction and marketing played their respective role in economic development, it is therefore necessary to ensure that both sectors provide balanced inputs into economic growth plans. Too much of construction inputs at a time when marketing is still lagging behind, can lead to white elephants and under-utilized infrastructural facilities (i.e. over-build). Similarly, when marketing is actively in place, construction must provide adequate infrastructural support to avoid transportation gridlocks and logistical potholes (i.e. under-build). The need to balance both construction and marketing was highlighted by Low (1995) for global economic development.

The macroeconomic views of construction and marketing were presented above. The construction industry has contributed to global climate change because of the massive carbon emissions generated by processes in the industry (Wu and Low, 2010). There is now an urgent need for the construction industry to move towards more sustainable practices. Fundamentally, there are two ways to accomplish this: (a) through cutting-edge technology and (b) better management. Adopting new and appropriate technology (such as renewable building materials and photovoltaic cells in buildings) can be effective but may turn out to be very expensive for the sustainability agenda. Effective management of the building process is seen as a better alternative because it is able to prescribe a less costly solution towards sustainable construction (Low, 2009). In so far as management is concerned, marketing has a significant role to play in that as a business function, marketing helps to identify, anticipate and satisfy client needs at a profit (Kotler, 1967). Hence, just as in the macroeconomic phenomenon described above, there should likewise be a balance approach to matching construction with good sustainable practices through the marketing function.

Sustainability Markets and Development of Services

As the global environmental agenda gathered pace through the 1980s and 1990s, new markets emerged to address the demand for more sustainable solutions. Developed nations in particular experienced a rapid growth in 'sustainability services' aimed primarily at the construction, housing, transportation and corporate sectors. Supported by policies and directives enshrined in governmental legislation, the construction sector has increasingly sought specialist services to ensure acceptable levels of sustainability and achieve governmental standards and targets for performance.

The development of sustainability services in the UK is an example of the rapid growth in this market. The rise of environmental and sustainability discourses during the 1990s and 2000s had a profound and unprecedented impact on the UK construction sector. Whilst ecology and energy related policies have been a part of UK policy for a number of years, this period was characterised by a mushrooming of sustainability policies and increasingly more stringent technical and planning requirements for new developments. National, regional and local planning legislation have placed unprecedented levels of sustainability criteria on all stakeholders involved in construction, covering a variety of issues which include environmental impact of materials, water usage, and on-site waste generation during construction.

To meet these requirements and examine the full spectrum of options for sustainability, property developers working in the construction sector have turned to professional firms to fill the knowledge gap; these include specialist sustainability firms, architects and multi disciplinary engineering companies of various sizes. As a result, the market for sustainability services in the UK has become a competitive and tightly fought arena with companies vying for private and public sector contracts, in the UK as well as overseas (Verdantix, 2010).

The growth of the sustainability market has not been homogenous across the world. Developed countries have tended to enforce more stringent sustainability policies and mechanisms which has stimulated a demand for sustainability services. Specific knowledge and skills of the different technical and non-technical aspects of sustainability performance has become relatively wide spread which, in turn, has supported the growth of the market in these countries. In developing countries however, market growth has been significantly slower in response to a focus on the goals of economic development and less extensive awareness and knowledge in this field. In Malaysia, for example, there is not the national or local legislation in place to support high levels of sustainability in the construction sector and, therefore, sustainability efforts in the design and construction of buildings are currently carried out on a voluntary basis. As a consequence, the sustainability market has not developed at the same pace as a developed country and is unlikely to until there is greater commitment from government in terms of legislation and an appropriate supporting knowledge economy.

Marketing Sustainable Construction Consultancy Services

We live in a marketing-driven, if not marketing-dominated world. Sustainable construction has to be sold along with everything else. Marketing helps a firm develop a platform for telling others about its achievements. The sustainable construction phenomenon is no longer a fad; it's a full-fledged revolution. According to Yudelson (2008) between early 2000 and late 2007, the number of green buildings has grown from a handful to more than 8,000 actively seeking LEED certification. Lots of people already know this, and they want to

know, “How should design and construction firms and professionals profit from this change?”. Marketing sustainable construction is becoming increasingly important and will become a major point of differentiation for all architects, engineers, quantity surveyors and builders. People who take the lessons learned in this sustainability concept and principles seriously will have a major head start on the competition.

There are various ways of developing and marketing sustainable construction, for example:

i. Focus on Capabilities

- Know what the principals and senior level people are doing in the area of sustainable construction and learn what they are hearing about the need and demand for these services among the clients.

ii. Competitors

- Know the strengths and weaknesses of the competition in this area of design and construction, so that we will be prepared.

iii. Differentiate services

- The major focus of sustainable construction marketing has to be some form of service differentiation. Make sure clients know how the firms can approach the project differently from major competitors by showcasing the team design tools and understanding of sustainable construction.

iv. People

- The firm needs to realize that there is a huge commitment required to training and education, as well as to acquire specialized expertise and tools, to compete effectively in the sustainable construction and green building marketplace.

v. Publish results and press

- Tell the story aggressively to as many media outlets as we can. Successful sustainable construction projects are still rare enough in this country. This is one of the main vehicles for new clients to become aware of the firms.

vi. Membership and event activities

- Membership “has its privileges”, to borrow a phrase. The consultant and construction firms in Malaysia can join Green Building Index or Malaysian Green Building Confederation for example, and use their logos on proposals, stationery and brochures. It is probably the best investment a firm can make to establish credibility with clients.

vii. Narrow the focus

- Last but not least, narrow the focus. Not every client is a candidate goes green marketing at this time. Not every client wants to be the "first kid on the block" or to be a technology leader. Therefore, focus most of the marketing efforts on the more adventurous owners, the innovators and the environmentalist clients.

CONCLUSION AND RECOMENDATIONS

As the economic benefits of green and energy-efficient buildings become apparent to more developers and builders, the demand for advice and consulting on technologies and processes is skyrocketing among developers and builders large and small. That is a great business opportunity for entrepreneurs and job seekers with expertise in green architecture, design, and engineering. There will be demand for firms and individuals with expertise in very specific areas, such as the latest window glazing, solar roof system and rainwater harvesting, as well as those skilled in green building project management and accountability. As the sustainability agenda gained momentum through the 1990s, new markets emerged to satisfy the requirement for sustainable solutions in the built environment. However, the growth of sustainability services has been characterised by a distinct global unevenness; relative economic prosperity in the developed world has afforded market and policy expansion whilst developing countries have been unable to prioritise sustainability in the same way.

As demonstrated in the paper and reflective of the global trend more generally, the sustainability market in the built environment sector is experiencing a continuing growth. Based on the evolution of sustainability services, opportunities globally and in particular in developing countries can be identified and include improved policy instruments, capacity building, and public awareness.

Change is inevitable, and should the markets in developing countries follow the trends observed in the developed countries, sustainability in the built environment will become a more mainstream part of the business. Therefore, currently the built environment sector in emerging economies offers a unique opportunity for businesses to invest and develop sustainability services while this part of the marketplace is still at its infancy. Companies focusing on capacity building and development of skills and expertise in sustainability will benefit when policy implementation and enforcement follows the resulting government commitments. The same companies will benefit from a strong Corporate Social Responsibility commitment, enhanced public image and increased recruitment opportunities. By investing in sustainability services now, the construction business has the potential to enjoy the benefits of being a market leader in the future.

The global construction sector would benefit from more detailed recommendations on implementation measures to support the growth of the sustainability service market in the built environment. Research on the specific areas suffering the most from shortages of skills and expertise, could assist in prioritising the capacity building and knowledge transfer exercise. Finally, a comparative assessment of the businesses in the global construction sector on the status of their sustainability services is another area where further research is recommended. Such an analysis within the individual sector groups (such as developers, contractors, consultants, engineering and architectural firms) could provide an interesting insight into the sector, identify gaps and business opportunities.

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SUSTAINABLE CONSTRUCTION WASTE MANAGEMENT IN MALAYSIA: A CONTRACTOR'S PERSPECTIVE

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ABSTRACT

The Malaysian construction industry continues to grow, benefiting the country's economy and providing essential infrastructure. However, this thriving industry is responsible for one of the single largest waste streams in the country. This paper focuses on the current status of waste management in the Malaysian construction sector. It builds on existing research and assesses the level of sustainable practices on construction sites in terms of waste management. It is a reflective paper examining the attitudes and reaction of Malaysian contractors towards a more structured approach to on-site sustainable resource and waste management, the "Site Waste Management Plan". The Site Waste Management Plan, is a framework that has been used in Europe and has successfully reduced on-site construction waste generation. The aim of this study is to gauge the industry's appetite and commitment to sustainable waste management and ultimately guide the future development of a framework for the management of construction wastes in Malaysia. A number of semi-structured interviews were conducted with Malaysian contractors, with no previous experience of Site Waste Management Plans. This exercise allowed the researchers to explore the industry's level of awareness and commitment to sustainable waste management, identify current barriers and suggest future recommendations for an implementation strategy.
Keywords: sustainable development, construction waste management, contractors, Malaysia, environment

INTRODUCTION

The construction industry is one of the main contributors towards the development of nations, providing the necessary infrastructure and physical structures for activities such as commerce, services and utilities. The industry generates employment opportunities and

injects money into a nation's economy by creating foreign and local investment opportunities (M. Agung, 2009). However, despite these contributions, the construction industry has also been linked to global warming, environmental pollution and degradation (Jones & Greenwood, 2009).

Construction waste generation and unsustainable use of depleting natural resources as building materials, are also linked to the adverse environmental impacts of the construction industry. Globally, it is estimated that approximately 10 to 30 per cent of wastes disposed off in landfills originates from construction and demolition activities (Fishbein, 1998). In Malaysia, construction waste is one the single largest waste stream and yet despite a number of government policy initiatives to address this issue,, sustainable resource and waste management on site remains a low priority for the majority of the contractors (Begum, 2009).

This study explores the Malaysian contractors' perspective in relation to sustainable resource and waste management and in particular the application of a more structured management framework, based on the "Site Waste Management Plan" (SWMP) approach. The paper examines what appetite there might be for the adoption of SWMP, to explore the industry's level of awareness and commitment to sustainable waste management, to identify current barriers and suggest future recommendations for an implementation strategy. The paper concludes with recommendations for the formulation of a Malaysian SWMP, based on the empirical findings of this investigation.

SUSTAINABLE WASTE MANAGEMENT AND THE MALAYSIAN CONSTRUCTION SECTOR

Sustainable Development and Waste Management in Malaysia

During the second half of the 20th Century, there were increasing calls for action by scientific, political and civil society groups who raised the need to address the negative impact of human activities on the natural environment. The publication of the Brundtland Report in 1987 followed by the Earth Summit in Rio de Janeiro in 1992 helped to establish the concept of 'sustainable development'; an approach to development now supported by a wide spectrum of governments. The concept rests on the notion of 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland, 1987).

As a developing country aspiring to achieve developed country status by 2020, Malaysia is faced with the challenge of decoupling economic growth and waste generation (National Economic Advisory Council, 2010). Sustainable growth is a central theme of the 10th Malaysia Plan (Economic Planning Unit, 2010) and demonstrates the Government's commitment to sustainable development. In 2005 the "National Strategic Plan for Solid Waste Management" was adopted forming the basis for solid waste management policy and practice in peninsular Malaysia until 2020 and providing the foundation for the subsequent years (United Nations Development Programme, 2008). The Government's efforts to address this pressing issue include the introduction of the Solid Waste and Public Cleansing Management Act 2007, and the establishment of two new federal institutions aiming to implement the country's solid waste management policy, the National Solid Waste Management Department and the Solid Waste Management and Public Cleansing Corporation, the latter being the operational arm.

Solid waste management has been a concern in Malaysia for some time, due to poor management and handling practices which in turn affect the environment as well as the public. Malaysians produce approximately 25,600 tonnes of waste daily, in response to rapid

development and urbanisation (Fazleena Aziz, 2010). Solid wastes are generated from residential, industrial, commercial, institutional, construction and demolition, municipal services and other human processes (UNESCAP, 2009). Only 76 per cent of solid wastes are successfully collected in Malaysia, and only around 5 per cent is recycled, with 95 per cent of collected wastes disposed at the country's 112 landfills (Alam Flora Sdn. Bhd., 2007). According to the Ministry of Housing and Local Government (MHLG), the majority of landfills are at full capacity and operate to old standards with limited leachate and landfill gas control. This is a far reach from the Government's target for 22 per cent waste minimisation and recycling (Nadzri, 2007), 100 per cent separation at source and closure of all historic, unsanitary dump sites by 2020 (Japan International Cooperation Agency, 2006).

It is clear to see that current practice does not reflect waste management policy in place. Factors such as a lack of implementation, weak enforcement, uncertainty over roles and responsibilities amongst governing authorities and limited stakeholder coordination have all contributed towards this disconnect between policy and practice. Furthermore, despite efforts by the MHLG, public awareness of the environment and, more specifically, waste management is low. However, the Malaysian Government recognises that appropriate waste management is essential in achieving sustainable development as highlighted by the Malaysian Government Model (National Economic Advisory Council, 2010).

In terms of general awareness of sustainability in the Malaysian construction and building sector, the launching of a national initiative called the Green Building Index (GBI) and increasing attention towards international sustainability assessment standards, such as Greenmark, LEAD and BREEAM have served to raise awareness of the broader issues associated with sustainability. However, as long as these initiatives remain voluntary and outside of the remit of government legislation, broad scale uptake of sustainability standards across the sector will remain low.

Status of Construction Waste Management in Malaysia

A study from Mohd Nasir et Al., (1998) reported that 28 per of municipal solid waste originates from industrial and construction waste in the central and southern regions of Malaysia. Waste minimization, reuse and recycling practices are limited in the construction sector and natural resources required as building materials are available at relatively low cost (Begun et al 2009). In addition there is no mandatory requirement for construction companies to practice sustainable resource and waste management and illegal dumping is still an issue for the authorities (Begun et al 2009).

In response, the Government formed an agency called the Construction Industry Development Board (CIDB); one of its aims is to transform the industry by improving its environmental performance. In support to national policy, CIDB has reinforced the industry's commitment to sustainable development and an environmentally responsible industry in the "Construction Industry Master Plan" (Construction Industry Development Board, 2007) and is continuing to educate the industry's key players with series of training courses, workshops and awareness raising events. In addition, the introduction of the GBI is providing a framework to design and construct green sustainable buildings and raises awareness within the sector.

In 2009 the Malaysian construction sector reported a 5 per cent productivity growth (Malaysia Productivity Corporation, 2009). On one hand this figure demonstrates the crucial role the Malaysian construction sector can play in contributing towards the Government's commitment to sustainable development. On the other, it supports predictions that construction waste generation rates will continue rising, putting increasing pressure on the already overstretched waste management infrastructure of the country.

In summary, there are number of policies and voluntary initiatives supporting sustainable resource and waste management in the Malaysian construction sector, however the reality remains challenging. The continuous growth of the sector provides an opportunity for a wider uptake of sustainable waste practices, contributing to the country's aspirations for sustainable development.

Site Waste Management Plans

A Site Waste Management Plan (SWMP) provides a framework which can help contractors or project managers to forecast and record the amount and type of construction waste that is likely to be produced in a project, as well as assist in setting up appropriate management actions that reduce the amount of waste that will be sent to landfill (WRAP, 2007). A construction waste management plan aims to improve materials resource efficiency by implementing reuse, recovery and recycling as well as to minimise issues such as illegal dumping by properly documenting waste removal processes (Defra, 2009).

In number of developed countries such as United States, United Kingdom and Australia, construction waste management plans have been gaining popularity as an important tool to minimise the adverse impacts of the construction industry towards not only the environment but also the nations' economies. The plan requires the cooperation between all parties involved in a construction project, including the client, contractor, designer, engineer, sub-contractors, workers and even the suppliers. It is initiated during the project's pre-planning stage and involves activities throughout the duration of the project up to its completion to ensure the waste management plan's effectiveness and efficiency.

In United States, the framework called Leadership in Energy and Environmental Design (LEED) Green Building Rating System is popularly used, which is a set of standards for environmentally sustainable construction incorporating practices for sound waste management into construction activities (LEED, 2004). Construction projects gain points when they adhere to LEED requirements which subsequently secure a certification. Similar frameworks for sustainable buildings and developments include the Building Research Establishment's Environmental Assessment Method (BREEAM) rating system in the UK, the Green Building Index certification (Real Estate and Housing Property Developers' Association Malaysia, 2010) in Malaysia, Green Mark in Singapore, Green Star in Australia and many more. Sustainable resource and waste management features in all of these frameworks, encouraging the adoption of a form of site waste management plan to guide the process from the design to the decommission of the development.

In most countries SWMPs are voluntary. However, in 2008 SWMPs eventually became compulsory for projects in England exceeding £300,000 (BRE, 2009). This move was supported by developing and offering a SWMP template and other related tools such Netwaste and SMARTwaste for designers, engineers, contractors, developers and other professionals in the constructions industry (WRAP,). Guidance and training courses are freely available to aid the industry achieve waste reduction, re-use and recovery, from the procurement, pre-construction and construction phases of a project.

Typically a SWMP will require the project manager to provide basic information about the type, scale and value of the project, identify the responsible persons involved in the stages of the project (principal contractor, engineer, client, designer, person responsible for waste management on site etc), a proposed timescale and programme of works. The Key Performance Indicators (KPIs) for waste minimisation, recycling, materials recovery or waste generation per area unit, or other relevant targets will be agreed during this initial stage. Figure 1 presents a broad outline of a SWMP.

In the next stage, the series of waste prevention, waste reduction, waste management and recovery actions to be taken during the design, procurement and construction will be agreed and recorded by the project team. Following this, the type, source and quantity of waste arisings anticipated from the project are forecasted with the aid of benchmarks for the various types of development (residential, education, health, infrastructure, commercial, retail etc).
Details of the suitably licensed waste carriers and ultimate waste management destinations of waste arisings are recorded to ensure Duty of Care and prevent illegal dumping or other inappropriate handling of wastes. The actual waste arisings, prevention, recovery, recycling and reuse actions are recorded and compared against the forecasts and KPIs to measure performance, adjust and improve the SWMP as required. Training of staff on site is crucial to the success of a SWMP. Monitoring and reporting continues for the duration of the construction project and informs the final project review and recommendations for future improvements.

***Figure 1**: Proposed Outline of SWMP*

Project Stage	**SWMP Actions**
Project Set Up	• Enter project details
Concept Design	• Record waste prevention actions
Detail Design	• Forecast waste • Record waste reduction actions
Pre Construction	• Specify waste carriers • Plan waste destinations • Record waste management and recovery actions
Construction	• Enter actual waste arisings, reduction, recovery and management activities. • Carry out training, monitoring and recording.
Post Construction	• Compare actual against forecast waste management activities • Assess performance based on KPIs • Suggest improvement for next project

Note: Adapted from WRAP Site Waste Management Plan Template version 2.3

METHODOLOGY

The study included a literature review on sustainable development, the effects of human activities on the environment, the solid waste management systems used in Malaysia and their impact to the nation's development and environment. SWMPs from developed countries were reviewed to identify their main elements and how they affect a project for contractors. An outline SWMP was created by simplifying the elements in the site waste management plans from other countries, extracting the perceived best practices and combining them into one proposed framework to be tested in Malaysia.
Seven semi-structured interviews were conducted as part of this research to determine the uptake of any form of SWMPs by Malaysian contractors, the suitability of existing SWMPs in relation to the local environment, and their impact on the actual project and the environment as a whole. According to the literature review carried out, SWMPs are relatively new in Malaysia and levels of awareness and adoption by contractors are low. Therefore, the target sample chosen were eight (8) contractors located around the Kuala Lumpur and Selangor area who have never implemented SWMPs. The selected contractors were seen as a

representation of the Malaysian construction industry which does not have an official system or guidelines for managing construction wastes on site, yet.

The contractors interviewed, were randomly chosen and are considered a convenience sample. The selected companies had different backgrounds and experiences, and are assumed to be reliable samples by the researchers as they will represent different groups in the construction industry. In this research, seven (7) out of the targeted eight (8) contractors located in the Kuala Lumpur and Selangor area were successfully interviewed using exploratory, semi-structured interviews. All chosen contractors were class G-7 companies with extensive experience in civil, infrastructure works and structures for the commercial, industrial and residential uses, among others. Meanwhile, the respondents interviewed were experienced project managers and engineers with extensive involvement in construction projects.

The interviews were conducted to obtain reviews for the outline SWMP produced by the researchers based on literature review. The selected contractors were asked to review and comment on the proposed framework, in particular the perceived benefits to a project and its effectiveness. Contractors were also asked about their awareness of the campaigns made by the Government and Construction Industry Development Board (CIDB) in encouraging contractors to take up a SWMP, and the incentives that can be awarded by the Government to encourage contractors to adopt SWMPs.

There were limitations to this research which could have inadvertently affected the results. Some of the selected firms were unresponsive and unsupportive, therefore making the data for the research incomplete and possibly biased. There were also time limitations to complete the research, thus fewer interviews were conducted than initially planned for. One the main barriers to this study was the low level of awareness amongst Malaysian contractors regarding sustainable resource and waste management and in particular SWMPs. The lack of knowledge about SWMPs made contractors more reluctant to implement any form of a SWMP. Finally, this study was conducted as a preliminary exploratory exercise to gauge the industry's level of awareness and commitment to sustainable waste management, identify current barriers and suggest future recommendations for an implementation strategy. Further investigations would be required to build on the findings of this study.

FINDINGS AND DISCUSSIONS

Specific Findings

From the target sample of eight contractors, seven were successfully interviewed for the purpose of this research. The questions asked to the interviewees were broadly grouped in the following categories: barriers to SWMPs, awareness of environmental impacts, on site sustainable management practices and recommendations for improvements. The following section details the findings from these specific questions before leading into a broader discussion of the implications for sustainable waste management in Malaysia.

Barriers to SWMPs

The interviewees felt that the main factors preventing contractors from using SWMPs in Malaysia are the lack of promotion and encouragement by the Government and CIDB, and the perception that appropriate solid waste management practices reduce contractors' profits. 57 per cent of contractors stated the perceived cost implications of SWMPs as the main reason why they would not implement one, whereas 43 per cent identified the lack of

available information and guidance, incentives and practical tools about SWMPs as the main barrier.

Level of awareness of environment impact of construction waste generation and current waste practices

The majority of the interviewees (85 per cent) were unaware of the adverse impacts of waste to the environment. 6 out of 7 contractors send all of their wastes to landfill or burn them on site illegally, while 1 contractor admitted to disposing construction wastes on site.

Sustainable resource and waste management practices on site

Despite the low levels of environmental awareness and unsustainable waste management activities, there are some examples of sound waste management practices on site.
According to the contractors that were interviewed some waste segregation at source is practiced with the ultimate aim to recycle materials with some value. Waste materials such as scrap metal are separated and stored on site to be sold on to waste recycling companies, while other wastes are mixed together into one container and either sent to landfill, burned or illegally buried on site.
There are some sustainable practices carried out on site by the contractors, such as recycling and re-using of certain materials or using Industrialised Building System (IBS) which reduces the amount of wastes produced on site. None of the interviewed contractors have targets with regards to waste management on site, which shows that contractors still lack knowledge and awareness on encouraging sustainable practices.

Recommendations for improvement

Six of the contractors felt that the Government should promote SWMPs better, while financial incentives such as tax reduction were perceived the best way to increase uptake. Finally, the interviewed contractors felt that they would support the creation of legislation making SWMPs compulsory as it would ensure the success of their projects and allow them to deal with their wastes more responsibly.

Discussion

Based on the contractor interviews, it can be concluded that there is a greater likelihood of adoption of SWMPs by contractors if there is the correct level of encouragement, incentives, promotion and training. The factors preventing contractors from using SWMPs could be eliminated with suitable training, guidance material and awareness raising. Indeed, the main issue preventing the use of construction waste management plans on site relates to the lack of information on both the contractors and CIDB's part. Before any of these parties can develop construction waste plans for the Malaysian construction industry, they must first equip themselves with the knowledge and understanding of the topic. However, given the limitations in the research as well as the small number of samples taken, more data is needed to confirm this assumption.
The interviews reveal that the Malaysian construction sector relies solely on initiatives led by the government bodies and CIDB and is reluctant to invest time and effort to drive change. The UK experience demonstrates that industry driver initiatives are also required to change the face of the industry. Based on the SWMPs developed in other countries, it is evident that the implementation of construction waste management plans is beneficial to contractors in

terms of the promotion of good management practices, reduction of unnecessary wastes on site, cost and time savings and more. CIDB should also take a step towards increasing promotions for construction waste management as part of the industry's need to deliver sustainable practices for the benefit of the society, economy and the environment.

The study also tested the industry's appetite for regulation on sustainable construction waste management, making SWMPs a mandatory requirement. The industry appeared surprisingly positive and supportive for such a measure appreciating the business benefits it could lead to. This response suggests that a the Malaysian government should consider creating regulation on construction waste management which will address the increasing problems caused by excessive development and environmental degradation and create awareness among contractors to implement SWMPs for their projects. By creating legislation on construction waste management, the efforts in promoting recycling, reducing and re-using activities which the Government has been campaigning in the past years would be fully addressed.

The interviewed sample's response to proposed outline SWMP framework was positive. The contractors felt that the proposed waste guideline was comprehensive and encompassed all stages of a construction project. Most of the activities carried out in the guideline were also seen as achievable and beneficial for contractors if properly carried out. Furthermore, the contractors highlighted the need for waste reduction during the design stage, avoiding unnecessary designs and specifying using durable and reusable building materials.

Finally the inadequate waste management infrastructure of the country and current policy lacking coordination were raised as a concern by the Malaysian contractors. The interviewees were aware that suitable and adequate recycling plants and related infrastructure are crucial to ensuring the success of SWMPs. An example of the disjointed policy is the fact that the Public Works Department's authority has yet to certify and accept the use of recycled materials for construction projects. Therefore, currently the lack of relevant infrastructure, supporting policy, legislation and enabling mechanisms make it difficult to promote sustainable activities like recycling in the Malaysian construction industry and limit the number of options for contractors in the implementation of SWMPs.

CONCLUSION

SWMPs provide a useful framework for the sustainable resource and waste management of construction waste, offering environmental, social and financial benefits. The aim of their implementation on site is to increase the resource efficiency of materials through recycling, reusing or recovering products before they are disposed, and reducing environmental problems, such as illegal dumping and open burning (DTI, 2004). There are many proven benefits of construction waste management plans for contractors, such as cost and time savings, increased productivity on site, good corporate social responsibility and the ability to control the quality and ensure the safety of project sites as a result of a clean site environment.

However, despite these benefits construction waste management remains poorly implemented in construction projects in Malaysia, despite some promotion from the Government and CIDB. It is clear that more efforts are required by CIDB and the Government to promote and develop SWMPs into the local construction industry and contribute to the country's aspirations for sustainable growth. Based on the results of this exploratory exercise guidance, practical tools, regulation and incentives are amongst the priorities highlighted by the Malaysian contractors. Construction waste management guidelines such as the one proposed by this research aims to promote sustainable construction practices by contractors in Malaysia to ensure a comprehensive and integrated management of wastes on site.

In terms of further research, studies exploring the practices that can be adopted by the construction industry to promote sustainable development are recommendation. Currently, there is limited if any research investigating behaviour change in the industry that would lead to improved waste management attitudes and practices. Furthermore, the development of a national standard for SWMPs for Malaysia supported and promoted by CIDB would benefit the sector and improve sustainable resource and wasre management of construction waste in the country.

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REDESIGN – UPGRADING THE BUILDING STOCK TO MEET (NEW) USER DEMANDS

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Abstract
Financial and real estate crises and "new ways of working" reduce the need for office space. As a consequence, office markets become replacement markets without a quantitative need for new office buildings: new buildings drive out bad buildings. In the Netherlands, currently 14% of the office space is vacant, of which 60% is redundant or obsolete. Office users, guided by the government, consider sustainable office space important for their image and status. Besides they want to be accommodated in high quality buildings that fit with their current and future need for space, taking into account expected shrinkage or further development and expansion. Quite often, new office developments were the response to these demands. Public opinion and emerging governmental awareness of sustainability oppose the construction of new office buildings in locations with a high vacancy level, while office users, real estate developers and investors crave for new office developments. Can redesign of existing office buildings answer to the demand for new sustainable office space?
In former research we have revealed that location and building characteristics have a strong influence on office users' preferences and decisions to move to other buildings. Knowledge about these characteristics is important when determining the potential future use of the existing office stock. Based on foregoing research, we propose new use of existing office buildings and delve into the measures that need to be taken in order to adapt existing buildings to new use.

Keywords: offices, vacancy, user preferences, sustainability, re-use

INTRODUCTION

After some booming years for the Dutch office market, this market is now characterised by continuous overproduction and oversupply, resulting in an overall national vacancy rate of 14%. What is even more alarming is that 60% of all vacant office space is vacant for three or more years, pointing towards the obsolescence of this office space. Research by Remøy (2010) showed that obsolescence is a result of the current replacement market. Office users move from existing buildings to new developments, leaving buildings behind that are not taken up by the market, because quantitatively there is no new office demand. Vacancy concentrates in buildings with specific physical characteristics. These are buildings in mono-functional office locations or industrial and distribution areas, typically with few facilities and not well accessible by public

transportation, with poor external appearance, poor flexibility and less parking places than surrounding properties. Residential transformation is a way of coping with obsolete office buildings. Former research (Barlow & Gann, 1993, Beauregard, 2005, Heath, 2001, Remøy, 2010, Remøy & Van der Voordt, 2007) has revealed the possibilities for such (re)developments, including the risks and opportunities for the different parties typically involved. However, though across use adaptation can help solve the problem of vacancy and obsolescence in the office market, continued development of new office buildings will increase the vacancy level and contribute to the persistence of the vacancy problem.

Table 1 *Summary of building adaptation criteria retrieved from Wilkinson (2009)*

Adaptive reuse criteria for existing buildings	**Relevant studies**
Age	Ball, 2002; Barras & Clark, 1996; Fianchini, 2007; Geraedts & Van der Voordt, 2007
Condition	Baird et al., 1996; Boyd & Jankovic, 1993; Kersting, 2006; Swallow, 1997
Height	Gann & Barlow, 1996; Geraedts & Van der Voordt, 2007
Depth	Gann & Barlow, 1996; Szarejko & Trocka-Leszczynska, 2007
Envelope and cladding	Gann & Barlow, 1996
Structure	Gann & Barlow, 1996; Geraedts & Van der Voordt, 2007
Building services	Gann & Barlow, 1996; Szarejko & Trocka-Leszczynska, 2007
Internal layout	Fianchini, 2007; Gann & Barlow, 1996; Swallow, 1997; Szarejko & Trocka-Leszczynska, 2007; Geraedts & Van der Voordt, 2007
Flexibility (for differing uses and functional equipment)	Brand, 1994; Fianchini, 2007; Gann & Barlow, 1996; Van der Voordt & Van Wegen, 2005; Geraedts & Van der Voordt, 2007
Location	Baird et al., 1996; Ball, 2002; Bryson, 1997; Remøy & Van der Voordt, 2007; Van der Voordt & Van Wegen, 2005; Geraedts & Van der Voordt, 2007
Heritage	Ball, 2002
Size	Ball, 2002; Gann & Barlow, 1996; Geraedts & Van der Voordt, 2007
Accessibility	Ball, 2002; Ellison & Sayce, 2007; Fianchini, 2007; Gann & Barlow; 1996, Kersting, 2006; Remøy & Van der Voordt, 2007; Geraedts & Van der Voordt, 2007
Parking	Ellison & Sayce, 2007; Geraedts & Van der Voordt, 2007
Character / aesthetics	Ball, 2002
Acoustic separation	Gann & Barlow, 1996; Geraedts & Van der Voordt, 2007
User demand	Ball, 2002; Geraedts & Van der Voordt, 2007
Site conditions	Baird et al., 1996; Geraedts & Van der Voordt, 2007

Knowing that the construction industry is responsible for 30% of all energy use, waste production and transportation by road, resulting in a substantial carbon footprint, multinationals and governmental corporations lead the way in an increased demand for sustainable

accommodation. For instance, the Dutch government's building agency demands that all new governmental real estate purchases and leases must be CO2 neutral from 2010 on, and aim at reducing energy use by 25% before 2020 (RGD, 2011). Internationally, cities worldwide like Sydney, Cape Town, Vancouver, Aguascalientes, Nagoya, Copenhagen and Amsterdam aim at becoming climate neutral or CO2 neutral by 2020 or 2030. Building adaptation is a sensible means of reducing the carbon footprint of the construction industry, as the site and a substantial part of the building materials are (re-)used for a longer lifespan. Several studies (**Table 1**) have been conducted that show physical criteria for the adaptation of office buildings. These studies considered both transformations from offices into housing, and within use adaptations of offices. Research by De Jong (2005) and Van den Dobbelsteen (2004) has proved that adaptation of existing buildings has a sustainable advantage compared to demolition and new construction. Though this far adaptation is not taking place on a large scale, building adaptation could be the egg of Columbus! In this paper, we propose new use of existing office buildings as a means for sustainable office development. Can existing office buildings be adapted or redeveloped to cope with the demands of future office users? We will discuss this question, based on literature and results of former research.

NEW WAYS OF WORKING

The quantitative demand for office space is determined roughly by two factors; the number of office employees at work in a specific office market, and the number of square metres used per employee. The number of employees in a market is determined by demographics, macro-economic conditions and the employment market. The number of square metres per employee on the other hand is determined by the way an organisation works. The organisation's view on what kind of work space best supports its activities, its use of new technologies, demand for flexibility, and finally its demand for a specific appearance, are all important factors of an accommodation strategy (Van Meel *et al.*, 2010). The last decade office accommodation goes towards open, flexible, non-territorial office space with desk-sharing and a variety of activity based workspaces, resulting in less square metres per employee than office concepts based on cellular offices (Van der Voordt, 2003).

According to the expectations of real estate agent and advisor DTZ (DTZ, 2011) the demographic trend of an ageing population and less employees together with less square metres used per employee will result in a higher vacancy rate in the years to come. While at the end of 2010 the Dutch office stock in use was 40 million square metres, DTZ expects that by 2030 the office stock in use will be 30-32 million square metres. If this holds true and the stock stays the same, the vacancy will more than double from 7 million in 2010 to 15 million in 2030. That equals one third of the current office stock! A possible trend-break could be that the current oversupply of office space will lead to lower rents in the office market, so that the price of office space will generally become lower. However, research by Keeris and Koppels (2006) has shown a stratification in the office market, where rents in the top segments increase, while only rents in the lowest segments decrease. This layering of rents shows that the preferences of office organisations for high quality office space are not influenced by the availability of cheap office space in other market segments. The vacancy in the low quality segments is expected to increase, while the demand for high quality offices will last.

QUALITY AND OBSOLESCENCE – EXPERT-BASED PROPERTY ASSESSMENT

In property investment, quality is thought to improve investment return and reduce risk (Baum, 1993, Baum & McElhinney, 1997, Bottom *et al.*, 1998, Salway, 1987). Baum refers to obsolescence (categorised as aesthetic, functional, social, legal, economic and environmental obsolescence) as a result of changing quality and as a source of risk for investors. Following Baum, the quality of office buildings could be determined in terms of occupier utility and hence utility for investors. Applied to the currently unbalanced Dutch office market, we expected to discover differences of quality between office buildings functioning well in this market and office buildings with a high level of structural vacancy.

The relationship between quality, obsolescence and investment returns and risks can be studied using so-called expert-based appraisal techniques (Baum, 1993, Bottom *et al.*, 1998, Duffy & Powell, 1997, Salway, 1987). In studies by Duffy and Bottom, (Bottom *et al.*, 1998, Duffy & Powell, 1997) inflexibility was found to be an important indicator of depreciation in commercial buildings, whereas other studies (Healey & Baker, 1987) also included the quality of internal finishes, entrance hall and the external appearance of the building. Baum related depreciation to obsolescence in a series of studies, using both terms to imply low quality (Baum, 1991, Baum, 1993, Baum & McElhinney, 1997). Depreciation may result from tenure-specific or property specific factors. Baum speaks of site value and building depreciation, where building depreciation is a result of physical deterioration and building obsolescence. Building obsolescence, representing a decline in utility of the building, is again one of the major causes of long term vacancy. The investment return and risk are both factors that need to be considered when investing in office buildings. Though hedonic analyses are often used to determine the relationship between the physical characteristics of office buildings and locations and the rent prices of offices as an indicator for the value of office buildings, few studies focused on the risk of vacancy as a threat to the value of investments. However, as the vacancy rate in European cities has been rising the last years, the risk of structural vacancy in office buildings is becoming a more important factor in the equation than it used to be. Obsolete office buildings have reached the end of their functional and or economic lifespan; hence interventions are needed in order to upgrade these buildings for continued or new use. Knowledge about office user preferences is necessary to know which buildings can successfully be upgraded for renewed use.

QUALITY AND OBSOLESCENCE – USER-BASED PROPERTY ASSESSMENT

From studying physical characteristics that contribute to the quality or the obsolescence of a property, the characteristics are known of office buildings that are vacant in the current market. Using a Delphi survey (Remøy *et al.*, 2007), office accommodation advisors stated that office organisations prefer office buildings and locations with certain characteristics (**Table 2**) that enables the organisation to reach their goals. The results from the Delphi survey showed that vacant office buildings can be described by characteristics that are not preferred by office users. However, we did not interview the office organisations or its employees during this study. Bottom et al. (1998), presented an approach combining the former discussed expert-based

appraisal technique with a user-based appraisal technique, best described as a post-occupancy evaluation (POE). The advantages of using POE are recognised in facility and property management (Preiser, 1995, Preiser & Vischer, 2005) because of the possibility of providing feedback information for proactive management. Combining expert-based and user-based property assessments could further help to understand mutations in the office market, revealing which adaptations should be made to enhance the lettability of office buildings.

Table 2 *Physical property characteristics that influence office user preferences*

Building characteristics	**Location characteristics**
1. Car parking	1. Accessibility by car
2. Exterior appearance	2. Status
3. Layout flexibility	3. Accessibility by public transport
4. Space efficiency	4. Facilities
5. Comfort	5. Safety
6. Interior appearance	6. Business cluster
7. Recognisable user	
8. Technical state	
9. Building facilities	
10. Year of construction	
11. Security	
12. Energy performance	
13. Routing	
14. Bike parking	
15. Commodities logistic	

EXAMPLES OF SUCCESSFUL ADAPTATIONS

Studies of the Amsterdam and Melbourne office market (Wilkinson & Remøy, 2011) revealed that adaptations of existing office buildings reduce the risk of obsolescence. The adaptations included in this study all considered larger interventions, registered as building permits. 100 office buildings in Amsterdam were studied and 1500 adaptations of Melbourne office buildings (could be multiple adaptations of the same buildings). A total of 18 building attributes were found to be important drivers for commercial office adaptations in Melbourne and Amsterdam (**Table 3**), of which five were shared (number of storeys, GFA, typical floor area, age and aesthetics). Of the five attributes found important only in the Amsterdam study, namely facade material, long term vacancy, entrance spatiality, provision of sanitary and pantry facilities and the number of elevators in the building, this data was not collected in the Melbourne study and therefore no further comment can be made as to whether this data would have been found to be important; this is an area of possible further research. The final six attributes found to be important only in the Melbourne study were “Property Council of Australia building quality grade”, site boundaries, site access, vertical services location, property location and historic listing, which were not part of the Amsterdam study. One could also make the argument that “Property Council of Australia building grade” (a Melbourne attribute) could be a proxy for the level of amenities provided in a building such as number of elevators and sanitary

accommodation (two of the Amsterdam attributes). The importance in both studies of the number of storeys and total GFA of the building, show that the size of the building is important for the possibility that building adaptation will lead to increased future value of the office building. Typical floor area is an indicator for the flexibility of the layout and is an attribute that is not adaptable; hence its importance is also quite easily comprehended. The level of amenities in the building was found to be important both in the Amsterdam study and in the Melbourne study. Since adaptation of these services easily implies high building costs, the importance of the attributes for adaptations are easily explained.

Table 3 *Criteria for adaptations in Melbourne and Amsterdam. (+) implies that when the value of the attribute increases, adaptation is more likely.*

Important Building Adaptation Attributes	**Melbourne**	**Amsterdam**
Number of storeys (+)	X	X
GFA (+)	X	X
Property Council of Australia building quality grade (-)	X	
Typical floor area (+)	X	X
Site access (+)	X	
Parking places (+)		X
Street frontage (+)	X	
number of elevators/m2 (+)		X
sanitary and pantry facilities/m2 (+)		X
Spatiality of the entrance (+)		X
Historic listing (+)	X	
Age in 2010 (+, old buildings are more likely adapted)	X	X
Long term vacancy (+)		X
Facade material (+)		X
Facade quality / aesthetics (+)	X	X

EXAMPLES OF SUCCESFUL TRANSFORMATIONS

Table 1 showed a list of adaptive reuse criteria for existing buildings. These criteria, all physical characteristics of the property, correspond to both within use adaptation (retrofitting of the office function) and transformation from offices into new functions. Table 4 shows criteria that were found to enhance the transformation potential of office buildings, based on a cross case analysis of 14 completed transformations (Remøy, 2010; Remøy & Van der Voordt, 2007, 2009). The only location characteristic that could be said to be a veto-criterion for residential transformation is noise level on the facade and level of fine dust in the air. If the legal standards are not met, then residential transformation is not feasible. The other location characteristics are less critical, depending on the target group for housing and the combination of characteristics.

Table 4 *Criteria for high transformation potential (from offices into housing) retrieved from case studies (Remøy and Van der Voordt, 2007)*

Attributes	Criteria for transformation
1. Location	No serious health risk (pollution, noise, stench) Noise load on facade < 50 dB, according to Dutch building regulations Functional mix and facilities nearby Zoning plan permitting future modification e.g. with mixed use including housing No serious crime risk (vandalism, burglary, attacks)
2. Building	
Appearance	No "office building look", attractive identity and entrances A high spatial/visual quality
Facade	Replaceable or adaptable, not load-bearing Daylight admittance at least according to building regulations for housing Operable windows Acoustic and thermal insulation according to building regulations for housing
Flexibility / adaptability of the structure	Extendibility, horizontally or vertically Acoustic and thermal insulation according to building regulations for housing A structure that can accommodate floor plans for different target groups Preferably no load-bearing walls, but columns Sufficient escape routes according to housing legislation Free ceiling height > 2.60 m
Installations	No installations integrated in the load-bearing structure Possibility to add service ducts (possibility of cutting holes in floors for shafts)

Few building characteristics make transformation into housing or other functions impossible: A building is more easily manipulated than its location. The characteristics of the structure and the floors are most crucial for the transformation potential. The scale of the structure must allow separations into usable spaces. While older office buildings were not built according to standard measurements, office buildings from the 1980s onwards often have a structure that is a multiple of 1.8 metres, such as 7.2 metres, and is well suited for accommodating housing. The floors of office buildings normally provide enough strength for residential transformation. Problems may occur though when manipulating the floors. A typical floor in an office building is made of pre-stressed hollow core slabs. If the steel in the floors is cut, the floors loose strength. Apartment buildings require a higher density of vertical shafts than office buildings. Penetrating the floors to create shafts for water, electricity and sewer is one of the problems of transforming offices into housing. Though several building characteristics represent potential risks for the legal, functional, technical and cultural feasibility and thus also for the financial feasibility of transformation projects, only one characteristic represents a veto criterion: free floor height >= 2.6 metres. The characteristics of the facade influence the transformation potential of office buildings significantly. Though the facade is often adaptable, all adaptations imply extra building costs, and hence influence the financial feasibility of a transformation. As the requirements for thermal and acoustic insulation are higher for housing than for offices, adaptations of the facade

are needed in most transformation projects. Finally, the image of outdated office buildings does not always trigger positive reactions from potential residents. Except for monuments or renowned buildings that have a specific image or are even able to provide a specific identity to a whole neighbourhood, most office buildings come with 13 in a dozen and have an image too strongly related to office work. In these cases, the facade is often replaced, even if it is technically well maintained and meets the requirements for housing.

The adaptive reuse criteria of within use adaptation to a certain degree correspond to those of transformation. On a location level, the legal requirements for housing are stricter than for offices. On building level, generally the functional adaptation demands more from the technical adaptations. However, many of the same requirements exist for modern offices and housing.

ADAPTATIONS FOR NEW OFFICE USE

While the possibilities for redeveloping and adapting existing office building for the same or new use have been revealed, the question that remains unanswered is: which office buildings and locations could and should be reused for new, sustainable offices that meet future demands and can increase the value of the existing, obsolete office building? Although adaptation of existing offices is a means of reducing the amount of new office developments, not all office buildings can be successfully adapted. If a property is environmentally or locationally obsolete, adapting the building to fit new office user demands will not offer any solace. Additionally, some office buildings have unfavourable measurements or inflexible layouts that cannot accommodate the demands of modern office organisations. In some cases, the existing office building is too small and too technically outdated to be adapted: the costs of interventions that are needed to make the building suitable for new office use will result in a second-best office building that will lose the competition with other buildings and therefore will remain vacant. Moreover, fighting the oversupply in the office market means that some office buildings need to be taken off the market. Departing from the forecasts by DTZ (2011) that if no new office buildings are added to the office stock, 25% of the office supply should be demolished or transformed for other use.

CONCLUSION AND REFLECTION

In an office market with high vacancy rates, remarkably few adaptations have been carried out to enable re-use for office functions. The Dutch office market was mainly driven by expansion, and the development accelerated from the 1980's onwards. The local and national government together with developers and investors viewed the office market expansion as an everlasting gold mine. As the market could not recover from the 2001 crisis before the 2008 crisis hit, the inevitable end of the growth is hard to face. Adaptations of existing buildings have taken place in this expanding market, but the Dutch office market has a lot to learn from other markets, where adaptations are well documented and the goals for future development are clear. Adapting existing office buildings to accommodate modern offices is a possibility of limiting office vacancy by ending the overproduction of new office space. However, if all office buildings are adapted, the quantitative oversupply of office space will persist. Therefore, redevelopment, functional transformations and demolition are inevitable in order to develop a balanced future

office market. Based on former studies, the characteristics of buildings that are best suited for functional transformation can be recognised. Furthermore, the characteristics of office buildings that are best suited for within use adaptation can be described based on the appraisal of the existing building. Following this train of thoughts, buildings that do not expose adaptation potential could better be demolished.

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ORGANIZATIONAL AMBIDEXTERITY IN THE CONSTRUCTION INDUSTRY

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Abstract
Organizational ambidexterity refers to an organization's ability to both exploit existing knowledge, assets, and positions for short-term profits and also explore new knowledge, technologies, and markets to enhance long-term development. Ambidexterity research has mostly focused on firm or business unit levels. Studies dealing purely with project or alliance levels in project-based industries are non-existent. The purpose of this conceptual paper is to examine if it is a useful concept for discussing sustainability and competitive advantage in the construction industry, to what degree ambidexterity is present, and how it may be affected by procurement procedures and project governance. Short-term project focus and decentralization inhibits learning from one point in time and space to another, making it more difficult to reap the benefits of exploration than of exploitation. Due to strong path dependence there is an apparent risk that construction industry actors may be trapped in suboptimal stable equilibrium by focusing too heavily on exploitation and too little on exploration. This paper discusses how procurement procedures and project governance can affect the possibilities to achieve ambidexterity in construction projects. Joint specification, partner selection, incentive-based payment, and collaborative tools are important means to affect ambidexterity so that a suitable balance between exploitation and exploration can be obtained in construction projects.

Keywords: ambidexterity, exploration, exploitation, innovation, procurement.

INTRODUCTION

Background
Recently, the focus on trade-off relationships in organizational research has been shifted to paradoxical thinking (Eisenhardt, 2000), which is pinpointed in research about organizational ambidexterity. Although the concept of organizational ambidexterity was first coined by Duncan (1976), most literature on the subject stems from March (1991) and his seminal work on exploration and exploitation in organizational learning. Exploration includes things captured by terms such as search, diversity, adaptability, risk taking, experimentation, flexibility, discovery, innovation, and long-term orientation. Exploitation on the other hand involves refinement, alignment, control, constraints, efficiency, and short-term orientation (March, 1991; Gibson & Birkinshaw, 2004; Andriopoulos & Lewis, 2010). Accordingly, ambidexterity involves the capability to both exploit existing knowledge, assets, and customers/markets for short-term profits and also explore new knowledge, technologies, and customers/markets to enhance long-term development (O´Reilly & Tushman, 2008). Due to exploration's greater uncertainty most organizations focus more on exploitation (Uotila et al., 2009), resulting in short-term success but long-term stagnation and failure (O´Reilly & Tushman, 2008). Achieving an appropriate balance

between exploration and exploitation is therefore critical for sustainable competitive advantage (March, 1991; Gupta et al., 2006).

Earlier ambidexterity research has mostly studied firm level or business unit level (Mom et al., 2007; Raisch & Birkinshaw, 2008). Koza and Levinthal (1998) were first to adopt the exploration/exploitation paradox in an inter-organizational context when investigating strategic alliances. In recent years additional investigations have contributed to this knowledge, suggesting that ambidexterity is a highly relevant concept in external relationships among firms. However, in spite of the emerging interest for ambidexterity in alliances, there is limited understanding of how exploration and exploitation impact alliance performance and how ambidexterity can be facilitated through different organization designs and governance forms (Im & Rai, 2008). Prior investigations that focus on how to achieve ambidexterity at various organizational levels have found that ambidexterity is heavily affected by both formal organizational aspects (e.g hierarchical structures, control mechanisms, formalization, partner selection procedures, forms of payment) (Koza & Lewin, 1998; Jansen et al., 2006; Lavie & Rosenkopf, 2006; Jansen et al., 2008) and informal social aspects (e.g. connectedness, shared vision) (Jansen et al., 2006; Jansen et al., 2008; Tiwana, 2008). However, Tiwana (2008) argues that pure project-level investigations, in which both ambidextrous behaviors and their effects on performance are studied within projects, are very scarce although much of alliances' innovation work is performed within the boundaries of projects. This gap may be due to that ambidexterity studies have not yet investigated project-based industries, such as the construction industry (Eriksson & Westerberg, 2011).

Although sometimes challenged, the conventional view is that the construction industry lacks innovation (Widén & Hansson, 2007), but the suggested improvement agenda fails to address the specificities of innovating within the project-based context (Dubois & Gadde, 2002; Harty, 2008). In prior construction management literature the need to break down barriers to innovation and the need to resolve conflicts between project actors are generally revealed as conclusions rather than starting points (Harty, 2008). Hence, it is vital to develop a more detailed understanding of how a balance between exploration/exploitation can be achieved in inter-organizational projects and how it affects project performance. In construction projects both formal and informal aspects are affected by procurement procedures and project governance, which determine responsibilities and authorities in the entire construction process, affecting the degree of integration and cooperation among project participants (Eriksson & Westerberg, 2011). Formal and informal mechanisms related to procurement procedures and project governance are therefore relevant to investigate in order to increase our understanding of how they may affect the achievement of organizational ambidexterity.

Purpose of the paper

This paper addresses the abovementioned gap in the ambidexterity literature by conceptually investigating ambidexterity in inter-organizational projects in the project-based construction industry. When investigating this subject for the first time in the construction context, it seems pertinent to examine if it is a useful concept for discussing sustainability and competitive advantage in this industry, to what degree ambidexterity is present, and how it may be affected by procurement procedures and project governance.

This paper thereby aims to address and conceptually discuss three research questions:

1) Is organizational ambidexterity a useful concept that can enhance sustainable project performance in the construction industry?
2) To what degree is organizational ambidexterity apparent in construction projects?
3) How can organizational ambidexterity be facilitated through procurement procedures or other related mechanisms?

THEORY

Three types of ambidexterity

In early research, authors have typically viewed ambidexterity in 1) *structural* terms by separating exploitation and exploration activities in different business units (Duncan, 1976; Tushman & O´Reilly, 1996; O´Reilly & Tushman, 2004) or parallel structures involving task partitioning within a single business unit (e.g. project team or quality circle) (Goldstein, 1985; Adler et al., 1999) or 2) *sequential* terms by temporal separation (i.e. punctuated equilibrium) through focusing on first one type of activity and then the other one (Duncan, 1976; Adler et al., 1999; Gupta et al., 2006). True paradoxical thinking is however obtained only when 3) *contextual* ambidexterity is adopted, that is, when there is a capacity to simultaneously and synchronously pursuit exploitation and exploration within a business unit or work group (Gibson & Birkinshaw, 2004; Gupta et al., 2006). Most scholars focus on one or another of these different types of ambidexterity but recent research has found that in reality a combination of different types may be most practical (Raisch et al., 2009; Andriopoulos & Lewis, 2010).

Ambidextrous performance

There is a lack of studies that explicitly address the paradox of ambidextrous performance, including both exploitative results (i.e. alignment with project objectives) and explorative results (i.e. adaptation to changes in the environment) (Tiwana, 2008). Projects are inherently bounded in time and space, making it natural to address and focus on short-term exploitative performance. However, since project objectives can evolve during development in synchrony with new information, unanticipated shifts in underlying technologies, and emerging market requirements, exploration may be equally important (Tiwana, 2008).

In the construction industry, project performance is measured through the short-sighted iron triangle of cost, time, and quality (Chua et al., 1997; Swan & Khalfan, 2007). For industrial actors with concern for sustainability, the exploitation focused “iron triangle” is too limited. Also more long-term and explorative elements, such as lifecycle costs, environmental impact, and innovation, need to be addressed in order to obtain a more sustainable perspective on project performance (Eriksson & Westerberg, 2011). Furthermore, most construction projects are characterized by high complexity (making it hard to estimate an accurate cost of the finished project) and uncertainty (increasing the risk for changes in scope and content) (Palaneeswaran et al., 2003; Eriksson, 2010b), making explorative adaptations required. This paper therefore discusses ambidextrous performance in order to achieve a more sustainable perspective on project performance than the iron triangle obtains.

AMBIDEXTERITY IN DIFFERENT ENVIRONMENTS

Prior research indicates that ambidexterity is applicable in several different environments. 1) Even if empirical findings have identified some differences in how to manage ambidexterity they suggest that ambidexterity is relevant and applicable across different industries in both high-tech (Brown & Eisenhardt, 1997; Beckman, 2006; Lavie & Rosenkopf, 2006; Mom et al., 2007) and low-tech manufacturing industries (He & Wong, 2004; Sidhu et al., 2004). 2) Other empirical investigations concur that exploration is particularly important in a changing environment, whereas it becomes less critical in slow moving environments (Mom et al., 2007; Uotila et al., 2009). Exploitation may thereby be efficient also in a somewhat longer time perspective when slow technological change do not make current knowledge obsolete (Uotila et al., 2009). However, O´Reilly and Tushman (2008) mean that low rates of change do not make ambidexterity pointless; it merely makes it possible to divide exploration and exploitation into different sequences instead of performing them simultaneously. Another study have investigated the uncertainty dimension of dynamic environments and found that ambidexterity is especially vital in contexts with high environmental uncertainty, in terms of fluctuating revenues (i.e. volatile net sales) due to economic booms and downturns (Lin et al., 2007). 3) Another environmental aspect is the degree of competition, reflected in the number of competitors and the number of areas in which there are competition. Through a large scale survey Jansen et al. (2006) found that exploitative innovations improve financial performance in highly competitive environments. In order to tackle tough price competition, exploitation then serves to improve existing products and increase cost efficiency without the substantial risks and costs associated with exploratory innovations (Jansen et al., 2006).

Due to the broad applicability of the ambidexterity concept it is difficult to see why it should not be relevant in the construction industry. 1) Although construction often is labeled as a low-tech industry this notion is not theoretically grounded and is increasingly questioned as new and advanced tools and technologies are utilized to a growing extent (Harty, 2008). 2) In terms of change rate, the construction industry is often said to be characterized by a slow technological change, but Gann and Salter (2000) mean that construction firms operate within a dynamic environment in which rapid economical and societal changes create demands for new types of buildings and infrastructures. In addition, the construction industry is very sensitive to economic booms and downturns, thereby facing an economically volatile and uncertain situation that supports the argument for ambidexterity. 3) In the construction industry the degree of competition is varying in different countries, in different types of projects and at different points of time. In a quantitative study performed by Reichstein et al. (2005) it was found that the competitive forces requiring construction firms to innovate were weak in the UK. In Sweden, there are only a few large contractor firms that compete for major infrastructure contracts, whereas the number of competitors is significantly higher for smaller projects, especially in housing. The competitive environment also fluctuates heavily with economic booms and downturns. In economic downturns there are many companies that compete with low prices to win a project to keep their staff busy. In addition, competitive tendering based on lowest price is the most common way to select a partner (Eriksson, 2008b), indicating tough price competition. All in all, there are some inherent characteristics that suggest that exploitative behaviors may be somewhat more beneficial than exploration but a pure focus on exploitation or exploration is probably not as beneficial as a mix, indicating that ambidexterity is suitable.

Proposition 1: Ambidextrous behaviors among project actors enhance ambidextrous construction project performance.

DEGREE OF AMBIDEXTERITY IN CONSTRUCTION PROJECTS

Divorce of design and construction

For subsystems (e.g. business units or projects) with scarce resources sequential ambidexterity is more practical than structural solutions (Beckman, 2006; Gupta et al., 2006). Sequential ambidexterity is also more suitable in slowly changing environments, whereas exploration and exploitation must be performed simultaneously by structural ambidexterity in fast changing environments (O´Reilly & Tushman, 2008). Sequential ambidexterity can be achieved by focusing more on exploration in the early stages of a project and on exploitation in the end of the project during production/implementation (Raisch et al., 2009; Andriopoulos & Lewis, 2010). Prior ambidexterity research has found that formalization, which acts as a frame of reference that reduces variance and deviation from existing knowledge, is an important factor that enhances exploitative innovation (Jansen et al., 2006). A related finding was made by Mom et al. (2007) in a quantitative investigation of 104 managers in a US company. They found that top-down communication and knowledge inflow enhance a manager's exploitation activities (Mom et al., 2007).

As construction projects are often characterized by scarce resources and a slow or moderate technological change, sequential ambidexterity may be viable. However, ambidexterity is often achieved through a combination of structural and sequential strategies by letting consultants/architects first explore different types of technical solutions during the design phase and then letting contractors exploit their existing knowledge to efficiently build the specified product. The traditional way of procuring construction contractors based on detailed and fixed design specification entails formalization and top-down knowledge inflow from the contractors' perspective. This structural and sequential divorce between design and construction results in a prolonged project duration (Pietroforte, 1997) and poor buildability (Eriksson, 2010a). The divorce also hampers innovation and implementation of explorative solutions during the construction stage due to lack of joint problem-solving (Korczynski, 1996). Hence, the traditional sequential and structural approach enhances more exploitation than exploration and is not reaping the benefits of ambidexterity.

Partner selection based on competitive tendering

Prior research has found that purposeful staffing of subunits and groups is important for ambidexterity (O´Reilly & Tushman, 2008). Diversity is important for creativity and ground-breaking advancement, while cohesiveness nurture mutual understanding and smooth group work and thereby efficiency (Beckman, 2006; Andriopoulos & Lewis, 2010). When partners are familiar with each other, they can rely on prior experience and existing arrangements to enhance the predictability and reliability of the collaboration (Lavie & Rosenkopf, 2006). Exploitation is thereby facilitated by establishing teams of members who have previously worked together, whereas exploration is enhanced by heterogeneous teams in which individuals have different prior experiences and affiliations (Beckman, 2006; Lavie & Rosenkopf, 2006; Andriopoulos &

Lewis, 2010). In addition, Koza and Lewin (1998) argue that output control is most suitable in exploitative alliances. Output control, defined as the degree to which the focal firm monitors the results or outcomes produced by the partner (Aulakh et al., 1996), is closely related to the price mechanism (Hennart, 1993). In line with this reasoning, rigid client constraints (e.g. financial and technical) have been found to turn the focus to exploitation and inhibit exploration (Andriopoulos & Lewis, 2010), whereas slack in human and monetary resources enhance exploration, as they condition information search, experimentation and risk-taking (Sidhu et al., 2004).

These related aspects are relevant in a construction industry context. In a survey study, Eriksson (2008b) found that the most important factor influencing construction clients' choices of governance forms and procurement procedures was the client's project constraints, in terms of budget and time schedule. As a consequence, the most dominant partner selection routine involves competitive tendering with multiple bidders evaluated chiefly on lowest price, entailing a focus on output control (Eriksson & Laan, 2007). Although the open bid procedure enhance the establishment of a heterogeneous team, the short-term focus on time and money in every single construction project results in scarce resources, indicating a propensity for exploitation rather than exploration.

Fixed price payment

A payment system rewarding the supplier for his output (e.g. a fixed price for a product delivered) indicates output control (Gencturk & Aulakh, 1995), which is appropriate in exploitative alliances (Koza & Lewin, 1998). When uncertainty is high, output control through fixed prices may lead to inflexibility since the supplier may resist adapting to changed circumstances (Aulakh & Gencturk, 2000).

In the construction industry fixed price payment is most common although it may generate many problems (Eriksson & Laan, 2007). It shifts all the risk to the contractor who will therefore focus on short-term efficiency and the use of known technological solutions. Since uncertainties in construction are high and derived from many different sources, the design is often changed because of changes in the client's preferences (Kadefors, 2004). The traditional output-based payment that enhances exploitation may therefore be inappropriate.

Exploitation focus

Firms may get stuck in suboptimal stable equilibrium for a long time since path dependence in terms of earlier experiences affects managers' choices more than the suitability of the various alternatives (March, 1991; Lavie & Rosenkopf, 2006). Indication of such path dependence hindering ambidexterity was found in a large cross-industry survey, finding that 67% of the studied firms relied on a single organizational structure (cross-functional teams) for all their development processes, although the results showed that firms tailoring the structure to fit the purpose (incremental vs radical new product development) were more successful (de Visser et al., 2010).

In the construction industry, path dependence seems to heavily influence clients' decisions related to project governance and procurement (Laedre et al., 2006). In fact, the third most important factor influencing construction clients' choices of governance forms and procurement

procedures is the client's earlier experience of the procedure (Eriksson, 2008b). Furthermore, studies of barriers to change in the construction industry have found that the conservative construction industry culture is the single most important barrier to change (Vennström & Eriksson, 2010). To conclude this discussion, it seems that there is an apparent risk that construction industry actors may be trapped in suboptimal stable equilibrium by focusing too heavily on exploitation and too little on exploration.

Proposition 2: Construction project actors rely much more on exploitative behaviors than on explorative behaviors.

HOW TO ACHIEVE AMBIDEXTERITY IN CONSTRUCTION PROJECTS

A viable option for subsystems with scarce resources is contextual ambidexterity (Beckman, 2006), which is less expensive than structural ambidexterity because the costs of coordinating, controlling, and supervising employees are much reduced (Gibson & Birkinshaw, 2004). Contextual ambidexterity is achieved by building a set of processes or systems that enable, encourage and reward individuals or sub-systems to make their own judgments about how to divide their time between conflicting demands for exploration and exploitation (Gibson & Birkinshaw, 2004). The balance between exploration and exploitation is thereby affected by the ways in which targets are set and changed, by recruitment and selection, by incentive systems, by organizational culture, and by risk preferences (March, 1991; Gibson & Birkinshaw, 2004; O´Reilly & Tushman, 2004). Since structural and sequential solutions alone may not be suitable in the construction industry, it seems pertinent to investigate how procurement procedures and governance forms can affect the achievement of contextual ambidexterity in construction projects.

Joint specification

Previous research has found that diverse and complementary assets and knowledge, along with integration and knowledge transfer are important mechanisms for enhancing ambidexterity (Beckman, 2006; O´Reilly & Tushman, 2008; Andriopoulos & Lewis, 2010). A related finding was made by Mom et al. (2007), who found that horizontal and bottom-up communication and knowledge inflow enhance a manager's exploration activities. Furthermore, high levels of uncertainty trigger substantial task interdependence among the involved project members, making participative coordination structures such as cross-functional teams necessary (de Visser et al., 2010). In line with these arguments the involvement of suppliers in design activities has successfully enhanced ambidexterity in the Toyota Production System (Adler et al., 1999).

Construction projects are mostly characterized by high uncertainty (Palaneeswaran et al., 2003; Eriksson, 2010b), due to lack of information concerning ground conditions, weather forecasts, and client requirements. This results in difficulties to forecast all future contingencies and outcomes, making integration among project actors an important means to enhance flexibility and coordination. As such, the integration of design and construction actors may be a viable alternative to the aforementioned combination of structural and sequential arrangements that

results in a divorce between design and construction. Early involvement of contractors and integrated design and construction (i.e. concurrent engineering) has shown to facilitate cost saving and shortened project duration (i.e. exploitation) due to increased buildability (Rahman & Kumaraswamy, 2004; Song et al., 2009) but also innovation (Ling, 2003) due to joint problem-solving and knowledge transfer among design and construction actors. Hence, such joint specification may be a suitable strategy to enhance contextual ambidexterity.

Partner selection based on multiple criteria

In order to enhance a balance between utilization of earlier experience and knowledge of related technologies and generation of fresh ideas and inputs, new product development teams should be constituted by both new and old members (Brown & Eisenhardt, 1997). Furthermore, ambidexterity research has found that during selection and hiring of staff it is important to assess both passion related attributes (exploration) and discipline related attributes (exploitation) in order to find people with ambidextrous identity (Andriopoulos & Lewis, 2010). Koza and Lewin (1998) argue that process (behavior) control is best suited for explorative alliances. Process control, referring to the focal firm's monitoring of the partners' behaviour or the input used to achieve the desired ends (Aulakh et al., 1996), can be accomplished during partner selection when inputs in terms of resources and capabilities are assessed.

When selecting partners for construction projects, process control entails bid evaluation based on multiple criteria (Eriksson & Laan, 2007). In order to enhance ambidexterity, it seems plausible to achieve a balance between direct negotiations with a long-term partner (enhancing exploitation) and more open bid invitations (enhancing exploration) by inviting a few new and old contractors/suppliers to bid and select the most suitable partner based on multiple criteria.

Incentive-based payment

Payment systems that reimburse the supplier for the time worked and the costs of input material (reimbursement payment) entails process control (Gencturk & Aulakh, 1995), which is most appropriate in explorative alliances (Koza & Lewin, 1998). Other studies have however shown that it is important to implement management systems that encourage and reward individuals and/or sub-systems to find a suitable balance between exploration and exploitation (Gibson & Birkinshaw, 2004). Ambidexterity is therefore enhanced by incentive-based payment (contingency rewards) that motivates actors to avoid sub-optimizations and to focus on the overall performance (O´Reilly & Tushman, 2004; Jansen et al., 2008; O´Reilly & Tushman, 2008).

In the construction industry, fixed price payment is common practice, while cost reimbursement and incentive-based payment are not very common (Eriksson, 2008b). Cost reimbursement means that the contractor gets paid for all costs that arise for which reason explorative and long-term development activities can be performed if the client so whishes. However, reimbursement payment may deter the implementation of new approaches and innovative solutions if these reduce contractors' time input and thereby their remuneration (Barlow, 2000). Reimbursement may therefore be coupled with incentive-based payment (e.g. gain/pain share agreement) in order to jointly reward cooperating actors for profits or other benefits resulting from innovative design solutions and effective adaptations (Barlow, 2000; Bajari & Tadelis, 2001). Eriksson and

Westerberg (2011) argue that incentive-based payment can enhance both short-term cost efficiency and long-term innovation, and thereby ambidexterity.

Collaborative tools

Although prior ambidexterity research has focused on formal hierarchical structures, also informal socialization issues and collaborative tools are important from an ambidexterity perspective (Jansen et al., 2006). Socialization, recognition and teambuilding activities improve the actors' connectedness (Jansen et al., 2006) and their generation of mutual tacit knowledge (Kristal et al., 2010). It helps individuals to think and act ambidextrously (Ghoshal & Bartlett, 1997) for which reason connectedness improves both exploratory and exploitative innovation (Jansen et al., 2006). Prior ambidexterity research has studied several collaborative tools. The use of joint IT systems facilitates ambidexterity (Gibson & Birkinshaw, 2004) since they can be used for exploitation purposes (e.g. automated billing and inventory management), explicitly focusing on enhancing efficiency, and for exploration purposes by enhancing collaboration in terms of gathering and exchanging information and new ideas across business units (Kristal et al., 2010). Furthermore, an overarching shared vision is an important integrating mechanism that facilitates ambidexterity by creating a common identity and motivating separate actors and groups to collaborate for the long-term prosperity of the overall system rather than to suboptimize small parts (Gibson & Birkinshaw, 2004; O´Reilly & Tushman, 2004; Jansen et al., 2008; O´Reilly & Tushman, 2008; Andriopoulos & Lewis, 2010). In order to enhance ambidexterity it is important that visions have a future oriented long-term oriented component (exploration), as well as an aspiration of the exploitation of current technologies and capabilities (Sidhu et al., 2004; O´Reilly & Tushman, 2008). A shared physical work space (i.e. joint office) enhance contextual ambidexterity by nurturing both cross-disciplinary work (diversity) and mutual understanding (cohesiveness) (Andriopoulos & Lewis, 2010).

Examples of collaborative tools utilized in construction projects are: developing joint objectives is vital in order to obtain a win-win situation (Crespin-Mazet & Ghauri, 2007; Swan & Khalfan, 2007), performing teambuilding activities is useful in terms of the socialization of partners (Bayliss et al., 2004; Crespin-Mazet & Ghauri, 2007), joint IT-tools enhance exploratory innovation (Gann & Salter, 2000) by facilitating communication and information sharing (Eriksson, 2008a; Woksepp & Olofsson, 2008), joint risk management is a useful way to deal with risks that are unforeseen or unquantifiable during the planning stage (Rahman & Kumaraswamy, 2004), and a joint project office on site in which all partners are located enhance communication through face-to-face encounters (Olsen et al., 2005). Although the use of these collaborative tools is low in traditional construction projects (Eriksson, 2008b), they should be an essential part of collaborative governance forms in which ambidextrous behaviors are demanded.

Proposition 3: Cooperative procurement procedures, including joint specification, partner selection based on multiple criteria, incentive-based payment, and collaborative tools, enhance ambidextrous project performance.

CONCLUDING DISCUSSION

In this paper organizational ambidexterity in the construction industry has been elaborated and discussed in terms of the exploration/exploitation paradox. Due to the project-based nature of the construction industry structural ambidexterity on firm and business unit level may not achieve desired ends. Hence, contextual ambidexterity at the project-level may be required in order to reap the benefits of an appropriate balance between exploration and exploitation. Earlier innovation studies within the field of construction management have highlighted the importance of inter-organizational cooperation in order to enhance innovation (Barlow, 2000; Dubois & Gadde, 2002; Widén & Hansson, 2007; Harty, 2008). Few earlier studies have discussed in more detail specific mechanisms that may enhance innovation. In this paper a procurement perspective has been adopted in order to discuss how cooperative procurement procedures may serve as mechanisms to achieve contextual ambidexterity in construction projects. This paper merely serves as a starting point for discussing organizational ambidexterity in the construction industry. Empirical investigations should be encouraged both in order to study if, when and why organizational ambidexterity is suitable in the construction industry and if so, how it may be achieved in real project settings.

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A DECADE OF CHANGE AND IMPROVEMENT? AN INDUSTRY VIEW OF CONSTRUCTION INDUSTRY DEVELOPMENT IN SINGAPORE UNDER CONSTRUCTION 21

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Abstract
Sir John Egan's report on UK construction industry in 1998, Rethinking Construction, inspired a similar review in Singapore in 1999. The Construction 21 (C21) report has served as the blueprint for developing Singapore's construction industry. A series of interviews was carried out in late 2009 to investigate the implementation of the C21 report during the ten-year period. The aim was to ascertain the achievements and challenges, and the consequent changes in practices and procedures in the industry. A representative cross section of samples was taken to include policy makers, clients, consultants, professional bodies, and trade associations. The general perception was that considerable progress had been attained in the development of construction industry, although the achievements had not as much as had been intended in the C21 report. Although a range of progressive practices highlighted in C21 have been adopted in the industry, some of the initiatives in the recommendations in the report are still in progress and some have been launched but have not been pervasively used in the industry. Although Singapore has made much progress in developing its construction industry, the extent to which the industry reforms have fulfilled their original intentions is not completely clear. The impact of the initiatives on the way companies and practitioners work is also not clear. Hence, there is a need to revisit priorities and review the progress so far and map out general strategies for the future.

Keywords: Construction 21, change, construction industry development, industry perspective, Singapore.

INTRODUCTION

In 1998, Sir John Egan published his seminal report on the UK construction industry entitled *Rethinking Construction* (Egan, 1998). This was followed by similarly high-profile reviews of the construction industries in other countries, such as Singapore and Hong Kong, the reports on which were published in 1999 and 2001 respectively (Construction 21 Steering Committee, 1999; Construction Industry Review Committee, 2001). Each of the studies was initiated to address concerns in the local construction industry. For example, in Singapore, the

intention was to attain a radical transformation of construction performance through a planned series of change initiatives.

In Singapore, the Construction 21 (C21) committee put forth 39 recommendations under six strategic thrusts to help achieve the vision of the industry, which is "To be a world class builder in the knowledge age" (Figure 1). The strategic thrusts were: (i) enhancing the professionalism of the industry; (ii) raising the skills level; (iii) improving industry practices and techniques; (iv) adopting an integrated approach to construction; (v) developing an external wing; and (vi) a collective championing effort for the construction industry. The C21 study aimed to transform the construction industry in Singapore from a Dirty, Demanding and Dangerous (3D) to a Professional, Productive and Progressive (3P) industry. Hence, C21 seeks to upgrade all aspects of the construction industry, from processes (improving practices and techniques as well as adopting an integrated approach to construction) and players (professionalising the industry and raising skills levels of construction workers) to the products of the industry (improving construction quality) (Construction 21 Steering Committee, 1999).

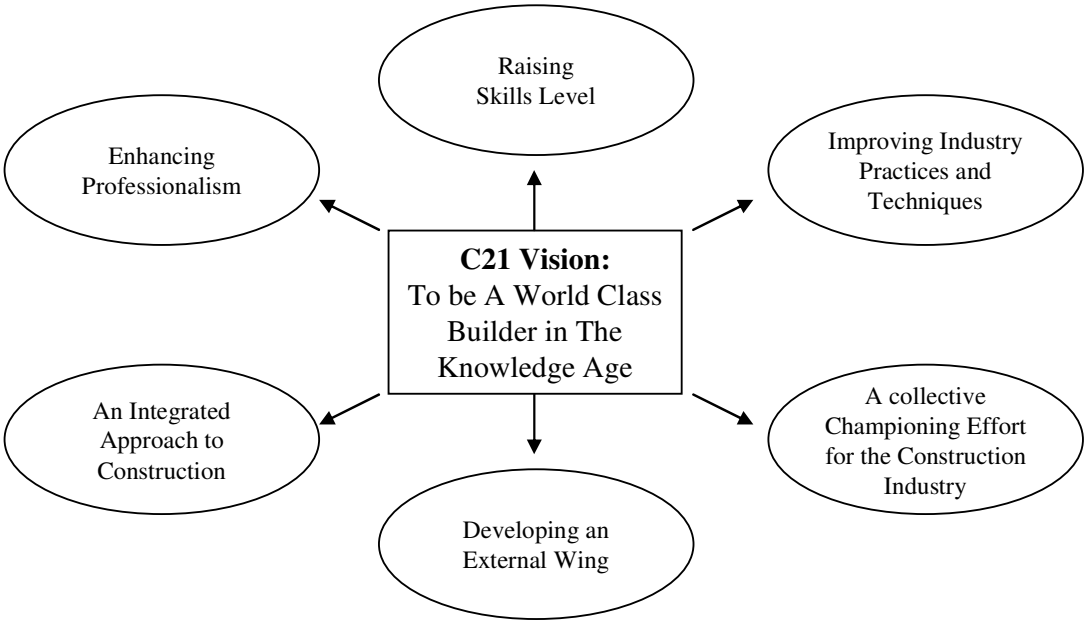


Figure 1*: The six strategic thrusts and vision of C21*
Source: Construction 21 Steering Committee, 1999

The C21 report has served as the blueprint for developing Singapore's construction industry. It has encouraged the adoption of a range of progressive practices and formal assessments, including Information and Communication Technology (ICT) adoption, greater consideration of buildability and quality during both the design and construction stages, and greater recognition of Continuing Professional Development (CPD). Construction and Real Estate Network (CORENET) is regarded by many as the most successful achievement of C21; it has led Singapore to be ranked the first in the world in the ease of doing business (International Finance Corporation, 2008).

Although most of the C21 recommendations have been implemented, by around the middle of the ten-year period set out for the implementation, the programme was losing some

momentum, with meetings to discuss progress becoming rather routine (Ang *et al.*, 2004). Some of the C21 initiatives and programmes have not succeeded. These include the promotion of Design and Build (D&B) and the intention to reduce the number of foreign workers in the construction industry by imposing stricter controls on the number of such workers (see Dulaimi *et al.*, 2003). As the programme was drawing to the end of its planned period of implementation, it was considered to be pertinent to assess its achievements and the continuing challenges facing the industry. The results of such an assessment would provide the basis for making proposals for enhancing the performance of the industry over the next decade.

This paper presents the results of a research project undertaken to examine the implementation of the C21 initiative in Singapore from 1999 to 2009. The study is founded on a review of the literature on industry development in Singapore (which formed the basis of a set of interview questions), and a series of interviews. Nine in-depth, face-to-face, interviews were conducted in late 2009 with 12 key people from the public and private sectors of the construction industry (Table 1).

INTERVIEWEE	POSITION	ORGANISATION TYPE
1A 1B	Director Deputy Director	Government
2	Executive Director	Consultancy firm
3	President	Professional body
4A 4B 4C	President and Chief Executive Officer (CEO) Executive Vice President Executive Vice President	Consultancy firm
5	Chairman	Consultancy firm
6	Past President	Professional body
7	General Manager	Developer
8	Executive Director	Trade association
9	Deputy Director	Government

Table 1: *Profile of interviewees.*

THE CONSTRUCTION 21 STUDY

The general perception from the interviewees was that each initiative under C21 has been followed up. There has been a major improvement, although a radical transformation as envisioned by C21 has not been achieved. According to Interviewee 1A, *"What had to be done, has been done. What was not undertaken back then in the initial stages (i.e. export promotion and research) has been done."* Interviewee 8 acknowledged, *"The report card on C21 would be a decent one because everything that can be done has been done. In many cases, they went beyond what was proposed."*

In terms of the transformation from a 3D to a 3P industry, in general, the interviewees agreed that the progress has been attained in the industry, but it had not been as much as had been intended in the C21 report. For example, the industry continued to depend on subcontracting and foreign workers. Interviewee 2 commented: *"Because of our system and dependence on foreign workers, you don't get the image of professionalism. Safety is still a concern because many foreign workers, who do not get proper training, do not understand dangers before they work on the site."* In Interviewee 4C's words, *"We are trying to achieve first world standards*

using third world workers." The reliance on subcontracting was not viewed as a problem; it has always pertained in Singapore, and is an integral part of the structure of the industry. The aspect which has been considered to be undesirable is the common phenomenon of multi-level subcontracting. Interviewee 4A noted, *"In Singapore, trade contractors do the bulk of the work. Hence, reform must go to that level, instead of focusing on the main contractors."* However, according to Interviewee 1A, the recent green initiatives have given opportunities for the industry to have a more positive image.

STRATEGIC THRUST 1: ENHANCING THE PROFESSIONALISM OF THE INDUSTRY

To achieve the vision to become a world class builder and to change the image of the 3D industry, the C21 report pointed out that the professionalism and capabilities of industry practitioners must be raised. The professional institutions have responded to the C21 recommendation by making CPD compulsory as a pre-requisite for renewing the practicing certificate. However, it is important to strike a balance. As Interviewee 2 explained, *"If you enforce it strictly, you may lose some members, but gain some respect as an institution."* Interviewee 6 noted that CPD may be more effective for certain professions than others; for example, it is more effective for architects than it is for quantity surveyors.

At the industry level, the development of CORENET has been influential in the business process reengineering of the construction industry. Furthermore, CORENET is inspiring similar developments in other countries. Singapore has been the top-ranked economy globally on the ease of doing business by the World Bank (International Finance Corporation, 2008). CORENET has been highlighted as one key reform that sped up the process for dealing with construction permits, reducing the time from 102 days to 38. Almost 99 percent of applications are now submitted electronically through the CORENET. According to Eastman *et al.* (2009), the Singapore effort in building code checking was the earliest, most mature and the farthest along. The interviewees agreed that CORENET has been the most significant achievement of C21.

C21 recommended that all contractors, including sub-contractors, be licensed to influence their standards and professionalism. To be licensed, firms must be financially sound, have good safety records, and employ qualified and experienced personnel to manage the firm and supervise its construction works. It took nine years after C21 before the contractor licensing scheme was launched. According to Interviewee 8, who was involved in the process of development and consultation, there had to be a lot of compromises along the way.

C21 recommended that an industry-wide code of conduct spelling out industry standards with regard to the working relationships among the various players be developed. The interviewees disclosed that the codes of conduct were drafted, but they have not been implemented because according to Interviewee 2, who was involved in the drafting process, the codes were too general and so they were considered to be unnecessary. Interviewee 6 noted that the development of the industry-wide code of conduct is very unreasonable. It is not possible to enforce it if there are no sanctions, while regulation should not go to that extent.

In summary, the professionalism of the industry has been improved. New awards have been created, incorporating key points from previous ones. There are now many new degree

programmes to meet the needs of the industry; however, a number of interviewees have expressed their concerns on the quality of the curriculum and graduates. CPD has become mandatory for some professionals in the industry. There is scope for further progress. Interviewee 4A noted, *"If you want professionalism, then you must downplay regulation, or have regulation with a lighter touch, and allow peer pressure to raise standards. We can say that professionalism has been achieved when the industry does the right thing without too many regulations."*

STRATEGIC THRUST 2: RAISING THE SKILLS LEVEL

Given its small geographical size, Singapore faces many physical limitations including the size of its population. The situation is worse in construction because, owing to the poor image of construction, the industry is unable to attract many Singaporeans. Thus, over 80 percent of the industry's workforce comprises foreign workers. There has been a set of initiatives and incentives to increase the proportion of skilled workers in the construction workforce. These include controls on the number of foreign workers; minimum training requirements for foreign workers before they are admitted into Singapore; and requirements for the employment of a resident engineer and a safety manager on each building project based on the value of projects.

The Man-Year Entitlements (MYE) system allows contractors to employ a maximum number of foreign workers for a specific project volume. To reduce reliance on foreign workers, the C21 report recommended that the MYE for projects should be tightened to 70 percent by 2005 and 50 percent by 2010, or earlier if practicable. The formula for calculating the MYE has since been adjusted a number of times in response to feedback from the industry (Ministry of Manpower, 2010). The interviewees agreed that MYE has not been an effective tool in addressing the supply of workers. Unexpected practices have developed, which gave an impression that the MYE is still at a comfortable level for the contractors.

The issue of foreign workers is the main concern for many interviewees. They highlighted the cultural differences, transient nature of the workers, hidden costs, skills, safety, and support from the government for the workers. There was a general feeling that the industry cannot do without foreign workers. Hence, the policies should be directed at integrating them into the industry. Currently, all incentives are intended to increase the number of locals joining the workforce. However, the interviewees felt that as it has been increasingly difficult to find Singaporeans who are willing to join the construction industry, the government should be more realistic and provide support for the foreign workers.

STRATEGIC THRUST 3: IMPROVING INDUSTRY PRACTICES AND TECHNIQUES

Enhancing Buildability

In Singapore, the concept of "buildability" is promoted for construction practitioners to take account of productivity during the design stage. The principles are: (i) standardisation – repetition of grids, sizes of components and connection details; (ii) simplicity – use of uncomplicated building construction systems and installation details; and (iii) single integrated elements – those that combine related components together into a single element that may be prefabricated in the factory. All new building projects with gross floor area

(GFA) of at least 2,000 sqm, are required to meet the minimum buildability scores. The total buildability score of a design is obtained by summing up the scores of the Structural System, the Wall System, and Other Buildable Design Features. The score is subject to a maximum of 50 points for the structural system, 40 points for the wall system, and 10 points for other buildable features. The maximum score that can be achieved is 100 points. The minimum buildability scores have been increased progressively over time. They were last adjusted with effect from 1 August 2008. The building designs were required to meet prescribed minimum buildability scores ranging from 60 to 77, depending on the building type. The C21 report noted that government intervention is required to achieve higher buildability.

The interviewees agreed that due to the increase in buildability scores, productivity has improved, but there is room for improvement. The policy on buildability has moved towards constructability. The most recent scheme to boost productivity is the Construction Productivity and Capability Fund (CPCF), which was launched in 2010 as part of the national drive to increase productivity. The government set aside S$250 million in the fund to help the construction industry to raise productivity. The fund, administered by the Building and Construction Authority (BCA), comprises incentive schemes to promote workforce development, technology adoption and capability development. It is still too early to assess the effectiveness of the schemes under the fund. The BCA has been actively promoting the schemes and the response from the industry has been encouraging.

Enhancing Maintainability

The C21 report recommended that a study be undertaken to devise a system that can be used to audit maintenance costs and produce manuals which give the design life and maintenance costs of components. A study, "Maintainability of Buildings" (NUS, 2005), an initiative of the BCA and the National University of Singapore (NUS),. aims to study the maintainability issues of various categories of buildings under tropical conditions. The research spearheads the incorporation of maintainability into processes right from the design stage by improving the knowledge of maintainability and setting maintainability benchmarks. The study developed a defects library, a materials manual, and a maintainability scoring system. Although the research results and findings have been disseminated through dialogue sessions, workshops, seminars, and publications, the interviews revealed that the results are not widely used in the industry.

Quality

The quality development programme is one of the BCA's key long-running initiatives. The Construction Quality Assessment System (CONQUAS) was developed to assess the quality of building work to provide a standardized, quantifiable, and systematic assessment system for grading the construction quality of a building (Construction Industry Development Board, 1995). CONQUAS sets out the standards for the various aspects of construction work and awards points for works that meet the standards. The points are then summed up to give a total CONQUAS score for the building project. Over the years, reviews have been carried out and key changes have been introduced to CONQUAS, considering industry concerns and end-user feedback. The average CONQUAS score has risen steadily (Figure 2). The C21 committee has set a target CONQUAS score of 79 by 2005 and 82 by 2010. In 2005, the average score was 80.6, above the target score of 79. In 2009, the average score reached 82, which was the target score to achieve by 2010. These figures are in line with the consensus among the interviewees that the quality of construction has improved.

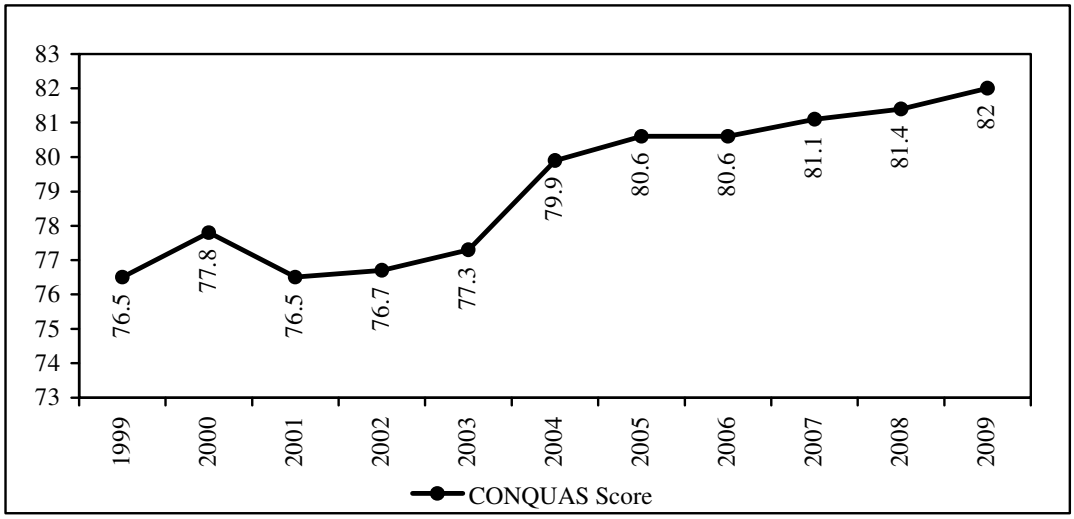


Figure 2: *Average CONQUAS score, 1999-2009*
Source: BCA (2002, 2006, 2008, 2010)

The formulation of a set of National Productivity and Quality Specifications (NPQS) was one of the recommendations of the C21 report. The NPQS is a set of standard specifications for building projects, which covers architectural, civil and structural, and mechanical and electrical works. NPQS aims to harmonise the specifications utilized in the building industry and provide a standard platform for achieving greater efficiency and quality in design and construction. Target users of the NPQS are developers, architects, consulting engineers, contracting companies, quantity surveyors, and suppliers y. It was launched in May 2004. The NPQS has not been pervasively used in the industry. Hence, there have been efforts to improve it. The NPQS is currently being revamped.

Health and Safety

The C21 report recommended the introduction of the Construction (Design and Management) Regulations after the enactment of the Occupational and Safety Health Act (OSHA) in 2000/2001. The new Occupational Safety and Health (OSH) framework was introduced on 10 March 2005. It was guided by three basic principles: requiring all stakeholders to eliminate or minimise the risks they create, instilling greater ownership of safety and health outcomes by industry, and preventing accidents through higher penalties for poor safety management (MOM, 2008). The Workplace Safety and Health Act (WSHA), which came into effect on 1 March 2006, is an essential part of the new framework. In the WSHA, general duties are prescribed for owners, occupiers, employers, designers, suppliers of machinery, equipment and hazardous substances, and individual workers. This is consistent with the principle of holding accountable those who create risks or have primary control over these risks (Joint MND-MOM Review Committee, 2005).

The MOM has been working closely with the Workplace Safety and Health (WSH) Council to improve WSH performance in Singapore. One area that they are working on is to develop the Construction (Design and Management) or CDM Regulations based on the UK's CDM Regulations. The regulations will require designers to work closely with contractors in thinking through safety management for the entire life-cycle of a project.

Implementing WSH 2018 for Construction Sector in Singapore (WSH Council, 2010) was published in April 2010 as part of the national WSH 2018 strategy. It sets the targeted outcomes, key strategies and initiatives to further enhance WSH standards in the construction sector and aims to guide all stakeholders to create a safer and healthier construction sector with a progressive and pervasive WSH culture. Its long-term goal is to achieve zero injury in the construction industry. Currently, the accidents in the construction sector by fatality rate and by injury rate are higher than those in other sectors (WSH Council, 2010).

The interviewees acknowledged the progress on the safety regulations. However, despite the extensive regulations on construction safety, Interviewee 2 believed that it is the mindset of the developers, project managers, and contractors that should be changed. Emphasis should also be placed on the lower levels, such as the supervisors and workers. Teo and Phang (2005) found that contractors understand the importance of a safety culture but do not have the right mindset or attitude towards implementing it. Interviewee 2 felt that Singapore construction still lags behind its comparable counterparts in terms of safety. He commented, *"In terms of safety, we are just two or three only on a scale of one to ten, considering where we've started from - zero."*

Stepping Up Research and Development

The C21 report recommended the establishment of a National Construction Research Institute (NCRI) to co-ordinate construction research and development (R&D) within five years after the publication of the report. The government's response to this recommendation was that it would consider it at a later stage. Hence, the proposed central body of construction research has not been set up. Research remains segregated in the industry. R&D activities are conducted separately or jointly by public agencies, companies and tertiary institutions. Research in construction has been encouraged by the Ministry of National Development (MND) Research Fund for the Built Environment, administered by the BCA under which S$50 million has been set aside for research during 2008-2013 (BCA, 2009).

Improving Construction Management

The C21 report recommended the development of a generic Construction Management System for all contractors and subcontractors and use appropriate incentive schemes to assist adoption of the system. In response to the recommendation, the Construction Productivity Benchmarking System (CPBS) was developed to help contractors to measure productivity and benchmark their performance against those of their competitors (*Framework*, 2001). CPBS is an IT toolkit comprising a smart card for identification of workers, Personal Digital Assistant (PDA) which acts as a tracking device and a desktop computer for generating reports. It enables contractors to analyse manpower usage, determine how activities are being performed on site, identify work patterns, as well as improve communication within the project team and with the head office. A web-based application for the Construction Management System was completed in 2004, but did not take off in the industry.

The C21 report also recommended the development of a pool of supervisors trained in proper site management and safety procedures to ensure high productivity and safety levels. The BCA Academy, the training arm of agency, offers certification courses for supervisors in the areas of precast concrete construction, waterproofing, and geotechnical instrumentation. It also offers safety courses for supervisors, on metal scaffold erection, formwork, co-ordination

of work, recognition of hazards in deep excavation temporary retaining structures, and general building construction.

The intention to minimise modifications to the standard forms of construction contracts for the private sector has not been realized. Many of the professional institutions has its own standard of contract. The interviewees agreed that there should be only one basic form. As Interviewee 4A noted, *"Everyone protects their own thing. That's all right but we need a uniform idea of what is a reasonable risk transfer."* Although there have been attempts under the umbrella of the Construction Industry Joint Committee (CIJC)t o unify the contracts in the, not much has been achieved. Interviewee 5 observed, *"It's a hugely end-user driven thing. Partly because there's no costing of the extra fees and other work. Our industry needs to mature to the point that architects and engineers must be allowed to charge for the extra work because of client's changing his mind."*

STRATEGIC THRUST 4: AN INTEGRATED APPROACH TO CONSTRUCTION

The construction industry is highly fragmented but the approach to construction is changing. The C21 report acknowledged that the development of more complex intelligent buildings, the demand by clients for greater responsiveness, guaranteed cost and delivery schedules of projects, and the push for greater efficiency, have increased the need to integrate the processes and roles of the various players. The C21 report recommended that BCA continue to promote D&B to private-sector developers.

The C21 report also recommended that the BCA undertake a comprehensive review of the Architects Act, Professional Engineers Act and Building Control Act to facilitate D&B arrangements. Following the amendments, with effect from 2003, D&B services can be offered by providing a single point of contact for the client. Moreover, the industry will have more choices of D&B arrangements. An architect or professional engineer can offer D&B without tying up with a builder's firm. Builders can offer D&B packages jointly with architects and professional engineers. Licensed corporations can also offer D&B services.

Despite the push from the government, there has not been much change in building projects. There seems to be lack of willingness of the parties involved in a D&B project to compromise. Among the issues cited are: the reluctance of architects to give away some of their 'traditional' control on projects (Interviewees 1A and 5); the small number of enlightened contractors which were willing to increase costs and let architects improve the design (Interviewee 4B); and the limited number of contractors which were capable of handling D&B projects (Interviewee 5). As reiterated by Interviewee 1A, D&B is used more on civil engineering projects than on building works. Interviewee 6 noted that D&B is only one type of many procurement methods, and it may not be appropriate for certain projects. In summary, the interviewees agreed that the use of D&B should be decided by the market; it should not be pushed by the government.

The interviewees agreed that the formation of multi-disciplinary firms which had been encouraged by C21 did not take off in the industry. They noted that some design firms have grown and added areas to their initial expertise, but they remain consultants. Similarly, contractors remain as they were. Consultants and contractors tie up in consortia to undertake some projects overseas (see below), but they do not form multi-disciplinary firms.

STRATEGIC THRUST 5: DEVELOPING AN EXTERNAL WING

One of the recommendations in the C21 report was that BCA should assist construction companies and consultancy firms to venture abroad. Despite the government's response which indicated that the emphasis should be given at a later stage and that BCA should focus on improving the domestic construction industry, the BCA launched an export promotion drive, which included the establishment of Export Digest, Export Link Services, workshops, seminars, overseas mission trips, and executive programmes (Framework, 2002, 2003a, 2003b, Pillars, 2008).

In general, Singapore-based architects have done quite well abroad. The contractors feel the need to go overseas, especially when there are fewer jobs in Singapore. In late 1990s and early 2000s, the depressed local market spurred firms on to seek opportunities abroad. From 2004 to 2009, except in 2008 when the global recession dampened construction demand, Singapore construction and engineering firms clinched more than S$2 billion worth of construction contracts each year (Figure 3). A number of consortia have been set up to pursue projects overseas. Several of these have been facilitated by the BCA.



Figure 3: *Construction exports, 2001-2009*
Source: BCA (2006, 2008, 2009, 2010)

STRATEGIC THRUST 6: A COLLECTIVE CHAMPIONING EFFORT FOR THE CONSTRUCTION INDUSTRY

The C21 report recommended that BCA should adopt the role of a champion agency for the construction industry and oversee the implementation of the C21 recommendations. The role of BCA as the champion agency in the efforts towards achieving the vision of C21 is significant, considering that BCA was appointed as the lead agency for 19 of the 39 recommendations set out on the C21 report. BCA has since steadily worked with the other relevant public agencies, professional institutions and trade associations, and universities to implement the recommendations.

The C21 report also recommended that BCA work in partnership with the CIJC to implement the C21 recommendations and develop the industry. Thus, the government encouraged and supported the formation of the Construction Industry Joint Committee (CIJC) in 2000 to formalise the co-operation among the key organisations in the construction industry. CIJC embraces clients, various design professionals, and contractors.

The interviews revealed that BCA has actively monitored and followed up on the list of C21 recommendations. BCA held quarterly meetings with CIJC to track the progress of the implementation, in addition to *ad hoc* meetings. Feedback sessions with the industry were also conducted. Within CIJC, each member institution was assigned specific C21 initiatives to spearhead. However, it is widely realised that CIJC has its limitations. It acts by consensus, which gives each body an effective veto on initiatives (Interviewee 3). It is a loose grouping of institutions (Interviewees 2 and 5). There is no real leadership; instead, there is a rotation of its president among the members every year (Interviewees 4A and 5). Each organisation tends to protect its own interests (Interviewee 7). The interviewees considered the CIJC important, and agreed that it needs to be strengthened.

CONCLUSIONS

The construction industry in Singapore has evolved since the publication of the C21 report a decade ago. There have been new regulations and initiatives that impacted on the industry's practices. In the past decade, the adoption of a range of progressive practices in Singapore has been encouraged by C21. CORENET has been one of the most successful initiatives. In addition, there has been greater consideration of buildability; widespread adherence to the construction quality programme; and greater adoption of CPD programmes. However, a decade after the publication of the C21 report, some of the recommendations have not been implemented. Industry-wide codes of conduct have been drafted, but they were considered to be rather too general. In the area of construction safety, Construction (Design and Management) Regulations were still in progress. Some of the C21 initiatives and programmes have not succeeded. They include the intention to reduce the number of foreign workers, MYE, maintainability study, NPQS, Construction Management System, standardisation of contracts, and multi-disciplinary firms.

The study reported on in this paper is based on interviews of some of the leaders of the industry in Singapore who were instrumental in the formulation, implementation and monitoring of C21. Their opinions were compared with the literature as well as the comments and views expressed by others in both the public and private sectors. The interviewees agreed that through C21, Singapore has made a considerable amount of progress in developing its construction industry. However, it is evident that more needs to be done in the future. The intended radical transformation of the industry has not been attained. After a decade, some of the underlying issues remain the same. The extent to which the industry reforms have fulfilled their original intentions is not completely clear. The impact of the initiatives on the way companies and practitioners work is also not clear. Hence, there is a need to revisit priorities and review the progress so far and map out general strategies for the future.

Considering the nature of the construction industry in Singapore, there will be continued reliance on subcontracting and foreign workers into the future. Thus, long-term solutions are needed. Improvement in quality must be accompanied by sustainability considerations. It is evident that the focus in construction industry development in Singapore will be on

improving productivity as part of the national, economy-wide drive. The government is also aggressive in promoting health and safety, and this will be another major consideration. In the area of IT, Building Information Modelling (BIM) will be used as a platform to facilitate the integration of knowledge in design, construction, and facilities management.

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SUPPLY CHAIN SUSTAINABILITY – A RELATIONSHIP MANAGEMENT APPROACH MODERATED BY CULTURE AND COMMITMENT

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Abstract
This research explores the nature of relationship management on construction projects in Australia and examines the effects of culture, by means of Schwarz's value survey, on relationships under different contract strategies. The research was based on the view that the development of a sustainable supply chain depends on the transfer of knowledge and capabilities from the larger players in the supply chain through collaboration brought about by relationship management. The research adopted a triangulated approach in which quantitative data were collected by questionnaire, interviews were conducted to explore and enrich the quantitative data and case studies were undertaken in order to illustrate and validate the findings. The aim was to investigate how values and attitudes enhance or reduce the incorporation of the supply chain into the project. From the research it was found that the degree of match and mismatch between values and contract strategy impacts commitment and the engagement and empowerment of the supply chain.

Keywords: supply chain sustainability, relationship management, Queensland, culture, convergence.

INTRODUCTION

Relationship management is a system that provides a collaborative environment and a framework for all participants to adapt their behaviour to project (and longer term) objectives. It is about open communication which needs to be facilitated and nurtured. The, a 'sustainable supply chain' requires a clear relational strategy that takes into account individual values within the organisation structure (contract strategy in this case) and so empowers decision making, free communication and encourages relationship building.

Effective supply chain management enhances organisation performance and competitiveness through the management of operations across organisational boundaries (Giannakis, Croom, & Slack, 2004). Relational contracting approaches facilitate the exchange of information and knowledge and builds capacity in the supply chain, thus enhancing its sustainability. Relationship management also provides the conditions necessary for the development of collaborative and cooperative relationships. It is about open communication, sharing resources and experiences, exposing the 'hidden' risks in the project. However, subcontractors and suppliers are not empowered to attend project meetings or to have direct communication with project based staff (Dainty, Briscoe, & Millett, 2001). With this being a common phenomenon in the Australian construction industry, one might ask: what are the

barriers to implementation of relationship management through the supply chain? In other words, the problem addressed in this research is the engagement of supply chain through relationship management.

Relationship management is a business strategy. It is a system that provides a collaborative environment and a framework for all participants to adapt their behaviour to project objectives and allows for engagement with the supply chain. On the other hand, relational contracting is an approach. A relational contract tends to be of a fixed duration, with exchange of relations in light of opportunities for future cooperation among the contracting parties. After all, companies do not collaborate for the sake of collaboration. They would only engage in relational exchanges when the perceived benefits derived from these activities outweigh the cost incurred.

A contractual arrangement with strong relationship management, such as committed joint-venture or alliance, allows collaborative and cooperative attitude to develop between project participants. Project parties focus on the organisations' business future and aim for long-term success. The reason for this is a paradigm shift. Relational approaches assist and develop a collaborative and cooperative working environment where trust can be developed and this leads to community benefit and a sustainable supply chain.

Research Aim and Objectives

The aim of the research is to explore the association between relational contracting structures and processes and supply chain sustainability in the construction industry. The underlying principles which frame this research are relationship management, motivation values, culture and contract strategy. The objective of this research is to investigate perception of relationship management from a contractor's perspective and the impact of moving relational contracting down the value chain; thereby empowering and developing a sustainable supply chain.

Contract Strategy

Rowlinson defines contract strategy as being a subset of procurement systems (Walker & rowlinson, 2009; Rowlinson & McDermott 1998) and uses a typology consisting of seven key variables to uniquely define any particular contract strategy. One of the more important variables is organisation form and it is this dimension that is applied here in this research. Motivation values are context dependent and in construction the organisation form clearly distinguishes one project from another and, in some senses, demands more or less focus on relationship management as a consequence. For example, the degree of integartion inherently present in an organisation form can be represented in Figure 1 below. The common organisation strategies adopted in Australia in this research were:

Minor Works Contract (design then construct); Roadworks Performance Contract (RPC,design then construct); Road Construction Contract (RCC, design then construct); Road Construction Contract with Relationship Management (RCC(RM) design then construct); Design and Construct (design and construct); Early Contractor Involvement (ECI design and construct); Alliance (design, construct and maintain).

The number of such contract types in the research sample is shown below.

D&C (4)	Minor Works (8[a])	RPC (10)	RCC (10)	RCC (RM) (26)	ECI (10)	Alliance (30[a])

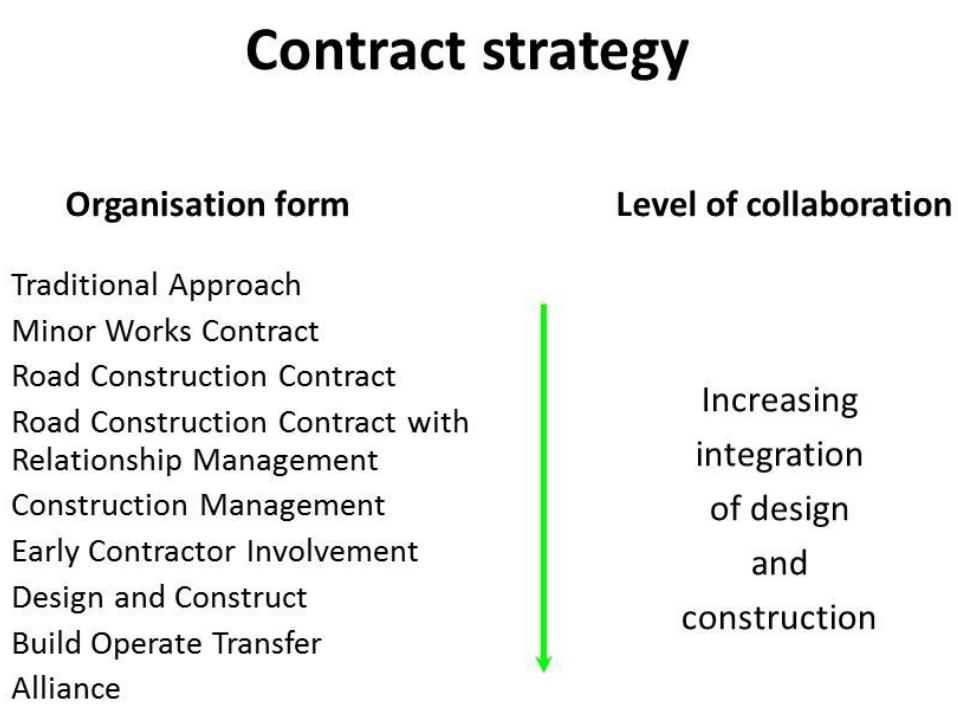


Figure 1: Contract strategy and collaboration potential

Relationship Management

There are many definitions of relationship management (RM). One of the most widely adopted definitions is Berry's description of RM as 'attracting, maintaining and – in multi-service organisations – enhancing customer relationships' (Berry, 1983, p.25). Grönroos (1996) describes RM as a process of managing the organisation's market relationships by which allows organisations to identify and establish, maintain and enhance and, when necessary, terminate relationships with customers and other stakeholders, at a profit so that the objectives of all parties involved are met through mutual exchange and fulfilment of promises (Grönroos, 2007) i.e. interactions and continuous improvement. Sheth's definition of RM reflects similar theme. Sheth (1994, p.2) describes RM as 'the understanding, explanation and management of the on-going collaborative business relationship between suppliers and customers' and companies must align their business processes to achieve higher level of efficiency and effectiveness when operating under a RM regime (Sheth & Sisodia, 2002). One common message is relationships are built on past behaviour and future promises.

In construction, the traditional hard-dollar procurement system can be seen to less suitable for today's complex construction environment, where rapid change and unanticipated decision situations are constantly encountered (Shirazi, Langford, & Rowlinson, 1996). One cause of this is that the construction industry is not unitary but comprises temporary multi-organisations (Murray, Langford, Hardcastle, & Tookey, 1999). While a pure mechanistic organisation form was appropriate for a completely stable environment (Winch, 2000a); for flexible and changing environments, an organic organisation form is much more suitable. The

project team changes its structure and organisation style in different phases of the project life cycle and hence is described as a 'living organism' (Sidwell, 1990). The project organisation is made up of members drawn from parent organisations. Sidwell also points out that all projects have a distinct life-cycle, the organisational forms change over time from chaotic to mechanistic to bureaucratic, depending on the project stage and the project team. For example, the consultant team tends to have a chaotic structure at the concept stage. Design and documentation is a more mechanistic process which then leads to the construction stage which involves heavy monitoring and a lot of bureaucracy. On the other hand, the contractor is likely to operate in an organic mode at the construction stage.
Relationship contracts are usually long-term, develop and change over time (Cheung & Rowlinson, 2007). Relationship management is a system that provides collaborative environments and frameworks for all project participants to adapt their behaviour to project objectives and allows for engagement of the supply chain. Relational approaches are particularly suited to the Australian culture, where open communications and direct confrontation are accepted and indeed preferred (Cheung, 2006a);such attitudes form a sound basis for relational approaches to be successful. This research seeks to explore the impact of values and attitudes on the success of the relationship management approach.

Key concepts for a successful relational contracting approach have been reported in recent studies (e.g. Cheung, 2006b; Dainty*, et al.*, 2001; Price, Bryman, & Dainty, 2004; Walker & Hampson, 2003). These studies identified empowerment, motivation, commitment, organisation structuring and culture as being significant in the implementation of a sound relational contracting approach to projects. Relational contracting approaches have received strong interest in the construction industry and the efficacy of relationship management in the client and contractor groups has been well documented. However, little research has been done in the supply chain context.

Studies suggest that relational approaches, such as partnering, alliances, framework agreements and relationship management, provide positive contributions to social, environmental and economic sustainability and help to satisfy client and stakeholder interests (Blau, 1963; MacNeil, 1978, 1985; Rousseau & Parks, 1993). In other words, relational contracts provide the means to achieve sustainable, on-going relationships in long and complex contracts by an adjustment process of a more thoroughly transaction specific, on-going, administrative kind (Kumaraswamy & Matthews, 2000). The essence of relationship management is also found in collaborative procurement. Collaborative procurement aims at engaging parties at all project stages; competitive bidding is no longer the only selection criterion for contractors and design consultants, as well as suppliers (Hughes*, et al.*, 2006). Also, some reliance is placed on the deliberate development of long-term working relationships which requires trust building. Another characteristic of collaborative procurement is the number of partners is limited. This is particularly crucial in countries such as the UK and Hong Kong, where multi-level subcontracting is a common practice.

The common aim of all relational contracts is to recognise and for strive mutual benefits and win-win scenarios between project parties in a long-term basis (Rowlinson & Cheung, 2003). Thus, relationship management places strong emphasises on collaborative relationships in the supply chain, proactive problem solving and open and honest communication between project parties; in other words, more collaborative working arrangements and sustainable practices. It is clear that relational contracting is predicated on a broader view of the procurement approach and requires clearly focussed contract strategies and strategic management; it implicitly incorporates supply chain engagement, essential if the performance indicators of

best value, community benefit and innovation are to be achieved. One of the main differences between relational contracts and traditional hard-dollar contracts is the problem solving mode where performance problems in relational contracts are solved in a more collaborative manner amongst project team members and senior management, without recourse to claims and litigation (Bresnen & Marshall, 2000a; Cheung, 2006b). In some cases, contractors would absorb extra costs in order to maintain good relationships with the client and increase the chances of gaining future business (Bresnen & Marshall, 2000a). After all, a partnering relationship between organisations is based on trust, dedication to common goals and an understanding of each other's expectations and values (Construction Industry Institute, 1991).

Commitment

Walker, Bourne and Rowlinson (2008) describe the connections between commitment and motivation using Allen and Meyer's theory (1990) and Maslow's theory (1970), as shown in 2. According to Maslow, human behaviour is controlled by both external and internal environments. Also, individuals have certain needs; these needs do not change in origin and are hierarchal in nature. One must satisfy lower level basic needs before recognises or pursues the next level in the hierarchy. As suggested by Walker *et al.* (2008), the strongest form of commitment is affective because it is 'want-to commitment' based on a motivation of self-actualisation and/or ego needs, and can move people to contribute beyond expectations.

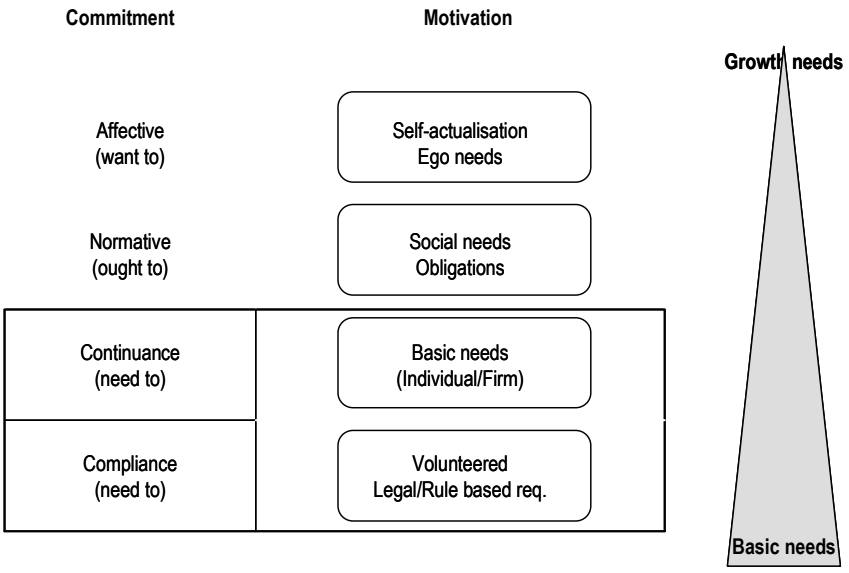


Figure 2: Commitment and Motivation
Source: Allen and Meyer (1996) and Maslow (1970) in Walker & Rowlinson, 2009

A relationship management approach cannot succeed if the collaborating organisations do not accept its ethos. Commitment is an important component of motivation (Meyer, Becker, & Vandenberghe, 2004). Hence, sharing values and being committed to the goals and objectives of the organisation is crucial in client, contractor and supply chain integration.

Values and Motivation

Cultures vary in their underlying values and attitudes (Wood, Wallace, & Zeffane, 2001). The way people think about such matters as achievement and work, wealth and material gain,

risk and change may influence how they view work and their experiences in organisations. Schwartz developed a value survey which examines individual motivational types of values and their goals. According to Schwartz (1992b), the meaning of a value can be inferred from its pattern of positive and negative associations with other values. Values '(1) are concepts or beliefs, (2) pertain to desirable end states or behaviours, (3) transcend specific situations, (4) guide selection or evaluation of behaviour and events, and (5) are ordered by relative importance' (Schwartz, 1992a, p.4). Thus, the meaning of a value is best captured by examining the structure of its relations with a comprehensive set of values thus providing insight into the development and consequences of a diverse range of behavioural attitudes and orientations, such as religious belief, political orientation and voting, social group relations, consumer behaviour, as well as the conceptualisation of human values across cultures. By comparing cultural value dimensions between different countries and regions/groups and, indeedworking teams and temporary multiorganisations, one can begin to understand the intercultural meanings in the project environment and so to establish effective relationships in project teams.

Relationship management is about a shared culture between organisations, where the motivation and attitude of the project participants is critical to success. Van de Ven and Ferry (1980) measure a whole series of organisational parameters including individual motivation, work processes and organisational structure. Winch *et al.* (1997) found autonomy at work, work coordination and work control along with job satisfaction, instrumental motivation and feedback as essential for enabling teamwork and individual motivation in construction projects. On the other hand, innovation, organisational commitment and motivation are strongly related (Khalfan & McDermott, 2006). Referring back to Figure , motivation is controlled by both internal and external environmental factors (Maslow, 1970) and is strongly associated with levels of commitment. It is important for construction organisations to be involved in the innovative procurement practices, such as relationship management, in order to take advantage of changes in markets. Financial reward might be a motivator for a client to build long-term relationships with other participants within the supply chain (Khalfan & McDermott, 2006). On the other hand, although money might be client's drive for relationship management, the supply chain might find further job opportunities and organisational competitiveness as attractive motivators for the initial buy-in

Motivation typology of Values

The motivation typology of values was measured with Schwartz Value Survey (SVS) (Schwartz, 1992b; Schwartz, 1994). Schwartz [Schwartz, 1992, 2005a] details the derivations of the ten basic values. For example, a conformity value was derived from the prerequisites of interaction and of group survival. For interaction to proceed smoothly and for groups to maintain themselves, individuals must restrain impulses and inhibit actions that might hurt others. A self-direction value was derived from organismic needs for mastery and from the interaction requirements of autonomy and independence. Each of the ten basic values can be characterized by describing its central motivational goal. The SVS measures values at both individual and cultural levels, using a 9-point Likert scale ranging from 1 to 7. Fifty-seven value items were clustered into 10 types of values using the statistical technique smallest-space analysis. The 10 values and their definitions are presented in 1 below.

Table 1: Definition of motivation values (adapted from Schwartz, 1994, p.22)

Motivational Types	Definitions
Power	Social status and prestige, control or dominance over people and resources
Achievement	Personal success through demonstrating competence according to social standards
Hedonism	Pleasure and sensuous gratification for oneself
Stimulation	Excitement, novelty and challenge in life
Self-direction	Independent thought and action – choosing, creating, exploring
Universalism	Understanding, appreciation, tolerance and protection for the welfare of all people and for nature
Benevolence	Preservation and enhancement of the welfare of people with whom one is in frequent personal contact
Tradition	Respect, commitment and acceptance of the customs and ideas that traditional culture or religion provide
Conformity	Restraint of actions, inclinations and impulses likely to upset or harm others and violate social expectations of norms
Security	Safety, harmony and stability of society, of relations, and of self

The 10 values are further grouped into four higher order value types: Self-Transcendence, Conservation, Self-Enhancement and Openness to Change, each containing two or three of the 10 values (3). Values under the same higher order value types are theorized to share similar meaning (Schwartz, 1994). For example, the value of benevolence is interrelated with universalism, conformity and tradition, constituting the higher-order value of self-transcendence. This value is considered to be opposed to and in tension with the value of self-enhancement; likewise openness to change and conservation.

Research approach

This research builds on the proposition that the values held by individuals will interact with their context, the type of contract strategy that they are working within, and thus affect motivation and performance and thereby supporting or interfering with the relationship management process by inducing either collaboration or conflict. Hence, the interaction of motivation values and contract strategy are investigated through statistical analysis of responses from individuals on 98 projects and the findings explained by reference to case studies and interviews undertaken during the study. Thus, the study has been triangulated but the data cannot be fully presented here due to space constraints.

The first step in the analysis was to check the scale reliability and validity, although Schwartz has argued (*op cit*) that his scale is universally applicable. The relationship between motivation values and contract strategy was then empically investigated and the results discussed with reference to the interviews and case studies.

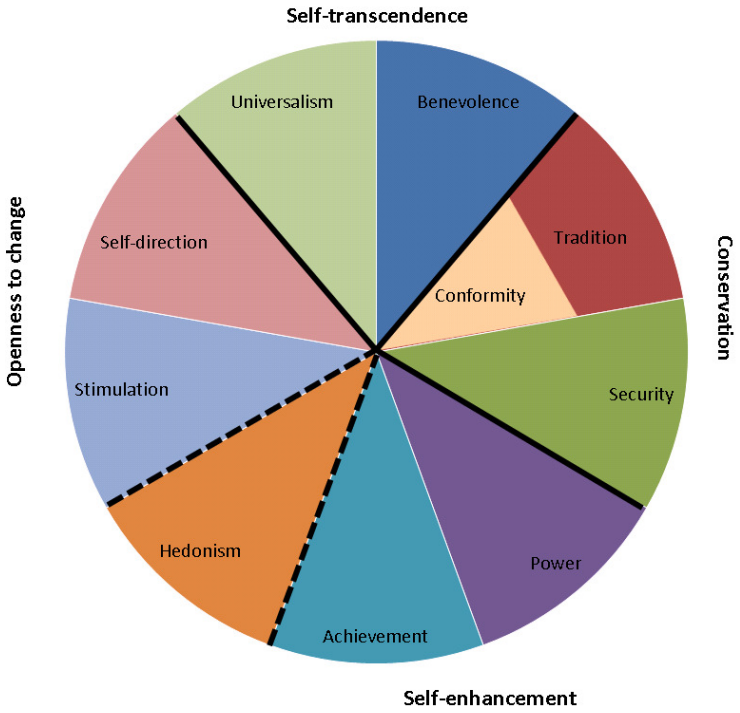


Figure 3: Value Types and Motivation Values (Schwartz, 1994)

Scale Reliability and Validity

Reliability analysis for the 10 motivation values was carried out. Out of the ten motivation values, *stimulation*, *tradition* and *security* have Cronbach's alpha less than 0.70, suggesting the items measured in these three values are not highly correlated and the value dimensions do not have high internal consistency.

Table 2: Scale Reliability and Validity - Motivation Values

Motivation Values	Cronbach's alpha	Motivation Values	Cronbach's alpha
Power	0.781	Universalism	0.786
Achievement	0.735	Benevolence	0.728
Hedonism	0.788	Tradition	0.597
Stimulation	0.627	Conformity	0.748
Self-direction	0.741	Security	0.619

Tables 2 & 3 and Figure 3 show the survey results of value dimensions of Australian construction professionals. The most important value for Australian construction professionals is *benevolence* (goodwill for work colleagues), followed by *self-direction* (independent thought and action), *achievement* (personal success) and *conformity* (self-restraint). Schwarz (2005a) states "Benevolence and conformity values both promote

cooperative and supportive social relations. However, benevolence values provide an internalised motivational base for such behavior. In contrast, conformity values promote cooperation in order to avoid negative outcomes for self." Hence, one might draw the conclusion that benevolence is an appropriate trait to display in promoting both relationship management and supply chain sustainability and that this appears to be a dominant value in the Australian construction profession sample. However, further analysis in relation to contract strategy is revealing.

Table 3: Mean, Median and Standard Deviation of Australian Professionals on the Subdimensions of the Schwartz Value Survey

	Mean	Median	Standard Deviation
Power	3.227	3.250	1.307
Achievement	4.791	5.000	.935
Hedonism	4.367	4.333	1.307
Stimulation	4.483	4.333	1.075
Self-direction	4.822	4.333	1.075
Universalism	4.434	4.375	.834
Benevolence	5.147	5.200	.723
Tradition	3.545	3.400	1.066
Conformity	4.739	4.750	1.020
Security	4.639	4.700	.866

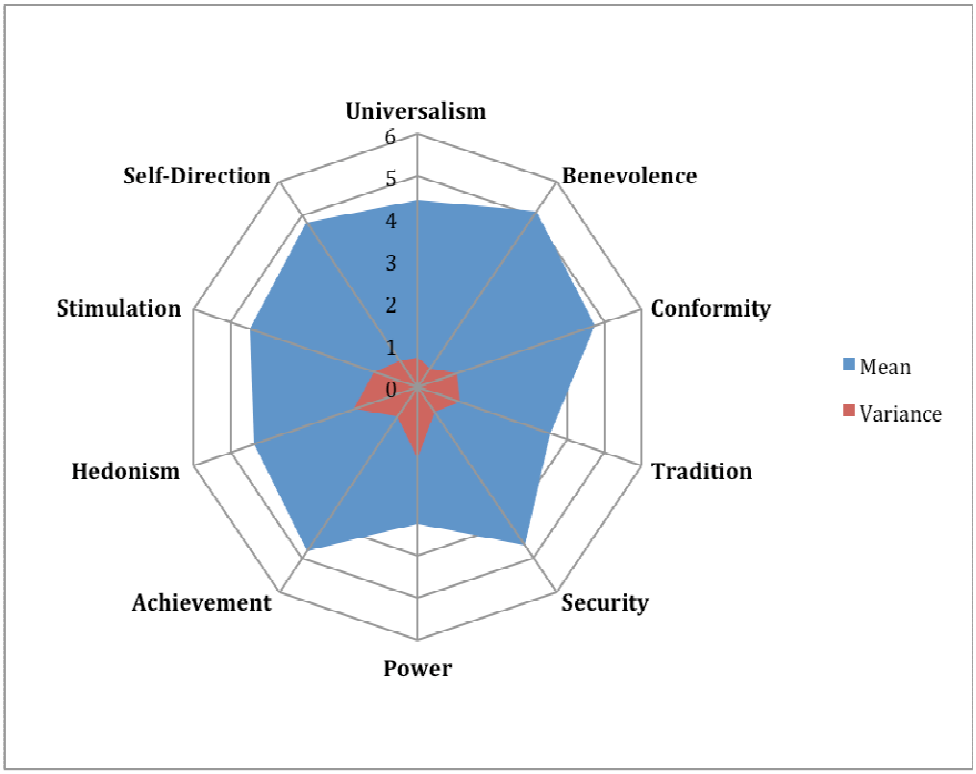


Figure 1: Australian Professionals' Value Dimensions

Motivation Values by Contract Strategy

Table 4 indicates that there is no significant variance difference in the mean motivation values, except *Self-Direction*, between each group.

Table 4: Test of Homogeneity of Variance - Motivation Values between Contract strategies

	Levene Statistic	df1	df2	Sig.
Security	.804	6	91	.569
Conformity	.482	6	91	.820
Tradition	1.336	6	91	.249
Benevolence	.178	6	91	.982
Universalism	.669	6	91	.675
Self-Direction	2.495	6	91	.028
Stimulation	.788	6	91	.582
Hedonism	.298	6	91	.937
Achievement	1.059	6	91	.393
Power	.604	6	91	.726

Results of ANOVA show how each of the motivation values varies with contract strategy as shown in Table 5. These result suggest that there is a significant difference in *Conformity* between different contract strategies (p<0.05). However, when sample sizes and variances are unequal, the Welch statistic is more powerful than the standard F or Brown-Forsythe statistics. The robust tests of equality of means suggest there is no significant difference in *Conformity*, but significant difference in *Self-direction* (p<0.05) between different contract strategies (Table 6). A post-hoc test was carried out to identify which groups are different. The test shows that RPC form is significantly different from ECI form, with a mean difference of -.980 and a p value of .037, with an *ES* of -.841. Self direction reflects independent thought and action and is exhibited in decisive actions such as choosing, creating and exploring

Table 5: Motivation Values by Contract strategies - ANOVA

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Conformity	Between Groups	13.580	6	2.263	2.357	.037
	Within Groups	87.374	91	.960		
	Total	100.953	97			
Self-Direction	Between Groups	8.254	6	1.376	1.921	.086
	Within Groups	65.181	91	.716		
	Total	73.435	97			

Table 6: Motivation Values by Contract strategies – Robust Test of Equality of Means

		Statistic[a]	df1	df2	Sig.
Conformity	Welch	2.353	6	22.049	.066
	Brown-Forsythe	2.399	6	40.095	.045
Self-Direction	Welch	2.851	6	22.179	.033
	Brown-Forsythe	2.060	6	43.773	.078

[a] Asymptotically F distributed.

Results on how *Self-Direction* may vary with contract strategy are shown in Table 7. Findings suggested there are significant differences in the degree of *Self-Direction* with different contract strategies (p<0.05). the post hoc test using Games-Howell reveals that professionals who work on RPC projects have significantly lower levels of self-direction than professionals who work on ECI projects. On the other hand, professionals from D&C, Minor Works, RCC, RCC (RM) and Alliance projects do not statistically differ in their level of self-direction.

Table 7: Motivation Values (Self-Direction) by Contract strategy

Motivation Value	**Contract strategy** (# of cases)							**ANOVA** (Welch)	
	D&C (4)	Minor Works (8[a])	RPC (10)	RCC (10)	RCC (RM) (26)	ECI (10)	Alliance (30[a])	df1, df2	F
Self Direction									
Mean	5.45	4.95	4.34	4.88	4.58	5.32	4.89	6, 22.179	2.85[#]
S.D.	.37	.40	.59	.76	.79	.25	.49		

DISCUSSION AND CONCLUSIONS

The finding that the motivation value of self-direction is strongly correlated with ECI projects is interesting and fits in with the notion that ECI involves both high degrees of collaboration and exploration of alternatives at a stage in the project process where ideas can be "tossed around" and solutions developed. When this is combined with the motivational value of benevolence this provides an ideal context for collaborative working and inclusion of the supply chain. This proposition is backed up from the case study and interview data. That the converse relationship exists for RCP (hard dollar contracts) is then no surprise with the focus being on delivering a set product for a fixed price with no scope for exploration nor any perceived need to include the supply chain. This was again backed up from evidence in the interviews.

From the questionnaire survey it was found, but not reported in detail here, that project teams with strong inter-organisational influences, easy access to information, strong personal acquaintance and frequent group communication are found to have good understanding of organisational structuring and communication. Principal Contractors and project stakeholder groups generally exhibited medium to high levels of consensus. When disagreements arose, the most frequently used resolution method was by directly confronting the issues. As expected, the more often professionals directly confronted issues, the less likely professionals were to avoid or smooth over issues.

Professionals communicated by telephone conversation mostly, followed by face-to-face discussions. Quality of communication between Principal Contractors and project stakeholder groups was found to be highly satisfactory. Findings suggest that good communication quality and strong personal acquaintance result in high levels of agreement. There was an fair degree of agreement between Principal Contractor and project stakeholder groups.

Findings indicate that alliance and Early Contractor Involvement (ECI) projects achieve higher performance effectiveness at short-term as well as long-term levels than projects with either no or partial relationship management adopted as a management strategy. The motivation values of self direction and benevolence were to be found in such project teams and, taking a context dependent view, were instrumental in bringing about supply chain inclusion and, hence, the prospect of sustainability.

Out of the four most important values indicated by Australian construction professionals, no significant relationship was found between *benevolence* and any organisation variables. On

the other hand, *self-direction* related significantly with level performance effectiveness, particularly the longer term view of the company's strategic direction.

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TOWARDS THE USE OF PROJECT ALLIANCE: JOINT DEVELOPMENT OF A TEAM SELECTION PROCEDURE AS AN EXAMPLE OF STEPS TAKEN

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Abstract

Project alliance is a relatively fresh project delivery method where the owner and service providers, the designer and the constructor, share the risks of the project in order to intensify their collaboration for the best of the project. Experiences from the model from "down under", where it has broken through, reached Finland some years ago. Since then, the Finnish Transport Agency (incl. its predecessors) has been intending to introduce the system in its transport infrastructure projects. The paper discusses related challenges and sheds light on an industry-wide joint effort and the progress made to date. In that respect, the development of the qualitative team selection process and criteria are presented in more detail. Moreover, the paper introduces the first two projects that are to apply the project alliance model: a rural rail renovation and an urban road tunnel construction one. The ambience generated by the efforts so far is promising, and it seems that all the parties look forward to taking up the practical work and seizing available benefits.

Keywords: project alliance, collaboration, selection criteria, shortlisting, competition

INTRODUCTION

Project alliance is a relatively fresh project delivery practice that has broken through especially in Australia and New Zealand. In project alliance the owner and service providers, the designer and the constructor, share the risks of the project and the payment to the service providers is tied to the overall success of the project. It is, first and foremost, a project delivery system for large, complex and risky projects. Success stories from the use of the project alliancing approach and news on related benefits reached Finland some years ago. Since then, various activities have been organised for the introduction of the delivery system also in Finland. *The Finnish Transport Agency* is the enthusiastic commissioner of the system and the first planned projects involve rail renovation and urban road tunnel construction that are about to start in the very near future.

This paper sheds light on the present state of the preparations for applying project alliance in Finland. After reintroducing the key ideas and principles of project alliance and how they reached Finland, the presentation focuses on the initial joint development between *the Finnish Transport Agency*, the industry and *VTT*. The development of qualitative team selection criteria is singled out for more detailed review as an example of steps taken so far. Finally, the paper proceeds towards the introduction of project alliance in practice by looking into the two transport infrastructure projects that are to be the first of this type in Finland. The procurement process for service providers has already started with one of the projects and will start later this year with the other.

AWARENESS OF PROJECT ALLIANCE

Features of project alliance

The concept of *alliance* refers generally to an association and agreement between actors aimed at integrating their goals and/or operations. An arrangement of the type made for a given project is called a *project alliance* or an *alliance contract* to distinguish it from so-called *strategic alliance* which is a collaborative arrangement covering several projects or other long-term activity.

More precisely, *project alliance* is a project delivery method based on a *joint contract* between the key actors to a project whereby the parties assume joint responsibility for the design and construction of the project to be implemented through a *joint organisation*, and where the actors *share* both positive and negative *risks* related to the project and observe the principles of information accessibility in pursuing close cooperation:

- *Joint agreement*. The tasks of an alliance include project planning and implementation tasks and (possibly) ones related to them and to the promotion of the project traditionally performed by the owner, which said actors are jointly responsible for. The parties enter into a single joint multi-actor contract instead of several bilateral contracts (different in spirit).
- *Joint organisation*. The alliance organisation comprises people from all partner organisations, including the owner's. Decisions on project implementation are taken jointly by the parties. The cost estimate covers all related tasks and persons. The project target cost is defined correspondingly and is consequently the total cost of the project.
- *Risk sharing*. Alliance partners share the risk of project implementation as concerns the bulk of both positive and negative risks. Thus, the reward of service providers is also based on the success of overall project implementation, not on their performance of their own tasks. The practice requires observing the principles of openness in cost monitoring.

In addition to these structural features, the collaborative features of trust, commitment and cooperation are of primary importance in project alliance (see e.g. DTF 2010).

The project alliance system evolved from the need to improve the implementation of demanding and risky investment projects. In a project involving much uncertainty due to, for instance, new technology and project conditions or interfaces, risk premiums and/or adversarial behaviour characteristics of traditional contracting would lead to an uneconomical result from the viewpoint of the owner. On the other hand, the alignment of the parties' objectives by joint risk-sharing in a project alliance arrangement, supplemented by a joint organisation and decision making, is supposed to improve the performance.

The rise of enthusiasm

The first few alliance-type construction projects were realised in Australia in the late 90's, and only a few years later the delivery system came to the Finns' notice in the connection of the reporting of international interviews on the procedures and performance of different road project delivery systems (Koppinen and Lahdenperä 2004, also Pakkala et al. 2007). Since then there has been growing interest for the model and the thing that finally set the wheels in motion was a fact-finding tour to Australia by a group of the former *Finnish Road Administration*'s representatives in the beginning of 2007. At that time, a real breakthrough in the use of project alliance had occurred in Australia and the number of cumulative experiences was already significant (cf. Anon 2009). So far, hundreds of projects have already been implemented by the project alliancing system. Except for very few social infrastructure projects, they have been civil engineering projects for road, rail and water infrastructure (Ross 2006, Anon 2009).

INITIAL DEVELOPMENT EFFORT

Joint development entity

The above mentioned fact-finding tour led to the launch of a sort of feasibility study on the application of project alliance in Finland (Lahdenperä 2009). The general challenge was to understand the possibilities of alliance-type procurement in increasing production efficiency, chart the procedural solutions for project alliances to the extent the approach has been used worldwide, evaluate the feasibility of the application of the procurement method in local Finnish (and European) culture and business and legal environment (e.g. Directive 2004b) and, particularly, develop project processes, procedures and ground rules to support the use of the project alliance in said application environment.

The development work built on a literature study and expert workshops. The several expert groups involved focused on different sections of the problem field. More precisely, there was a steering committee for the entire study and three separate subordinated thematic workgroups for cost estimation and the payment/incentive system, organisational and administrational issues, and selection process and criteria. The work of the last-mentioned group will be looked into in more detail below.

The groups consisted of a few dozen experts and practical actors from transport network owner organisations (the then *Finnish Road Administration* and *Finnish Rail Administration*) as well as numerous companies offering corresponding design and construction services. The groups met regularly to comment on and direct development work and ideate new procedural solutions. Several dozen such workshops and meetings were conducted during the one year team work period (the 2008 calendar year), and the time spent attending them corresponds to a few person-months of labour.

Workshop activity was speeded up by literature surveys and presentations as well as procedural constructions prepared in advance by researchers. Although an attempt was made to utilise existing knowledge to the fullest, the research approach is rather constructive as a whole due to the scope and multiformity of the problem. The aim is to test the workability of solutions through later application and further development. The wide participation in the development project also prepared and committed the markets so as to allow launching pilot or actual alliance projects as soon as possible.

All in all, development work focused on process engineering and basic contractual solutions that form a starting point for later preparation of project documentation. The workability of project alliance which stresses cooperation also requires heavy investment in cultural and management issues, which were excluded from the initial development work reported here.

Selection process and criteria development

The workgroup on the selection process and criteria met ten times during the year in an attempt to adapt the existing model to the target market. The legal praxis concerning competitive tendering in public procurement was, however, found a special challenge which is why it was considered that the implementer selection procedure that is based on competence (or quality) only, i.e. the most common one in Australia at the time, could not be introduced as such. On the other hand, there was the desire to avoid heavy competition involving design and total pricing. A comparison method applied early on that stresses competence while also considering (partial) price was thus heavily weighted in the work.

According to the general guidelines for government procurement, price should – roughly speaking – carry a weight of clearly more than one third when using relative weighting of criteria although, in the case of service procurement, exceptions are allowed (Hytönen and Lehtomäki 2007). The joint view of participating experts and practical actors is that price should generally carry a weight of no more than one fourth or so in project alliance. This is because better overall economy is pursued by putting together the best possible team of versatile know-how already at the stage when the implementation solution still can be influenced and improved. It also makes for more profound evaluation of qualitative factors than is the norm with other procurement methods.

Another impact of the European legal environment on the shaping up of the selection process was that when using the negotiated procedure or the competitive dialogue, at least three candidates must be invited to the tendering process unless there are fewer suitable candidates (Laki 2007a). Tender phase workshops are so laborious that it is generally not justified to invite more than that minimum number.

The development of qualitative selection criteria, on the other hand, started on a slightly more independent basis. A global survey (Lahdenperä and Sulankivi 2001) carried out a few years earlier offered a good starting point since it comprised all thinkable qualitative criteria for the selection. Through reclassification, combination and elimination the set of criteria summarised below was created. The material from the survey was also complemented with alliance-specific issues drawn from actual alliance owners' requests for proposals (e.g. VicRoads 2006).

The development of actual qualitative selection criteria was also constrained by the local environment. Courts are known to have intervened in cases where clear enough distinction has not been made between reducing the number of candidates and tender evaluation as concerns suitability criteria. Thus, qualitative criteria must evolve between these phases from evaluating qualifications toward evaluation of project-specific procedures although in the case of project alliance evaluation during both phases focuses on quite similar issues.

SELECTION PROCESS AND CRITERIA

Selection process

The procedure of competitive selection is established for the early involvement of service providers through a collaborative approach. Service provides are selected as a team; in other words, designers and builders are not selected separately and matched. According to the model, selection takes place through elimination of candidates and a subsequent two-phase tendering process: the qualitative tender precedes the workshops that are part of evaluation, followed by submission of tender price data. The price is made up of unit prices, overhead rates and other components as appropriate in each case (although the issue is too multifaceted to be discussed here). Then, selected service providers develop the project and its designs in cooperation with the owner before the actual target cost is set and the parties are ready to finally commit to the implementation of the project in question.

The phases of this process are shown in the middle of Figure 1. The elements on the left represent the key inputs of each phase and those on the right are the key results from the phases or a characterisation of follow-up work.

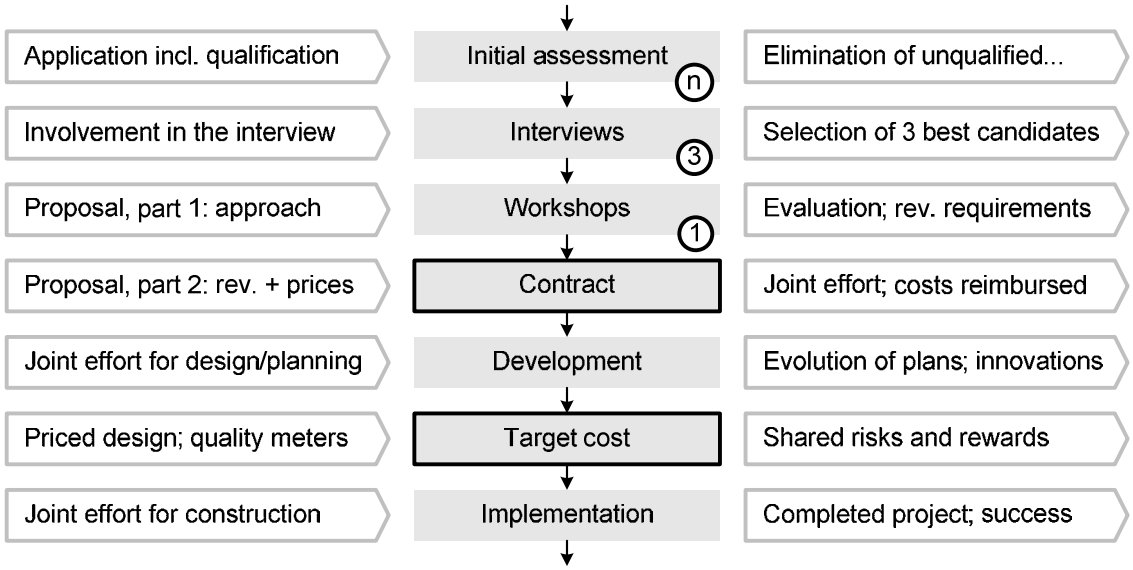


Figure 1: *Selection process with key input and output characteristics.*

Selection criteria

Overview

Different phases of the selection process for the implementer of the alliance contract use different criteria: at first minimum criteria concerning candidates are applied, followed by elimination (or shortlisting) criteria, and lastly tender evaluation criteria (Figure 2, Table 1). The meeting of minimum criteria (A) is evaluated on the basis of the request to participate, and that of elimination criteria (B) on both the request to participate and interviews. Tender evaluation has two phases. First, Part I of the written tender (C1–C3), submitted before the workshops are conducted, and the workshop performance of the tenderer's project group (C4) are assessed. After the workshops, Part II of the tender including price data (C5) is submitted as well as other information required by the specification of the call for tenders. The criteria are examined in more detail by phases below.

Verification of qualification

Application of minimum criteria ensures that candidates have the basic qualifications for successful implementation of the construction project in question. Minimum requirements include, for instance, that candidates have a transparent financial monitoring system suitable for cooperation as well as the required experience from design management and organising and implementing of projects involving design (Table 1, Section A). Candidates that meet the minimum requirements qualify and are invited to interviews organised by the owner. Candidates that fall short of the minimum requirements are rejected.

Reducing the number of candidates

Candidates meeting the minimum requirements are ranked according to their merits, initially on the basis of the requests to participate they submitted to the owner (Table 1, Section B). Candidates are also invited to interviews intended to clarify things already expressed in writing in the request to participate. On the basis of the interviews and the request to participate, the three best candidates are selected for the next round. These candidates receive the project's call-for-tenders material. The criteria used at this stage are the candidates' competence and technical capacity, proof of successful projects and planned project organisation.

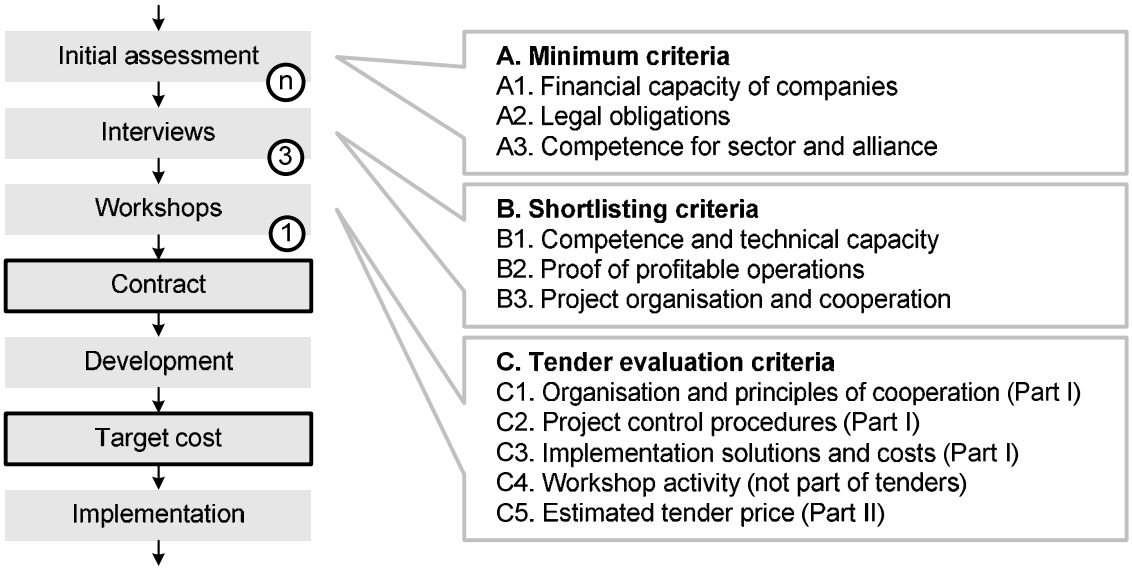


Figure 2: *Selection criteria headings combined with process phases.*

Selection of best tenderer
Evaluation of offers divides into two phases. The issues of the qualitative Part I (Table 1, Sections C1–C3) and workshop performance (Section C4) are evaluated first. At this phase, emphasis is on the suggested organisation and operating culture, project management procedures and implementation solutions and costs. After the selection workshop, the second part of the written tender, which contains the issues of Part I of the tender dealt with in the workshop and updated to the extent necessary, as well as Part II of the tender, that is, certain price data (Section C5), are submitted. The candidate that submits the most advantageous tender from the overall economic point of view is selected for negotiations.

Although both of the latter two phases of selection focus on the evaluation of the competence of actors, the general principle is that each selection criterion is used only in one phase of the selection process and the elimination-phase evaluations and corresponding scores of candidates are not considered as such at the tender evaluation phase. Naturally, the original project report (Lahdenperä 2009) describes in much more detail the process phases and tasks, selection criteria and the proof required by the owner of meeting the criteria.

THE WAY FORWARD

Pilot projects

Some time has now passed since the completion of the initial feasibility study described above. Appropriate transport infrastructure investment projects in which the model could have been applied were not found immediately thereafter. One reason for that was the need to immediately expedite some major projects as a part of the financial stimulus package launched to diminish the adverse effects of the global debt crisis. Although project alliance is generally the choice for demanding, urgent projects, it was not considered appropriate for those projects due to the significant amount of preparatory work and educational efforts that the first project of its kind would have required.

Table 1: *Selection criteria for service providers in project alliance.*

Selection phase >	Verification of qualification	Elimination of candidates		Selection of consortium	
Basis of evaluation >	Request to participate	Request to participate	Candidate Interviews	Tender (Parts 1 & 2)	Selection workshops
Selection criteria					
A. Minimum criteria					
A1. Financial capacity of companies	●				
A2. Legal obligations	●				
A3. Sector and alliance competence	●				
B. Elimination criteria					
B1. Competence and technical capacity		●	●		
B2. Proof of successful operations		●	●		
B3. Project organisation and cooperation		●	●		
C. Tender evaluation criteria					
C1. Organisation and principles of cooperation (Part I)					
• Alliance organisation				●	●
• Project management and operating principles				●	●
C2. Project management procedures (Part I)					
• Management of project quality and env. issues				●	●
• Safety management				●	●
• Risk management				●	●
C3. Implementation solutions and costs (Part I)					
• Technical approach to project implementation				●	●
• Budget critique				●	●
C4. Workshop activity (not part of tenders)					
• Commitment, attitude and cooperation of team					●
C5. Calculated tender price (Part II)				●	

An additional challenge was posed by the reorganisation of the owner bodies. *The Finnish Road Administration* and *the Finnish Rail Administration* were the owners involved in the earlier development, who soon thereafter merged with *the Finnish Maritime Administration*. Since the beginning of 2010 all three have operated as *the Finnish Transport Agency* (except for branch offices of the earlier *Road Administration* that are currently under *the Centres for Economic Development, Transport and the Environment*). *The Finnish Transport Agency* is a government agency operating under the jurisdiction of *the Ministry of Transport and Communications* and it is responsible for the maintenance and development of the transport system overseen by the government.

The search for the first projects where project alliance could be applied has finally produced a plan to adopt it at least in the two following forthcoming projects:

- *The Lielahti-Kokemäki rail section*. The section extends from the western boundary of the City of Tampere nearly 100 km towards the west. It is a replacement investment required by the decades old railway superstructure. Renovation of the superstructure to meet the standards of modern technology is a basic requirement for increasing the rail speed and axle loads of the section. In need of renovation are the rails, sleepers, crushed stone and gravel layers of the beds and switches. The project with a total cost of nearly €100 million also includes renovation of electrical, information and safety equipment as well as repair of bridges, culverts and platform areas.
- *The Tampere lakeshore road*. Arterial road 12 serves as a major entry road to the city as well as a through road for long distance traffic. Its current traffic volume is 30,000–45,000 vehicles/day and the road gets jammed regularly during commuting hours. Moreover, the 2+2 lane bypass road splits up the city. The aim is to bury part of the lakeshore road in two 2.3 km tunnels of three lanes in each direction, to widen the rest of it (along 3 km), and to connect it to the surrounding traffic network by graded interchanges. Besides the city infrastructure, the tunnels will also pass under the Tammerkoski Rapids, which traverse the city, at 20 metres below the river bed. The project is estimated to cost nearly €200 million.

The first rail project is by nature more of a normal reinvestment carrying no extraordinary risks or difficulties although it is a demanding project. Thus, it may not be ideal for implementation through project alliance. Yet, it was considered suitable as the first pilot project that would increase our experience since it might be too risky to start experiment with the most difficult projects. The road project is, by contrast, a challenging one. Tunnelling works involving all the junctions, temporary traffic arrangements and the stakeholder issues related to urban development surely pose a challenge.

The foreseeable future

As concerns the rail project, procurement of service providers for the planning and implementation of the project started in December 2010 by the publication of a procurement notice (Finnish 2010). In Finland procurement notices are to be submitted for publication on the free, electronic *Hilma* information system at *www.hankintailmoitukset.fi* as determined by *the Ministry of Employment and the Economy*. The aim is to select a project team in early autumn 2011 to start joint development of the emerging project alliance. Actual implementation would, thus, take place from 2012 to 2015. The road project will follow less than a year behind. Some uncertainty still exists about the road and urban plans becoming legally valid (at the time of writing in January 2011). Yet, the optimistic presumption is that the process can be expedited and it will catch up with the rail project so that the 3-year road construction project can also be launched in autumn 2012.

In connection with the preparation work related to service procurement for the rail project, two full day briefing and/or workshop events involving the industry were organised prior to the publication of the procurement notice in order to inform companies and discuss the procedures to be applied in the project. That prepared and committed companies to the forthcoming call and also gave valuable feedback to the owner.

To date, there are no signs that the selection criteria to be used in this project would essentially differ from those condensed in the paper. Naturally, the elaborateness and diversity of the practical criteria influence their format. However, the process differs more. Only a maximum of five teams can be selected for the actual shortlisting phase and two teams

for the subsequent competition phase involving price components and preceding the selection of the best team. The latter option is possible because the general law on public procurement (that requires at least three teams; Laki 2007a) does not apply to the rail sector whose procurements are controlled by a different law on special services sectors (Laki 2007b, Directive 2004a). The actual shortlisting phase including interviews takes places only after the candidate teams have submitted their proposals, and the workshops concern only the best two. This modification, for its part, illustrates the many possibilities for organising the alliance team selection. There is no 'one size fits all' process for all projects and situations.

The pricing arrangement will also differ from that of the feasibility study report (Lahdenperä 2009; not dealt with here). Although lawyers were involved in the initial development, only more recent legal consultations have encouraged the owner to depart from the use of the calculated/comprehensive tender price estimate as a selection criterion, and the price component is likely to be represented only by certain more restricted items (e.g. fee percentage). Therefore, the proper legal praxis concerning competitive tendering in public procurement, that was said to have been found a special challenge earlier, has not been established yet. Finland seems to have been more conservative (so far) in the application of the European directive and its economically most advantageous criterion than some other countries governed by the same directive.

Due to the simplified approach and the lack of price information at the time of selection, it is also not possible to apply the two-stage target-cost arrangement drafted in the feasibility study either. Yet, it is a concept (cf. Lahdenperä 2010) that needs to be examined further before it can be introduced in actual contracts. An effort to that effect is, however, likely to be included in the R&D project just about to start aimed at supporting the development of pilot project practices and more long-term alliancing solutions in general.

Final remarks

All in all, the aim is to take the further steps needed and utilise the project alliance model in Finland in the very near future. The key governmental transport infrastructure owner has committed itself to the model and the effort will be supported by considerable R&D efforts. Naturally, many practical challenges must still be met as we deal with indicative launch-phase views in this paper and its background material. It is also likely that views on the presented solutions will evolve as experiences are gained; as they have until now.

Anyway, the journey towards a more collaborative and, presumably, more innovative and efficient project protocol has started and you will soon be hearing more about Finnish project alliance solutions and experiences. Thus, stay tuned and be prepared for good news. Provided, of course, that the news from the other edge of the globe are true and the benefits can be seized to the same extent by the local stakeholders.

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TRACING RISK PATHS IN INTERNATIONAL CONSTRUCTION PROJECTS: A CASE STUDY

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Abstract
International construction projects are mostly known with poor cost performance. Their large sizes, multi-party environments, along with unfamiliarity of foreign firms with host country conditions create high chances of cost overrun and delay which lead to disagreements, claims and failures. Factors that result in cost overrun usually occur in the form of a chain of causally dependent events, each of which are either under the responsibility of one party, or shared among different project participants according to the related contract clauses. The diversity of the factors, namely global, country, company and project specific factors, increases the complexity of negotiation process between the project participants when cost overrun and delays occur in international projects. The major idea in this research is that cost overrun depends on causal relations between various risk sources (namely, risk paths) and sources of vulnerability that interfere with these paths. Using the data of 166 international construction projects and utilizing Structural Equation Modeling (SEM), a Risk-Path Model that represents the interactions among different risk and vulnerability paths is identified. In this paper, through a comprehensive case study, the complex risk emergence pattern in a real construction project is demonstrated.

Keywords: vulnerability, risk assessment, structural equation modeling.

INTRODUCTION

International construction projects are mostly known with poor cost performance [6, 7, 15]. Sources of cost overrun occur in the form of a chain of causally dependent events, each of which are either under the responsibility of one of the project parties, or shared among the parties based according to the related contract clauses. The diversity of these factors, namely global, country, company and project specific factors, is the other fact increasing the complexities of cost overrun negotiations, analysis, and estimations in international projects [13, 15, and 21]. Prediction of possible cost overruns and the influencing events, and formulating adequate mitigation and preventive strategies necessitate a comprehensive, proactive and systematic risk management process in international construction projects [4, 13, and 21]. Risk modelling is a critical step of risk management, however, as Han et al. [13] state, traditional methods are not adequate for modelling of diverse risks and complex interactions among risks in overseas projects. Cost-influencing risks should be identified in a way that is compatible to their emergence pattern in real construction projects, instead of

being studied as independent factors. The major idea in this research is that risk factors occur in the form of *interactive risk paths*, and that early identification, and documentation of such interactive causalities may enhance the accuracy of early estimates, and decrease the conflicts during negotiations over the occurred overruns. In this paper, utilizing Structural Equation Modeling (SEM), a Risk-Path Model that represents the interactions among different risk and vulnerability factors is presented and a detailed case study is discussed to demonstrate how the proposed model can be used to identify risk paths in international construction projects.

BACKGROUND AND LITERATURE REVIEW

Interrelations among risk factors

Various checklists, taxonomies and databases are developed to facilitate identification of factors affecting cost performance of construction projects. However, since cost overruns are affected by a combination of interdependent risk factors rather than sole effects of independent risks [9, 13, and 14], examining the interactions among different risk factors is necessary in real construction projects. Interactions among different risk factors and how these factors lead to cost overrun have widely discussed in literature. For example, Burati et al. [5] argued that adverse changes during design and construction phases are the main causes for further reworks which will finally lead to considerable cost overruns. Design changes are considered as the sources of cost overrun by other researchers like Sempel et al. [17]. Factors like design errors, increase in the scope of the work, and adverse weather conditions are also mentioned as main sources of cost overrun, which by itself is identified to be one of the major sources of claims. Investigating the causes of cost deviations in construction projects, Akinci and Fischer [1] have examined a number of possible causalities. For example, increase in the scope of the project is claimed to affect project cost overrun through increase in unit cost of work. Also, the ambiguities associated with project scope and client objectives are stated to lead to scope changes which are one of the main causes of cost overrun. Moreover, vague contract clauses are claimed to result in some disputes one of the outcomes of which will be cost escalations. Factors like, unknown geological conditions and bad weather conditions are considered as the main causes of changes in productivity and work quantity which will lead to delays and subsequent cost increases. As country specific factors, country economic conditions are stated to cause increases in unit cost rates that will lead to project cost overrun. In their cross-impact model, Han and Diekmann [12] have demonstrated a number of causalities affecting project cost performance. For example, low design quality is considered to lead to redesigns and subsequent scope increase and schedule deviations which will cause cost overruns. As country factors, political conditions are considered to affect government acts and regulations which may lead to variations in contract conditions and subsequent scope changes. Country economic conditions are assumed to affect the availability of the resources which will impact labour productivity and project cost performance. Country economic conditions are also considered to affect cost performance through inflations. Company related factors, such as managerial capabilities and resources, are considered to lead to delays and subsequent cost overruns. Makulsawatudom et al. [16] have studied the causes of low productivity as one of the reasons of time and cost overruns in construction projects. Factors such as lack of material, incomplete drawings, poor communication, inception delays, reworks, etc. are considered as the parameters directly affecting productivity. As a comparable study, Alinaitwe et al. [2] have identified lack of skills, reworks, poor construction methods, poor communications, inaccurate drawings, bad weather conditions, etc. as the major factors leading to decrease of productivity and subsequent time and cost overruns. Zou et al. [21] have considered factors such as design changes, disputes, price fluctuation of materials, and incomplete documents as the factors that

directly affect cost overrun some of which will have also effects on time overruns and decrease in quality of work. According to Alnuaimi et al. [3], client related factors, lack of national information, lack of experiences and skills, and country related factors are those leading to occurrence of change orders which will cause plan revisions and additional works that will subsequently result in time and cost overruns and disruptions. Sun and Meng [18] have identified factors such as inadequate managerial skills and experiences, bad weather conditions, unknown geological conditions, change in availability of resources, change in material cost, etc. as the causes of changes in construction projects. They mentioned extra works, rework, time loss, design revisions, decrease in productivity, etc. as the effects of occurred changes.

Problem Determination

In order for a realistic and accurate identification of risk scenarios and prediction of probable cost deviations, all of the aforementioned interrelations should be taken into account simultaneously. However, it is highly difficult, if not impossible, to consider all these dispersed interrelations without a systematic approach and a comprehensive risk model. Few studies have emphasized the importance of inclusive risk models that incorporate possible interactions, and the counter-effects among influencing factors. Han and Diekmann [12] argued that the existing risk models and analysis methods are inadequate since they are not realistic reflections of complex nature of existing risks in international construction projects. They propose the utilization of Cross Impact Analysis (CIA) method as an appropriate technique for analyzing the conditional probabilities of occurrence of various interrelated risk variables affecting project cost under high uncertainties. The integrated risk management system developed by Han et al. [13] is one of the most noticeable efforts in this regard. The notion of *risk path* is mentioned in this research and a scenario-based checklist that includes various causalities among risks throughout different stages of the project was developed. The SEM-based prediction model developed by Kim et al. [14] should be mentioned as one of the most recent efforts in this regard. The prediction capability of the SEM model, which comprises of a network of interrelated factors affecting project cost performance, is compared with that of ordinary regression analysis and Neural Networks. SEM is identified to show higher prediction performance mainly due to the fact that it considers the interrelations and complexities of the real case.

RESEARCH METHODOLOGY

This study is part of a larger research project whose ultimate objective is to develop a Multi Agent System (MAS) for simulation of argumentation-based negotiations among project parties, and for generation of a risk-sharing platform for the occurred cost overrun. At initial steps of the research, in order to develop the conceptual framework of the research, a number of case studies were conducted and cognitive maps demonstrating the risk emergence pattern of these projects were drawn. Examining these cognitive maps, the Vulnerability-Risk framework of the research and the notion of *risk paths* were generated [8]. Risk and vulnerability factors were identified and documented in a Vulnerability-Risk ontology-based database using data related to 75 international construction projects conducted by Turkish contractors in foreign countries [11]. A cost estimator agent is currently under development by means of Case Based Reasoning (CBR). In order to generate an independent agent supporting negotiator agents' arguments, a risk model comprising of a network of interactive scenarios was developed using SEM [10] . In this model, a total number of 82 vulnerability and risk factors are included as the model's observed variables. Using special features of SEM, 28 latent factors are identified to be indicated by these observed variables. The final

SEM-based Risk-Path Model includes a total of 36 interactive risk-path scenarios each of which deriving from one of the vulnerability sources inherent in project environment. Data related to 166 international construction projects are used for development of this model. The cross-impacts among risk paths are all estimated in a way that all are mutually significant at 5% level, and the whole model fits the data adequately.
SEM-based Risk-Path Model mitigates the aforementioned shortcomings of current risk models in that it possess a comprehensive and lifecycle look to the risk emergence pattern of projects by incorporating vulnerabilities, risk sources, risk events and risk consequences. Moreover, apart from considering causal relations among diverse risk factors, it includes the complex interactions among diverse risk-path scenarios. In this paper, a case study project will be given to demonstrate application of the SEM-based Risk-Path Model.

CASE STUDY

Overview of the project

A Bulgarian based company has awarded a contract for replacement and reconstruction of part of its power station. The scope of the project is defined as construction of circulating fluidized bed (CFB) boiler for an industrial power plant in Bulgaria. In 2006, as one of the subcontractors of this project, a Turkish company was engaged by the major contractor under four separate contracts. The first contract is the "Purchase Contract for the Delivery of Equipment and Steel Structure Fabrication and Delivery to the Site". This contract included manufacturing and delivery of steel structures, structural and miscellaneous steel, for Boiler Building, Silo Building, and for Crusher Building. The second contract is the "Subcontract for the Delivery of Erection works for Boiler Steel Structure". This contract included erection of steel structures, structural and miscellaneous steel, for Boiler Building, Silo Building, and for Crusher Building. The third contract is the "Subcontract for the Delivery of Boiler Erection". This contract included the erection of the boiler mechanical equipments/ components in accordance with the provided technical description. And finally, the fourth contract is an umbrella agreement entered into, in order to coordinate the three aforementioned contracts which are linked to each other. The total contract amount comprising of three initial contracts has been estimated about 7.5 million euro. The payment type of all contracts was lump sum. The works contracted to the Turkish company mainly included the fabrication of structural steel at a factory located at Turkey, followed by the delivery of fabricated material to the project site, and finally, erection of the boiler steel structure and the boiler itself.

In order to examine the initial vulnerabilities of the project, the problems and risks faced, and the occurred risk scenarios throughout the lifecycle of the project, one of the managers directly involved in all phases of the project, and in all of the claim preparation stages, was interviewed in separate sections.

Overview of the company

The firm under study is a Turkish company specialized in giving services in construction and steel structure fabrication. Since its establishment, the company have conducted diverse construction projects like power plants, refineries and petrochemical plants and civil works for both Turkish and international clients. In terms of fabrication, different products, ranging from heavy steel structures to many kinds of equipments, are being fabricated at the Steel Construction and Machinery Factory owned by the company.

The project that is going to be studied in this paper is the first experience of the company in Bulgaria. Although the technological complexity and the size of the project can be considered to be relatively low when compared with other projects conducted by the company in both domestic and overseas markets, the company faced lots of cost and time overruns, and numerous disagreements occurred among project parties. This project is used for examining the emergence pattern of risks that may affect performance of international construction projects.

Vulnerabilities of the project

Vulnerability sources representing the capacities, capabilities and characteristics of each project's environment are believed to trigger the occurrence of future risk scenarios. The vulnerability sources identified in previous stages of this research [8] and included in a Risk-Path Model [10] are examined for this project.

Design Problems:

This factor is mentioned as one of the most important and effective vulnerability sources of the project. The structural design of various elements of the project was contracted to another company located in a third country. The designer company, the manufacturing unit, and the erection team had to work in a highly coordinated manner since the design was not complete when the fabrication of the elements and the erection of the structures started. The drawings issued by the designer were to be sent to fabrications unit according to a predefined schedule. Then, the manufactured elements were to be sent to construction site in Bulgaria for montage and erection of the structure in accordance to the planned schedule. However, due to the lack of skills and experiences of the designer company in similar projects, and because of high levels of details and different types included, vast amounts of delays occurred in submissions of the drawings. These delays affected the planned schedules of both the manufacturing and the construction works. Due to the specific physical condition of the site (will be discussed in detail in subsequent sections of the paper), most of the activities have to be done in a finish-to-start pattern. That is, less parallel activities existed and most of the construction works had to be stopped in the case of significant delays in delivery of elements and equipments. Incomplete designs, late drawing submissions, the significant time losses in construction process of the project (approximately 1 year in some parts), and the loss of construction productivity, were some of the major subjects of the further disputes.

Existence of lots of design errors was the factor that affected the performance of the project more than late submissions. The structural elements were mostly unique, possessing different dimensions, shapes and technical specifications. Therefore, the elements fabricated based on such incorrect drawings became useless for other parts of the structure most of the time. The sudden escalation of steel price caused the additional costs of such wastes to substantially increase. The Turkish company faced problems like significant cost increase, negative cash flows, several reworks, decrease in productivity, and lots of time loss. For example, each type of the steel beams had holes and welds in different places with different dimensions that errors in specifying them correctly led to some additional work items such as 1) Additional holes were added, 2) Holes were removed, 3) Welds were added, 4) Weld were removed, 5) Dimensions were changed, and 6) Details were added.

Design revisions, most of which were sudden and without early notice, is the other factor having led to reworks, productivity losses, decrease in work quality, and further cost overruns.

Adverse Site Conditions:

One of the other most important vulnerability factors mentioned by the company representative is physical boundaries and working conditions prevailing the construction site of the project. The erection area at the project site was surrounded from three of its sides with the existing buildings. The erection works had to be started from the back side of the boiler unit which was adjacent to the existing building and had to be carried out from backward to the front direction. Moreover, the access to the erection area was only possible from the front side due to buildings surrounding other sides. The limited access and dangerous position of the erection area eventually imposed certain technical priorities and restrictions related to the erection process. Such physical limitations made the construction process very sensitive to the sequence of the activities. For example, the erection of some portions of 4^{th} floor could not be started before the lifting of coal gallery, otherwise the coal gallery could never be lifted to its final position since there was existing building adjacent to it, which had made the lifting process impossible. The other example for the tasks having been affected by adverse site condition was the placement of the elements like supports for the coal and limestone silos that had to be placed on the beams of the 2^{nd} floor. In the case that the steel structure erection was carried out without the installation of these supports, these silos could not be placed due to access limitations to the back side of the area. The Turkish company was only responsible for the erection, and the material supply of such supports and silos was under the responsibility of another company located in a third country. The procurement and delivery of such materials faced significant delays due to unexpected harsh sea storm. This caused substantial time loss in construction process since the erection had to be stopped until the installation of the supports. Also, the access limitations of the erection site limited the lifting radius of the tower crane. This caused difficulties in subsequent phases of erection in lifting of some bigger or heavier elements. Therefore, a mobile crane was hired. This brought about additional costs and some time losses due to problems like unavailability of crane and certified local operator, and also erection time of the crane. It is claimed that, although the occurred delays in supply and delivery of the material by either supplier party or the manufacturing unit would have probably caused time losses in erection process even if there had not been any site constraints, the finish-to-start relations of the activities resulted from the backward erection of the elements, and from access limitations, have significantly intensified the idle times.

Country Related Conditions:

Newly joined to European Union, Bulgaria was subject to lots of sudden and substantial changes in its laws and regulations. The first one was the visa requirement. Acquisition of visa for Turkish workers became obligatory. This resulted in significant delays in the supply of manpower from Turkey. The lack of local skilled manpower and certified technicians in some areas intensified this problem. According to the company's representative, this fact affected the construction productivity and quality of the work. For example, the company faced difficulties in finding a skilled operator for the newly hired mobile crane. This led to some idle times of the crane, and to delays in erection process. Finally, in order to prevent further losses, the company employed some uncertified workers resulting in conflicts with health and safety inspectors. Other notified problem was high levels of bureaucracy, especially in custom procedures that caused significant delays in the procurement of materials and equipment which were mostly outsourced from other countries. Lack of local material and equipment were other notified country related vulnerabilities of the project.

Contractor Related Vulnerabilities:
Besides the drawing errors, revisions and supplier delays, lack of coordination and poor communication among the erection team and manufacturing unit were other factors that affected the manufacturing process, supply and delivery of the structural elements, and erection process. For example, there were elements having been sent to the site long before their prerequisite parts were fabricated. Lack of managerial skills of contractor is the other notified vulnerability. Poor planning was one of the most important vulnerability that apart from its effects on project time and cost performances, caused the company to face difficulties in gathering the necessary documents for supporting their arguments in raised claims. Poor quality management for both manufacturing and erection parts can be considered as the other managerial vulnerability of the contractor. For example, there were some unnoticed differences among some fabricated beams and their specifications in the design drawings. Such quality deviations led to reworks and time losses. The site organization and management team of the contractor changed frequently throughout the project. The company representative believes that this factor mostly affected the productivity of the erection team. Contractor's lack of experience with client, and with the general conditions of the country is other contractor related vulnerabilities mentioned by the company representative.

Unexpected Events:
Harsh and extreme weather conditions are mentioned as the most important unexpected events in this project. Unpredictable and exceptionally high speed of the wind during July and August months forced contractor to stop erection with cranes due to health and safety issues. Also, the erection process of the top floors had to be stopped for several weeks since their construction was postponed to winter's freezing months because of delays, especially due to the design related delays.

Client's high level of bureaucracy, negative attitude, and technical, managerial and organizational incompetency are client related vulnerabilities, and strict quality, and strict health and safety requirements are the vulnerabilities of the project mentioned by the interviewee.

Application of the SEM-based Risk-Path model
The identified SEM-based Risk-Path Model [10] comprises of 36 interactive risk-path scenarios each deriving from one of the project vulnerabilities. Using the prediction capability of SEM models, the magnitudes of the future risk factors and the probable risk paths can be estimated by inserting the known severities of the vulnerability sources as the inputs of the model.

For the project studied in this paper, the most significant vulnerabilities are mentioned above. The interviewee is asked to rate the severity of these critical vulnerabilities, and the others included in the model, in a 5 Likert scale: Very Low (1), Low (2), Medium (3), High (4), and Very High (5).
Based on these values, and using the estimated path coefficients, the probable magnitudes of risk factors, and the level of project cost overrun are estimated. Figure 1 shows all the 36 interactive risk paths, the inserted severities of the vulnerability sources, and the estimated magnitudes of the risk and cost overrun factors. This gives an overall picture of the complex risk emergence pattern of the project. The total effect of each of the 36 risk-path scenarios will be the product of coefficients of all paths underlying that scenario. Multiplying the total effect of the scenarios with the severity levels of their initiator vulnerability sources, the

impact of different vulnerabilities on the cost overrun will be calculated. Ranking these impacts, the most effective risk-path scenarios for the project will be obtained. Table 1 shows the risk-path scenarios, their impacts on project cost overrun, and the most critical ones for the project under study.

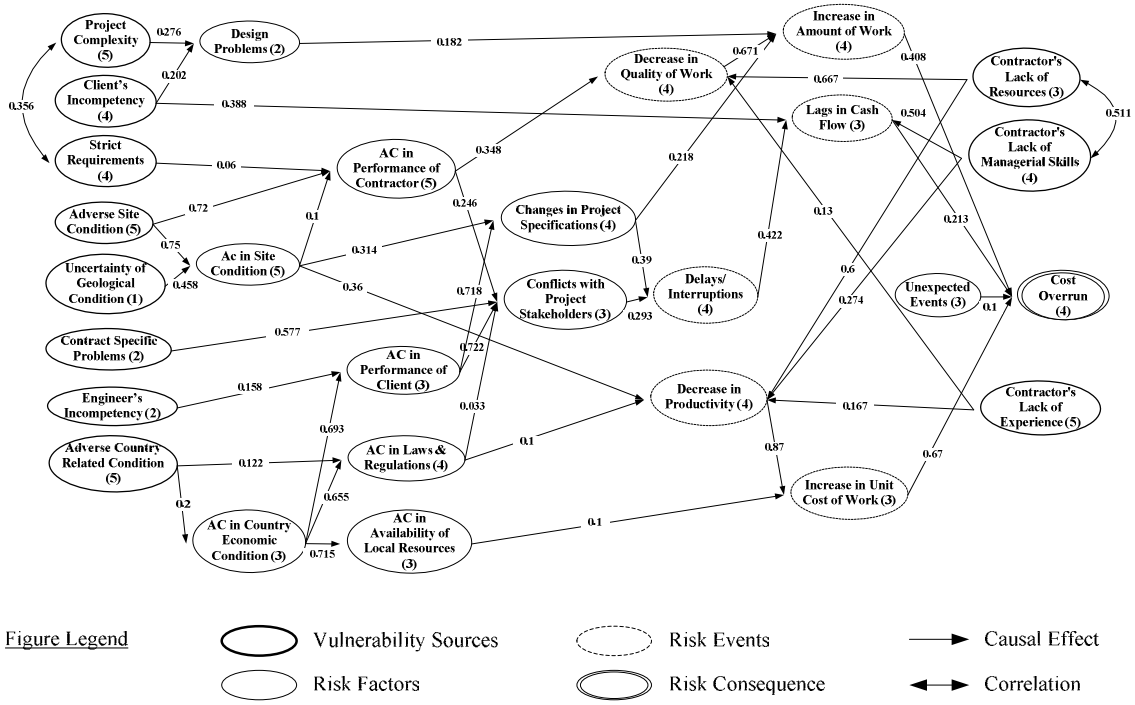


Figure 1: *Risk-Path Model for the case study*
Note: A) Values in parenthesis are inserted or estimated magnitudes of the vulnerability/risk factors in 5 scales. B) All paths are mutually significant at 5% level.

Discussion of findings
Figure 1 shows the general risk structure and the emergence pattern of the possible risk-path scenarios for the case study project. Such a comprehensive risk map gives a wider and more realistic view about the future when compared to that of common risk checklists. For example, as mentioned by company's representative, *adverse site condition* was one of the main vulnerabilities of the project the severity of which was known from the beginning of the project. If the company had considered the direct and indirect impacts of this source on other areas like *quality decreases*, *specification changes*, *delays*, *etc*., and at the same time the subsequent effects of these events, more effective strategies may have been made, and more realistic cost and time planning may have been possible. On the other hand, the influence of alternative mitigation strategies can be traced not only on a specific risk and possibly on its outcomes, but also on the whole network of interrelated risks. The statement of "*missed opportunity*", mentioned by Ward [19], being generated from the ignorance of such interdependencies, refers to the existing gap of various risk checklists that are improper in clarifying the effects of any response strategy on the whole system of risks. Moreover, the probable magnitudes of diverse risk factors, their cross-impacts on each other, and their impacts on project cost overrun are estimated (Figure 1 and Table 1). A total of 36 general risk-path scenarios are considered. Based on the specific conditions of different projects,

these paths may have different impacts on project cost overrun, and hence, different scenarios may become critical.

***Table 1**: Risk-path scenarios and their impacts on project cost overrun for the case study project*

Path	Identified Risk Paths Derived from Vulnerabilities →							Impact of Scenario	Total Impact
	Vulnerability	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6		
1	(Conty-Cndtn)	(Conty-Econ)	(Avlb-Res)	(Unt-Cst)	(Cst-Ovrn)			0.008	
2	(Conty-Cndtn)	(Conty-Econ)	(Law-Reg)	(Prdcty)	(Unt-Cst	(Cst-Ovrn)		0.0064	
3	(Conty-Cndtn)	(Conty-Econ)	(Law-Reg)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)	0.0001	
4	(Conty-Cndtn)	(Conty-Econ)	(Clt-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)	0.0024	
5	(Conty-Cndtn)	(Conty-Econ)	(Clt-Prfc)	(Prjt-Sps)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)	0.0024	
6	(Conty-Cndtn)	(Conty-Econ)	(Clt-Prfc)	(Prjt-Sps)	(Wrk-Amnt)	(Cst-Ovrn)		0.0072	
7	(Conty-Cndtn)	(Law-Reg)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)			0.0056	
8	(Conty-Cndtn)	(Law-Reg)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		0.0001	**0.0322**
9	(Pjt-Cmx)	(Dsgn-Prblm)	(Wrk-Amnt)	(Cst-Ovrn)				0.0434	0.0434
10	(Glgcl)	(Chng-Sit)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)			-0.1338	
11	(Glgcl)	(Chng-Sit)	(Prjt-Sps)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		-0.007	
12	(Glgcl)	(Chng-Sit)	(Prjt-Sps)	(Wrk-Amnt)	(Cst-Ovrn)			-0.0181	
13	(Glgcl)	(Chng-Sit)	(Con-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)	-0.0004	
14	(Glgcl)	(Chng-Sit)	(Con-Prfc)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)		-0.0056	-0.1649
15	(Strct-Rqr)	(Con-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		0.0002	0.0026
16	(Strct-Rqr)	(Con-Prfc)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)			0.0024	
17	(Cont-Prblm)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)			-0.0128	-0.0128
18	(Eng-Incpt)	(Clt-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		-0.0022	
19	(Eng-Incpt)	(Clt-Prfc)	(Prjt-Sps)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		-0.0029	
20	(Eng-Incpt)	(Clt-Prfc)	(Prjt-Sps)	(Wrk-Amnt)	(Cst-Ovrn)			-0.0073	-0.0124
21	(Clt-Incpt)	(Csh-Flw)	(Cst-Ovrn)					0.0581	**0.0686**
22	(Clt-Incpt)	(Dsgn-Prblm)	(Wrk-Amnt)	(Cst-Ovrn)				0.0105	
23	(Sit-Condtn)	(Chng-Sit)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)			0.3549	
24	(Sit-Condtn)	(Chng-Sit)	(Prjt-Sps)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		0.0181	
25	(Sit-Condtn)	(Chng-Sit)	(Prjt-Sps)	(Wrk-Amnt)	(Cst-Ovrn)			0.0475	
26	(Sit-Condtn)	(Chng-Sit)	(Con-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)	0.0113	
27	(Sit-Condtn)	(Chng-Sit)	(Con-Prfc)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)		0.0158	
28	(Sit-Condtn)	(Con-Prfc)	(Coflt)	(Dely-Intrpt)	(Csh-Flw)	(Cst-Ovrn)		0.0113	
29	(Sit-Condtn)	(Con-Prfc)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)			0.156	**0.6149**
30	(Con-Expr)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)				0.0603	**0.0827**
31	(Con-Expr)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)				0.0224	
32	(Con-Res)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)				-0.0663	**0.101**
33	(Con-Res)	(Qlty)	(Wrk-Amnt)	(Cst-Ovrn)				-0.0347	
34	(Con-Mngt)	(Prdcty)	(Unt-Cst)	(Cst-Ovrn)				0.0701	**0.117**
35	(Con-Mngt)	(Csh-Flw)	(Cst-Ovrn)					0.0469	
36	(Unxpt-Evnt)	(Cst-Ovrn)						0.1011	**0.1011**

Note: A) All impacts are standardized estimates. B) Highlighted paths are the most effective scenarios.

In the Power Plant Reconstruction project, the standardized impacts of each risk-path scenario are estimated (Table 1) based on the severity levels of project vulnerabilities reported by the interviewee and discussed before through the paper. The total impacts of the vulnerability sources (i.e. the sum of the impacts of each scenario deriving from the vulnerability) are also reported in this table. The highlighted scenarios are the most effective ones deriving from each source. Also, the highlighted total impacts indicate the highest total impacts on project cost overrun, belonging to sources like adverse site condition, contractor's managerial incompetency, unexpected events, contractor's lack of resources, contractor's lack of experience, client incompetency, and adverse country conditions. Although some conclusions can be made by comparing the prediction results of the Risk-Path Model with the details discussed in the case study section, the identified paths and the predicted magnitudes were consulted with the company representative to ensure their compatibility with what happened in real project. All the identified critical risk paths were confirmed by the interviewee to be effective scenarios in the project.

According to company representative, the complex and interrelated nature of the occurred events was one of the factors having made the identification of responsible parties, and determination of their contribution rate on the raised overruns, a tedious task resulting in lots of time/cost consuming disagreements. According to the related clauses of the binding contract, each of the risk factors forming the project Risk-Path Model is under the responsibility of one of the project parties, or is shared among them based on their contribution to its occurrence. It is believed that integrating the identified risk paths with contract clauses will provide project parties with a supporting tool to facilitate their negotiations over the occurred cost overruns. Having knowledge about their approximate fault rate in the occurred scenarios will assist negotiators in determination of their reservation values, in getting ideas about the reasonable offers, and in forecast of the counter-offers during the negotiation process.

CONCLUSIONS

This paper reports a detailed case study for examining the complex risk emergence pattern of an international construction project. The results of the case study illustrates that incomplete design, errors in drawings, and sudden and frequent revisions have been some of the major problems of the project causing lots of time, cost, and productivity loss. Restrictions in accessibility of different construction areas and adverse site conditions were other main sources of poor time and cost performance in the project. Country, contractor, and client related vulnerabilities were other important fragility sources for the case under study. The results of the case study show that these vulnerabilities have caused a number of interrelated risks. In order to examine the discussed risk emergence pattern of the project in a systematic way, the Risk-Path Model developed in previous stages of this research is applied. Knowing the severities of project vulnerabilities, which are the most certain knowledge sources at early stages, the probable magnitudes of risk factors, and possible risk-path scenarios and their impacts on project cost overrun were predicted. The results of the Risk-Path Model are identified to be highly compatible with what have happened in the real project. Finally, it should be noted that, the aim of this case study is not to test the reliability of the model and predictive capability, but it is to demonstrate that how the proposed model may be used to assess risk paths in international construction projects.

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THE AGENT-CONSTRUCTION SYSTEM FOR PROCURING MEGA PROJECTS IN CHNIA

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Abstract
While heated discussions have been directed towards various innovative procurement systems such as PPP, PFI, and BOT that carry the great expectation to help materialise the projects and deliver value to the society, a procurement system named agent-construction system (ACS or in Chinese Dai Jian Zhi) is being prevailing in China's public procurement. This research aims to examine ACS by relating them to China's particular Political, Economics, Social, Technological, Environmental, and Legal (PESTEL) background. It is found that the ACS is promising in procuring public projects owing to two merits: (a) clearly defined right and responsibilities; and (b) appropriate allocation of resources and risks amongst parties involved. The research is particularly useful when governments worldwide are searching for innovative procurement approaches to help deliver public projects and services. It also sheds light on how to devise an innovative procurement system. A word of caution, nevertheless, is that readers should not follow this "good practice" slavishly. One ought to truly understand the essence of procurement innovation and devise suitable innovative procurement systems in a given PESTEL setting.

Keywords: Procurement innovation, Agent-Construction System, Construction procurement, China

INTRODUCTION

In the course of procuring public construction projects, no matter whether it is in socialist or capitalist countries, or whether it is in developing or developed worlds, there have been widespread problems discovered. Particularly in China, though its construction industry has made significant development owing to its strong economic growth and unprecedented urbanization plan, several problems have been frequently mentioned, such as cost overrun, late delivery, delay of payment, low efficiency, overstaffed organizations and/or corruption (Yan, Yan, & Yin, 2009; Yin & Yan, 2006; Zhang, 2008). To address these problems, governments worldwide are searching for innovative procurement approaches that can help procure projects in a more efficient way and thus truly deliver values to the society. The often-discussed innovative procurement methods may include, inter alia, Build-Operate-Transfer (BOT) first introduced in Turkey, Private Finance Initiatives (PFI) initially put forward by UK government, and Private-Public-Partnership (PPP) that has been ubiquitously discussed around the world.

It is generally observed that there are two trends in these innovative procurement approaches. Firstly, public procurement is shifting from traditional state-led approaches to partnering between public and private sectors, expecting that the private sector can be more active in improving efficiency and delivering value (Egan, 1998, Winch, 2000). Secondly, integrated approaches were adopted to reduce the problems of fragmentation and discontinuity by which the construction sector has long been plagued (Anderson et al., 2000). Together with the trends is the systems view to construction procurement which emphasizes a procurement system including elements such as contract strategy, culture (e.g. trust and institutions), and finance, should deserve more attention of the construction and project management fraternity (Rowlinson, 1999).

With the success of the procurement systems in some mega projects, they have been introduced to other economies for procuring new projects. However, “one size does not fit all”; a procurement system growing from a certain Political, Economics, Social, Technological, Environmental, and Legal (PESTEL) background may not be of full applicability to other economies with different PESTEL settings. Adopting them slavishly may cause loss or even failure of a project. The big issue is thus to devise innovative procurement systems that are suitable for a given PESTEL setting and should truly deliver value to the society. On the other hand, notably in China, an Agent-Construction System (ACS or in Chinese *Dai Jian Zhi*) is widely adopted in the procurement of public projects, for example, the Beijing 2008 Olympic Games projects. It is intriguing to examine why the ACS became the most widespread procurement approach and what are the implications to procurement innovation that can help procure projects in a more efficient way.

The aim of this research is to shed light on procurement innovation by skeptically examining the ACS and relating it to China’s particular PESTEL background. The rest of this paper is structured into three sections. Firstly, research design and methods are described – this is comprised of extensive literature review and interviews with practitioners. Secondly,

discussions are conducted to deepen the understanding of the ACS in terms of its history, strengths and weaknesses. Of particular importance is to project the procurement systems into China's PESTEL background. Research findings are presented in this section. Finally, key conclusions are drawn together.

RESEARCH METHODOLOGY

The principle underlying in this research is that a procurement system should be examined skeptically in terms of its suitability to a certain PESTEL setting. This principle is an extension of the systems view to construction procurement contributed by Rowlinson (1999). This investigation thus adopts PESTEL as an analytic framework. PESTEL analysis, standing for Political, Economics, Social, Technological, Environmental, and Legal, is a framework of macro-environmental factors used in the environmental scanning component of strategic management. It also gives an overview of the different macro environmental factors that a procurement system has to take into consideration.

Bearing in mind the PESTEL framework, the authors investigate various sources by using a literature survey in order to truly understand the ACS in China. There are three prevailing books (Zhang, 2008; Yin and Yan, 2006; Hou, 2006) about the ACS. The understanding of the ACS was enhanced by a body of articles published on different journals but being organized under a Project Manager Union (2010) website. Archived papers, presentations and in particular keynote speeches by governmental officers in the First National Summit on "Agent-Construction System: theories and practices" provide very useful literature for this study. The search of the literature was further enhanced by using a CNKI database for research papers. All the literature on the ACS is in Chinese. This presents a possibility that information will be lost in the translation but it also provides a chance for cross referencing by perusing them in two languages. The literature survey has projected the procurement system into China's PESTEL background, which is changing rapidly, though in various speed.

The second stage of this research adopts interview as the main method for investigating the ACS in China. Interviews allow for an in-depth interpretation of the comparisons. Three interviews have been conducted. Somehow, these took place over a long period with the first one being conducted in December of 2009 with the vice president of an international construction company and the last one in December of 2010 with a government officer in charge of audit of government-invested projects including those adopted the ACS. Each interview lasted 40–60 minutes and the transcriptions are used to cross validate the understanding from the previous literature survey. The data from the literature survey and interviews is to be analyzed in the next section.

ANALYSES, DISCUSSIONS, AND FINDINGS

General PESTEL Background for public project procurement in China

In order to effectively understand the Agent-Construction System (ACS), it is necessary to relate the system with China's PESTEL background. China is known as a socialist country adopting a Marxism-Leninism ideology. Based on this ideology, a centrally planned economy system has been adopted and there was no private sector. Since 1978 when the country adopted an "open-door" policy, the economy has been reformed from the traditional planned economy to a market economy. Lu (2009) used the spectrum as shown in Fig. 1 to illustrate the transition of the economy systems. Yang (2004) also effectively summarize that all the significant affairs taken place in China since 1978 can be understood by putting them into two spectrums similar to Fig. 1, one for political reform and the other for economy. It can be seen from the spectrum that gradually economic activities and factors of production are configured by the market as "the invisible hand" instead of a central plan. The zigzag of the curve represents its struggling with two briefs of "plan (state planning)" and "market (incentive-based competition)", which were traditional labeled as "socialism" and "capitalism" respectively. Whilst Western economists argue that these two are not natural partners, it is generally accepted in China that "government planning and market regulating are two integral parts of the socialist market economic system". It should allow the market to allocate factors of production and to increase efficiency while the central planning is indispensable in ensuring healthy development of the whole economy. Although the market economy is now dominant, the whole economy system still has a strong "planning" culture. For example, the economic goals have been achieved through its "Five-Year Plans", which are a series of economic development initiatives shaped by the Central Committee and National Congresses to map strategies for economic development, set growth targets, and launch reforms. Currently, it is in the 12th "Five-Year Plans" (2011-2015). As a result of the economy reform, China's GDP grows at an average rate of about 10%, reaching a GDP of $4.99 trillion in nominal term in 2009, becoming the world's second largest economy after the United States.

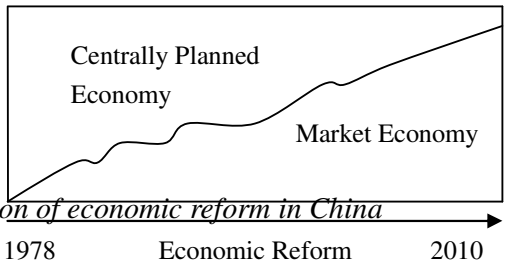


Figure 1: *An illustration of economic reform in China*

Intertwined with the political and economic development is its unprecedented urbanization in China. Urbanization has been the major drivers of China's GDP growth over the past decades and it will become even more so over the next 20 years. According to the UN World Urbanization Prospects (UN, 2009), the level of urbanization in China is 46.1, with a population of 620million living in urban areas, while this level will be 73.2 in 2050 and the urban population will be 1 billion. A McKinsey report (2009) forecasted that 1 billion people

will live in China's cities even early in 2030, and 5 billion m^2 of road will be paved, 170 mass-transit systems could be built, and 40 billion m^2 of floor space will be built in 5 million buildings by 2025. These resonate with China's fixed-asset investment on property, roads, and other infrastructures to sustain the economic growth as well as the urbanization ambition. For example, in 2009, the total fixed-asset investment was 22,486 billion Yuan (NBS, 2010). Although the government investment system is in transition, for example, in 2004, a regulation named *Decision on Reforming the Government Investment System* was promulgated by the Chinese State Council, the government is still dominant in both the public spending and the procurement of government-invested facilities driven by the urbanization. Normally, there are two types of government-invested projects: (i) non-profit-making, for example, urban roads, schools, hospitals, libraries, museums, government offices(These are called institutional buildings in Hong Kong), and (ii) profit-making utilities, i.e. water, gas, sewage facilities, tolling roads, bridges and tunnels, etc.

In the face of the ambitious urbanization plan, Chinese government is keen to introduce innovative procurement systems that can help materialize the huge demand of public projects. Various writers (e.g. Liu, 2001; Zhang, 2007) summarized a genealogy of the typical government public procurement systems as follows:

(a) Self-build model, in which the end users (i.e. a university, or a hospital), more precisely, their long-standing project organizations, are in charge of the construction projects. They define project scopes, apply for budget from the government, and procure the project by themselves;

(b) Government construction commanding units model, in which a temporary governmental unit was set up to command the budgeting and construction of a given project, e.g. a road committed by a local government. The project will be transferred to the end users after completion.

(c) State-owned construction enterprises model, in which the State-owned enterprises are in charge of the construction of a project. For example, for Ministry of Railway (MOR), Ministry of Transportation (MOT), Ministry of Construction (MOC), they had their own construction bureaus which later were transformed to state-owned construction enterprises in charge of specific types of projects (i.e. railway, road infrastructure, and residential buildings).

Later, the market-oriented economy reform introduced competition. The competitive bidding and tendering has changed the system of construction project financing from traditionally government-free allocations to loans from commercial banks, and changed the project procurement system from traditional government assignments to competition through the tendering process as occurs in international practice (Shen and Song, 1998). But for the public projects, the government is still dominant in financing and procurement, mainly through the National Planning Commission, although it was renamed to the National Development and Reform Commission (NDRC). Public clients are remaining as various state-owned organizations; the construction commanding units model is still seen every now and then (e.g. Shanghai Expo 2010) while for some profit-making public projects, a Legal

Person system (e.g. Water Affairs Group Limited; Road and Bridge Corporations) is adopted as a legal entity to be responsible for the profit and loss of the projects. The state-owned construction firms were pushed into a competitive market and became real companies that are responsible for their own gains and loss. The above procurement systems, with a label of the planned economy, have been changed with the transition of the whole economy system. More diversified procurement systems appeared, for example:

(d) Legal person model, in which a project company will be set up as a legal entity, usually a qualified and authorized organization, to take charge of the procurement and also operation of the construction project.

(e) Governmental investment and development companies. This model is not significantly different from the Model (d) above but this one should be responsible for the financing of a project thus return of investment is of high concern.

(f) Government procurement center model, in which a government procurement center is established to be in charge of procuring a project which will be transferred to the end-users after its completion.

With a closer investigation, it can be summarized that the above models have actually struggled to streamline the relationships between government (as both a market regulator and a client), project contractors (state-owned or private enterprises), and end-users (often the public sector). Typical relationships between the parties underlying in different procurement systems can be seen in Fig. 2. The relationships could be underlying in any government investment project in any economy but this is more important as an issue in China which adopted a socialist economy. It is believed that the unclear relationships are the main causal factor for problems in public procurement. For example, budget overrun is widespread as a result of enlarging project scope by end users; quality is poor as no professional construction management is in place; rent-seeking in these relationships leads to misconduct and corruptions. The Agent Construction System (ACS) and the exotic systems such as PPP, PFI, and BOT, etc were introduced under this particular PESTEL background.

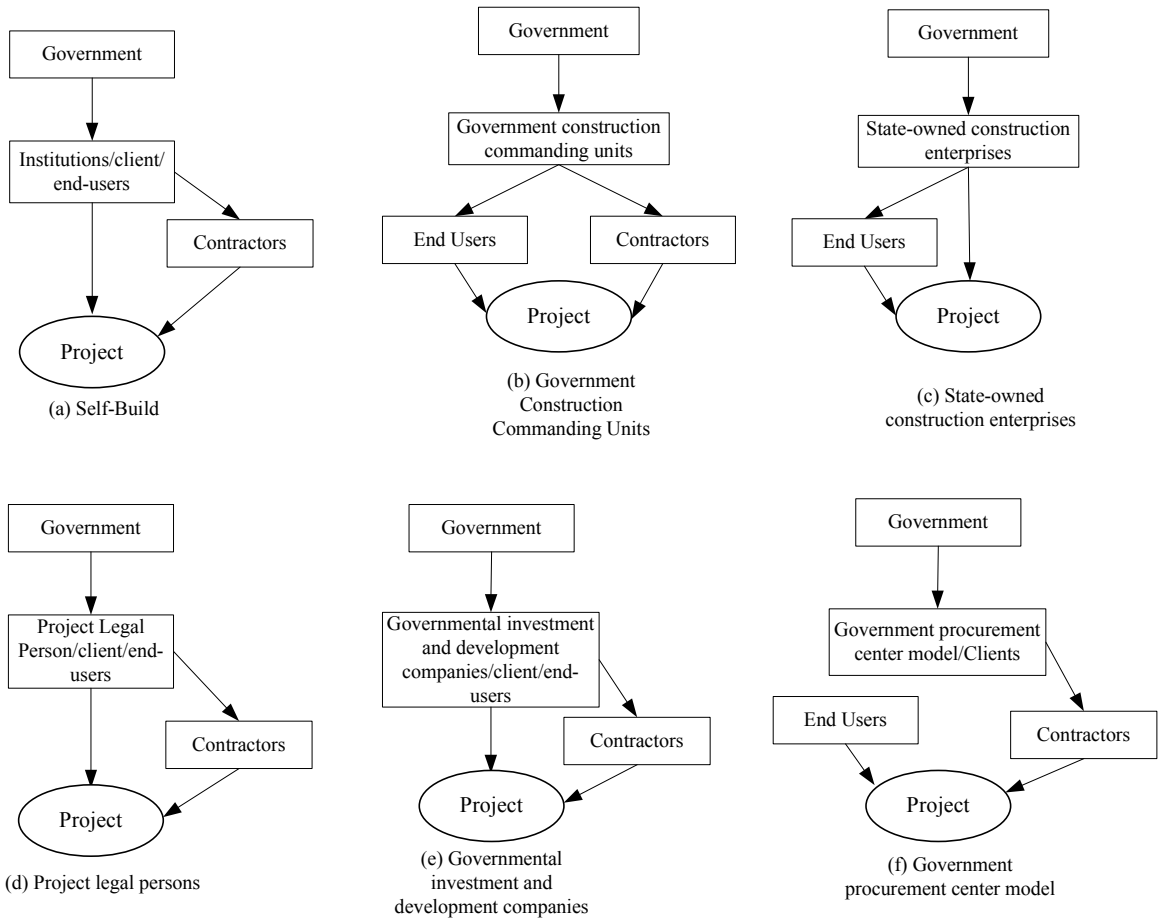


Figure 2: *The relationships of government, contractors, and end-users in various public procurement systems*

Agent-Construction System (ACS or Dai Jian Zhi)

It is generally agreed that the ACS was firstly trialed in Xiamen in 1993 and formally introduced in 2004 when the Chinese State Council issued a regulation named *Decision on Reforming the Government Investment System*. The term firstly appeared in the *Decision* in which it was stated that for procuring government-invested non-profit-making projects, professional construction management units are selected through competitive bidding and tendering to conduct the construction projects, to control project cost, quality, and time, and to turn over the projects to the future users or operators after they are successfully constructed. Similarly, the relationships in an ACS is illustrated in Fig. 3.

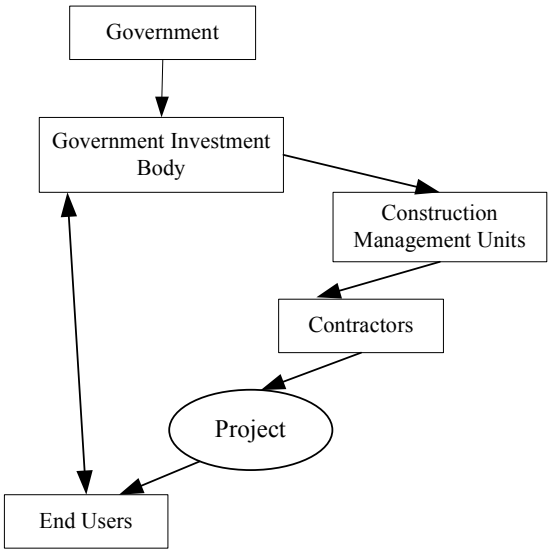


Figure 3: *The relationships of government, construction agents, contractors, and end-users in the Agent-Construction System*

By comparing Fig. 3 with Fig. 2, a major difference observed is that the construction management units (CMUs) are selected as an agent of the government investment body, through competitive bidding and tendering, to conduct a certain or all stages of construction projects, i.e. feasibility study, design, contracting, construction and handover after completion, meanwhile to strictly control project cost, quality and time. The ACS, therefore, is considered by many researchers as the construction management system originated in the U.S. This view places an emphasis on that the CMUs, with more professional knowledge than the government investment body or end-users, can help overcome the problems in procuring public projects. There is another view considering that the ACS can overcome the problems by streamlining the relationships amongst the parties. After the project was completed, it will be transferred to end-users, who applies for a project from the very beginning, while has no intervention during the execution of the project. All the details of rights and obligations are required to be clearly specified in an agent-construction contract, and so are the risk sharing mechanism and dispute solving approaches. Through this way, it is hoped that budget overrun can be reduced as end-users cannot enlarge project scope any more, and quality can be improved by introducing the CMUs. The latter view emphasizes a clear definition of rights and obligations of various parties that are involved in a public projects. Both views are correct while more analyses are needed to clarify the many ambiguities in the ACS.

The *Decision* only addresses a general principle (Yan et al., 2009) while applicable procurement systems are subject to detailed elaborations by individual provinces, autonomous regions and municipalities. For example, the government investment body could be Provincial Development and Reform Commissions (PDRC) themselves (e.g. in Beijing), or their authorized institutions (i.e. in Shanghai Chengtou Corporation as a professional industrial investment group company engaged in the construction and operation of the city's

infrastructure facilities), or ender users (i.e. the model in Chongqing). According to Zhang (2008), the last mode should not be regarded as the ACS. In addition, the professional CMUs could be professional project management companies which are complete legal entities, or government specially-set institutions which are extended government executive arms (e.g. Bureau of Public Works in Shenzhen). Actually, the latter form is not significantly different from the model (f) governmental procurement center as illustrated in Fig. 2. With different combinations of government investment bodies and CMUs, a wide variety of procurement systems which are generated and all claimed to be ACS. Yin (2008) summarized there are three models of ACS in China: Beijing Model with Beijing DRC as the investor and professional CMUs as the construction agent, Shanghai Model with project investment corporation and professional CMUs, and Shenzhen Model with government as the investor and Works Bureau as the agent.

During the course, there emerge various forms of ACS that respectively embody some features and strengths/weakness of emerging procurement modes such as BOT, PFI, EPC, or BT, which are more familiar to the construction and project management fraternity. Some state-owned companies, with their relatively strong financing, architecture, engineering, and construction capabilities, acted as the government's agent in procuring projects. Instead of operating for a certain years as BOT does, the projects will be completely purchased back by the government after 2 to 5 years. This model is reported as successful to create a win-win situation by complementing with each other using each party's strengths. It also reduces each party's weaknesses while introducing a risk sharing mechanism that is critical to the success of public construction projects.

Although there is no consensus on what the ACS is, it has become a widespread procurement system in China. According to Yan et al. (2009), by the end of 2008, 45 out of totally 47 regions including provinces, municipalities and special provincial-level cities in the mainland China have issued their guidelines on how to conduct the ACS in line with the *Decision.* In many regions, the ACS has been made as a mandatory system while in some others the system is promulgated with greater flexibility when procuring government-invested non-profit-making public projects. According to Yin (2008), by the end of 2005, there were 153 completed, 164 ongoing, and 85 planned projects adopting the ACS. The Beijing 2008 Olympic Games projects also adopted this procurement system. The discussions of the pros and cons of the system have been prolific. All these provide a good standing point to compare the ACS and PPP in China.

The ACS and Procurement Innovation

Hughes et al. (2006) suggest that to define procurement, the following six aspects of procurement must be defined at the same time:

1) ownership, initiation and funding, e.g. owner-financed, public sector-financed, developer financed, PFI;
2) selection method, e.g. negotiation, partnering, frameworks, selective competition, open competition;

3) price basis, e.g. work and materials as defined by bills of quantity, whole building, a fully-maintained facility, performance;
4) responsibility for design, e.g. architect, engineer, contractor, in-house design teams;
5) responsibility for management, e.g. client, lead designer, principal contractor, JV; and
6) amount of sub-contracting, e.g. 0-100%.

Innovation could be taken place in one or more aspects as listed above. Furthermore, the combination of these aspects provides a wide range of innovative procurement options. Their work provides a framework for analyzing the ACS as a procurement innovation here.

Ownership, initiation and funding: The adoption of ACS has not changed the fact that the public sector is still dominant in initiating, funding, and owning non-profit-making public projects. Unlike some governments which are suffering from lack of fund, Chinese government is relatively rich due to closely monitored fiscal policy and high saving rate of Chinese people. This mainly explains why PPP, PFI, BOT are not really popular in China. This ACS actually tries to streamline the relationships between investors, owners, professional management units, and contractors so as to overcome the problem of budget overrun.

Selection method: The ACS clearly stated that competitive bidding and tendering will be adopted in the selection of construction agents. However, this has not been fully implemented in some forms of ACS, for example, the Shenzhen model, similar to many other things, which copied from Hong Kong. Further studies to investigate the effectiveness of a similar system in two different PESTEL settings are envisaged.

Responsibilities for design and management: The ACS is much superior to other procurement systems for shifting the responsibilities for design and management to professional CMUs. As shown in Fig. 2, the part of responsibilities was traditionally assumed by government or its executive arms, which are not necessarily professional in design and management of public projects. Instead of managing individual projects, government was liberated by the system and can focus on regulating efficient market rules. It is through professional design and management that the problems of budget overrun, poor quality, and delayed delivery are expected to be reduced.

Price basis and sub-contracting: In the ACS, the issues were left to the professional CMUs with several principles. For providing the professional services, the construction agent will receive a service fee plus some incentive schemes.

Risk sharing mechanism: While has not been mentioned in Hughes et al.'s work, risk and reward allocation is critical for the success of an innovative procurement system. The ACS, particularly for the form similar to BT, creates a win-win situation by reasonably considering the risks bored by each party. It is noteworthy that instead of 30 years as PFI promises, 2-5 years is a reasonable period that the risk associated with the PESTEL background, changing in a high speed, can be handled by both the governments and the construction agents.

CONCLUSIONS

In the face of widespread problems in public project procurement such as cost overrun, low quality and delayed delivery, governments worldwide are searching for innovative procurement systems that can help procure projects in a more efficient way and thus truly deliver values to the society. The ACS is reported as successful in China's particular Political, Economics, Social, Technological, Environmental, and Legal (PESTEL) background, although its many weaknesses are yet to be eliminated. The innovations of the ACS are lying in two aspects: (a) clearly defined right and responsibilities; and (b) appropriate allocation of resources and risks amongst parties involved.

The ACS reported herein can be treated as a "good practice" in project procurement that may provide valuable reference to readers. A word of caution, nevertheless, is that readers should not follow this "good practice" slavishly. The main proposition of this paper is that one ought to truly understand the essence of procurement innovation and devise suitable innovative procurement systems in a given PESTEL setting. Further research is suggested to investigate a national guideline on the ACS, the service fee for the construction agents. But if aiming to provide more references to other economies in procuring public projects, research may be directed to devise a more thoughtful risk sharing mechanism that takes into consideration each party's strengths, weaknesses, rights, responsibilities, and rewards respectively.

Nevertheless, a word of caution is that readers should not follow one specific "good practice" slavishly. One ought to truly understand the essence of procurement innovation and devise suitable innovative procurement systems in a given PESTEL setting.

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APPLYING THE SHUFFLED FROG-LEAPING ALGORITHM TO IMPROVE SCHEDULING OF CONSTRUCTION PROJECTS WITH ACTIVITY SPLITTING ALLOWED

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Abstract

In situation of contractors competing to finish a given project with the least duration and cost, acquiring the ability to improve the project quality properties seems essential for project managers. Evolutionary Algorithm (EAs) have been applied as suitable algorithms to develop the multi-objective Time-Cost trade-off Optimization (TCO) and Time-Cost-Resource Optimization (TCRO) in the past few decades ; however, by improving EAs, the Shuffled Frog Leaping Algorithm (SFLA) has been introduced as an algorithm capable of achieving a better solution with faster convergence. Furthermore, considering splitting in execution of activities can make models closer to approximating real projects. One example has been used to demonstrate the impact of SFLA and splitting on the results of the model and to compare with previous algorithms. Current research has elucidated that SFLA improves final results and splitting allows the model find suitable solutions.

Keywords: Optimization, Multi-objective SFLA, Splitting, Leveling, Construction Management

INTRODUCTION

Project control plays an important role for contractors for scheduling, cost analysis and resource evaluation. The time and cost of projects are related to each other and considered in Time-Cost trade-off problems. From the researchers' point of view, developing highly efficient and robust

algorithms to solve highly complex Time-Cost trade-off problems is still a challenging subject (Afshar et al. 2009). On the other hand, the challenge in resource leveling problems is to make the resource requirements as uniform as possible and to force resource utilization to conform to a desired, predetermined resource distribution in order to meet the project milestones (Senouci and Eldin 2004). In addition, resource availability constraints may postpone activity start time, extend activity duration, and hence prolong the total project duration (LU and Lam 2008).

One of the factors that has significant impact on completed time and cost of project is delay. Delays are acts or events that extend the time necessary to finish activities under a contract (Stumpf 2000). If a project is delayed beyond its due date, a financial penalty is incurred by the contractor (Vaziri et al 2007). Delays during execution of projects can happen at the start of each activity or during activities. Delays at the start of activity change the initiation from early start to late start. If an activity is placed on Critical Path Method (CPM) or delay duration is longer than total float, then delay postpones project duration. We call it "splitting allowed" if delay happens during activity execution. It effects on total duration of activity, however, the active duration of activity will not be varied.

Accordingly, the key question is how to allocate resources to activities while taking into account splitting, in order to finish the project within budget and on time from the standpoints of contractors, sponsors, and the project client.

RESEARCH BACKGROUND

In an attempt to reduce processing time and improve the quality of solutions, particularly to avoid being trapped in local optima, Evolutionary Algorithms (EAs) have been introduced during last decade (Elbeltagi et al. 2005). EAs are stochastic search methods that mimic natural biological evolution and social behavior of species. One of the most important criteria of EAs is their capability of speed convergence to obtain a global optimized solution. Based on Elbetlagi's work (2005), the best solutions of TCO problems have been received by the Shuffled Frog Leaping Algorithm (SFLA). SFLA presented by Eusuff and Lansey (2003) is a meta-heuristic iterative method inspired from the memetic evolution of a group of frogs when seeking for food (Huynh 2009). In the SFLA, the virtual frogs are periodically shuffled and reorganized into new memplexes in a technique similar to that used in the Shuffled Complex Evolution algorithm (SCE) in order to ensure global exploration. The results demonstrated that SFLA produced better results than the Genetic Algorithm (GA) in terms of effectiveness and efficiency for all problems.

SHUFFLED FROG LEAPING ALGORITHM

Instead of using genes in GA, SFLA uses memes to improve spreading and convergence ratio. Meme (pronounced 'meem') is a contagious information pattern that alters human/animal behavior. The actual contents of a meme, called memotype, are analogous to the genes of a chromosome (Eusuff 2004). The main difference between a gene and a meme is related to its transmission ability. Genes can only be transmitted from parents or a parent in the case of asexual reproduction to offspring. Memes can be transmitted between any two individuals (Eusuff 2006). SFLA, in essence, combines the benefit of the local search tool of Particle Swarm Optimization (PSO) and the idea of mixing information from parallel local searches, to move toward a global solution which is called a Shuffled Complex Solution (SCE). The philosophy behind SCE is to treat the global search as a process of natural evolution (Duan et al 1992). On the other hand, PSO simulates a social behavior, such as bird flocking, to a promising position for certain objectives in a multidimensional space (Kennedy and Eberehart 1995). A population of particles is randomly initialized with position and velocities. The particles are improved according to the following equations:

$$\nu_i(t+1) = w*\nu_i(t) + c_1*r_1*(P_i(t)-X_i(t)) + c_2*r_2*(P_g(t)-X_i(t)) \quad (1)$$

$$X_i(t+1) = X_i(t) + \nu_i(t+1) \quad (2)$$

where w=inertia coefficient, which has an important role in balancing a global (a large value of w) and local search (a small value of w); c_1 and c_2=constants ; r_1 and r_2 =uniform random numbers in [0,1]; P_i=best position vector of particle *i* so far ("personal" best); P_g=best position vector of all particles so far (global best); $X_i(t)$ =current position vector of particle *i*; and $\nu_i(t)$=current velocity of particle *i*.

The whole population of frogs is distributed within a different subset called a memeplex. Each memeplex is considered a different culture of frogs, performing an independent local search. After a defined number of memetic evolutionary steps, frogs are shuffled among memeplexes, enabling frogs to interchange messages among different memplexes and ensuring that they move to an optimal position, similar to particles in PSO. The local search and the shuffling processes continue until defined convergence criteria are satisfied (Eusuff 2006). Figure 1 demonstrates the flowcharts of the SFLA. (See Eusuff-2004-for a comprehensive review of SFLA algorithm)

TIME-COST-RESOURCE OPTIMIZATION MODEL WITH ACTIVITY SPLITTING ALLOWED

Each frog in the TCRO model consists of *p*4* memes, in which *p* is the number of activities. Selected option and early start date can be placed as values of two first memes for each activity. After fixing CPM for each frog, Total Float (TF) and Free Float (FF) are calculated for each meme and are placed as values of the next two memes for each activity. In cases of splitting

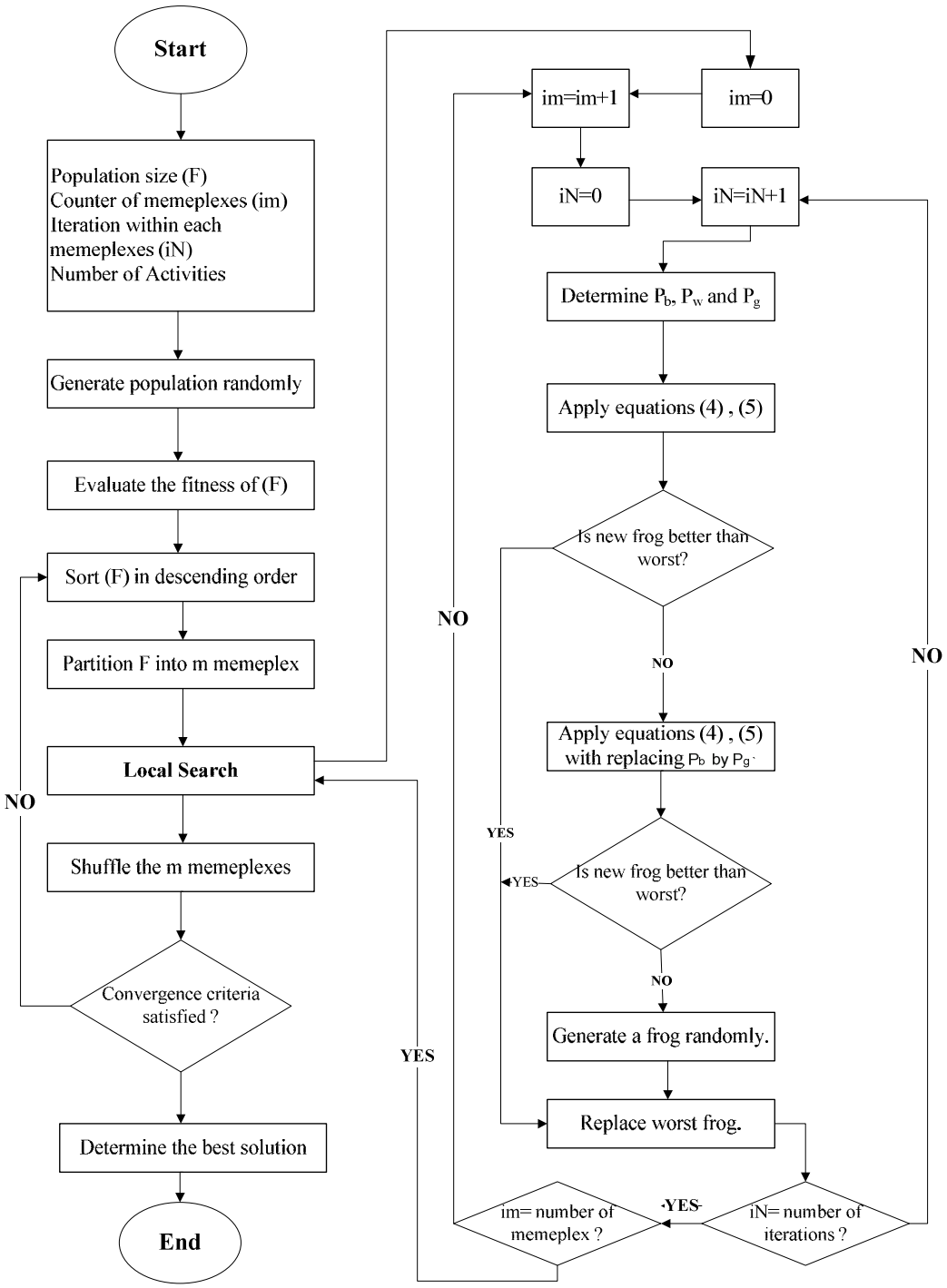


Figure 1. *The flowcharts of the SFLA*

allowed, these values will be used to optimize objective functions. The sequence of memes should be consistent with the order of activities in priority relations between activities. Each frog contains the information of one project based on the different chosen option of activities. Six main parameters are estimated for each frog.

- Critical path for estimating total duration of project execution;
- Total time of project;
- Total cost of project;
- Moment of resources;
- Logical parameter which shows validity of Daily Resource Limit (DRL) condition;
- Activities of project in which splitting has been applied to optimize objective functions;
- The binary parameters should display the active duration of each activity based on the selected option.

OBJECTIVE FUNCTIONS

The objective functions of the TCRO model are formulated to simultaneously minimize total project time and cost along with leveling and allocating of resources to different activities. (Zharaie and Tavakolan 2009). Based on Hegazy (1999), three resource moments have been applied based on the goal of the project manager in utilizing resources.

1. In order to reduce of fluctuations in utilizing resources (M_1):

$$M_1 = Min\left(\sum_{j=1}^{m}\sum_{i=1}^{n} r_{ij}^2\right) \tag{3}$$

Where r is the resource utilized in day i; and m and n are total number of resources and days required for project execution, respectively.

2. In order to release the resources in the least possible time (M_2):

$$M_2 = Min\left(\sum_{j=1}^{m}\sum_{i=k}^{n} (r_{ij} \times (i - k_j))\right) \tag{4}$$

Where k_j is the start time of using each resource.

3. In order to reduce fluctuations of resources utilization and release of resources in the least possible time (M_3):

$$M_3 = Min\left(\left(\sum_{j=1}^{m}\sum_{i=1}^{n} r_{ij}^2\right) + \left(\sum_{j=1}^{m}\sum_{i=k}^{n} (r_{ij} \times (i - k_j))\right)\right) \tag{5}$$

One of the above mentioned resource allocation objectives and the two following objectives of minimizing total time and total cost of project are the three objective functions of the optimization model:

$$M_4 = Min\ Z_c \tag{6}$$

$$M_5 = Min\ Z_t \tag{7}$$

CONSTRAINTS OF THE MODEL

The main constraint of the model considered is the fact that the structure of the model is related to the dependencies between activities. In other words, the relationships of the activities cannot be changed in a network of activities. Since we have only "Finish to Start" relationships between activities, the following constraint precludes the situation that the successor has started before the predecessor is finished by considering TF and FF of all activities in one frog.

$$(TF_p - FF_p - m + 1)^* \lambda_{km} + \lambda_{p(Dp+FFp+m)} + \lambda_{p(Dp+FFp+m+1)} + \ldots + \lambda_{p(Dp+TFp)} \leq (TF_p - FF_p - m + 1) \tag{8}$$

where $m=1,2, \ldots, TF_p - FF_p$.

Another important constraint that should be considered in the model is the Daily Resource Limit (DRL) condition. Where resources are allocated, the logical parameter should be considered in order to level resources. Considering splitting for noncritical activities gives the model more flexibility to optimize Pareto front solutions. Based on Son and Mattila's research (2004), the binary optimization model must reflect the duration constraint for each activity.

EXAMPLE

In order to demonstrate the effectiveness of SFLA on the TCO and TCRO models with splitting allowed, one example is adapted from Zheng and Ng (2005). It contains seven activities. The daily indirect cost of this project is considered to be \$1500, the same as prior research on this example. In total, 80 options have been considered for seven activities of the project. As Tables 1 and 2 show, 7 required resources with fixing unit costs (ranges from \$50 to \$4000) and defined number of options during construction have been considered for different activities of project.

RESULTS OF EXAMPLE

SFLA applied on this example demonstrates improvement of results of the TCO and TCRO model. For local exploration, the parameters of c_1 and c_2 in the equation (1) are set to 2. The value of inertia weight w is stipulated at 0.5. Results are evaluated in both splitting allowed and

not allowed. Before applying splitting, results of TCO and TCRO are compared with the previous works in terms of non-dominated solutions and processing time of convergence. The

Table 1: *Details of Example*

Activity Description	Activity Number	Precedent Activities	No. of Options	Types of Required Resources
Site preparation	1	-	11	7
Forms and rebar	2	1	11	4
Excavation	3	1	19	4
Precast concrete girder	4	1	9	7
Pour foundation and piers	5	2,3	9	7
Deliver PC girders	6	4	11	7
Erect girders	7	5,6	10	7

Table 2. *Different options for the first activity in Example*

Option No.	Duration	Number of Required Resources							Total Cost($)
		R1	R2	R3	R4	R5	R6	R7	
1	14	3	2	1	1	1	0	0	23000
2	15	3	2	1	0	1	2	0	21900
3	16	3	2	0	1	0	1	2	20800
4	17	3	2	0	0	1	1	0	19700
5	18	3	1	1	0	1	2	4	18600
6	19	3	1	1	0	0	0	0	17500
7	20	3	1	0	0	1	2	0	16400
8	21	2	2	0	0	0	1	2	15300
9	22	2	1	1	0	1	1	0	14200
10	23	2	1	0	1	0	0	2	13100
11	24	2	0	0	2	2	0	0	12000

results demonstrate that the least cost and fewest resource moments are decreased by SFLA. In addition, the processing time to obtain a final solution is improved by 25%, however, only least time and cost solutions are decrease in the TCRO model and resource moments solutions have not been changed by SFLA. The processing time is improved by 22% in TCRO model.

The other objective of selecting this example is comparing results when splitting is applied in the model. In order to apply splitting in activities, the values of TF and FF of each meme can be used. The results demonstrate that the time and cost are decreased by 6% and 0.4% respectively in TCO model and 6% and 0.3% in TCRO. The same procedure can be seen in resource moments solutions. They are improved by 0.07% to 1.8% by applying splitting in SFLA in both TCO and TCRO models. Compared to cases without splitting, the processing time increases in both models. It should be noted that every results in this example is considered with an unlimited resource condition. Table 3 shows the complete results of this example.

Table 3. *The results of Example*

Model		Algorithm	Splitting	Pop. Size	Min Time	Min Cost	Minimum Resource Moment among the pareto solution			Average of Processing time (min)
							M_1	M_2	M_3	
Zheng et al. 2004		GA	Not Allowed	5	66	236,500	-	-	-	-
Zahraie & Tavakolan (2009)	TCO model	NSGA-II	Not Allowed	250	65	226,350	8,539	98,120	41,057	12
TCO model		SFLA	Not Allowed	250	64	226,300	8,535	98,050	40,522	9
TCO model		SFLA	Allowed	250	61	225,450	8,405	96,201	39,982	13
Zahraie & Tavakolan (2009)	TCRO model	NSGA-II	Not Allowed	500	69	228,750	4,769	54,585	13,059	18
TCRO model		SFLA	Not Allowed	500	65	227,250	4,637	53,843	12,863	12
TCRO model		SFLA	Allowed	500	64	226,850	4,601	53,361	12,068	18

CONCLUSION

SFLA has been used as appropriate tools to obtain the best solutions with the least total time and cost by evaluating unlimited possible options. One of the problems of previous research is that assumptions make them unrealistic in comparison with actual construction projects. On the other hand, delay events during execution of activities have an important impact on total time and cost of projects. Therefore, the authors attempt to make the model better approximate real projects by considering splitting during execution of activities.

The example is adapted from Zheng and Ng (2005) to compare non-dominated solutions of SFLA by applying splitting to previous works in GA and NSGA-II. Results in both TCO and

TCRO models demonstrate improvement of solutions, convergence ratio, and the processing time to reach the optimum solution. It confirms that SFLA improves results, by comparing results before applying splitting. Moreover, splitting permits the model to become more flexible in finding the least time and cost and the fewest resource moments. Since in this case, we do not have any limit for resources, the impact of splitting on concepts of time-cost trade off and resource allocation has been investigated. The values of improvement demonstrate that splitting has significant impact on final results.

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TRUST AND MONEY: 20 YEARS OF (NO) PROGRESS?

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Abstract
In almost 20 Years since Latham published the interim report 'Trust and Money' in which he asserted that there was too little of either in the UK construction industry, has anything changed? This paper addresses issues of what trust is, how it is created and its fragility, and progresses to examine how trust operates in the construction industry. The second major thread, money, is examined in the context of the economics and financing of construction projects and organisations in an era in which globalisation of the finance industry has occurred as well as global and local crises in that industry and many countries economies. Market emphases and process changes have occurred at several levels, continuing existing trends but also spawning new ones. A key question, which is examined as the underpinning, central theme of this paper, is that although structural changes and procedural changes are highly evident, what has changed in behaviour within the industry, why, and with what consequences regarding trust and money?

Keywords: behaviour, construction, finance, globalisation, projects, trust.

INTRODUCTION

Money has always been a vital consideration for construction projects. Emperors in ancient China endured financial restrictions in constructing the Great Wall and the Forbidden City; Christopher Wren endured and overcame financial shortfalls in the construction of the new St. Paul's Cathedral, Sydney Opera House and the Channel Tunnel both vastly exceeded their budgets and securing the additional finance required proved hugely problematic and left notable legacies! A further complication was articulated by Denning LJ who identified cash flow as the 'life blood of the construction industry'. Indeed, it may be argued that the profession of Quantity Surveying, in its various guises and contexts, developed out of a desire to achieve financial control in the industry.

Trust has changed as processes and procedures have altered and relationships between people have responded. The industrial revolution seems to have been a watershed with a rapid transition from craft guilds' masters and journeymen transacting on reputation and trust amongst relatively few persons who conducted small numbers of transactions with the individuals well known to each other and the community, to numerous transactions amongst persons largely unknown to each other. A direct result was the increase in use and importance of contracts to govern relationships and enforcement of the terms of agreements. Thus, trust became replaced by (legally enforceable) assurance.

In December 1993, the interim report of the 'Latham' review of UK construction industry procedures was published under the title of 'Trust and Money' (Latham, 1993), forcefully asserting that there was not enough of either in the UK construction industry. The full report was published in 1994 which, although much more 'glossy' and detailed concerning payment terms and practices and the call for 30% improvement in productivity, much of the message regarding trust and various aspects on money was obscured (Latham, 1994). Nonetheless, the 'Latham Report' has had significant impact through consequent legislation (Housing Grants, Construction and regeneration Act 1996), promotion of 'partnering' in construction, outlawing 'pay-when-paid' terms, and promotion of the New Engineering Contract (NEC). Effects have reached far beyond the shores of UK.

Construction projects operate as informal joint ventures where both individual and aggregate performance is determined by behaviour of interdependent actors in the coalition; Sherman (1992) finds that '…one third of strategic alliances failed due to lack of trust among trading partners'. Thus, this paper examines the major issues of trust and money raised by Latham (1993) to determine their underpinnings in theory and practice and what has occurred in the (UK) construction industry to address those issues.

> I tell this tale, which is strictly true,
> Just by way of convincing you
> How very little, since things mere made,
> Things have altered in the building trade.
>
> (Kipling, 2011)

HUMAN BEHAVIOUR

The general behavioural assumption in many social sciences is of ultimate self-interest (e.g., Dawkins, 2006). Under that assumption, individuals behave to maximise their own satisfaction and firms behave to maximise their own profits – more appropriately, profitability. However, the severence of ownership and management in modern corporations and the recognised importance of growth of the firm has modified the single objective assumption to be replaced by the objective of maximising growth, subject to a minimum profit constraint (Baumol, 1959).

Even in highly developed Western capitalist market economies, grounded in very individualistic societies (see Hofstede, 2001), there is increasing evidence that such assumed behaviour by individuals and firms is not universal (e.g., Etzioni, 1988; Perrow, 1986). Not only do firms, of necessity, examine and respond to the demands of powerful stakeholders, their activities are increasingly subject to legislative constraints (health and safety, environmental protection, etc.). However, despite the evolution of apparently altruistic behaviour, including citizenship behaviour, corporate social responsibility (CSR) / performance (CSP), and greening/sustainability, a strong core of adherence to self interest remains (Friedman, 1970; Coase, 1937; Williamson, 1985).

Thus, human behaviour comprises a blend of motivators/drivers – self interest through utility maximisation (which tends to be highly materialistically oriented) and morality through the operation of ethics to give regard to the welfare of others. Resultant behaviour is dependent upon personality, culture and social institutions together with the context of the particular situation as perceived by the actor(s).

Commonly, personality is analysed through the 'big five' personality traits (Costa and McCrae, 1988) of Extroversion, Agreeableness, Conscientiousness, Emotional stability (Neuroticism), and Intellect or openness to experience. Traits describe what people are like, while values refer to what people consider to be import and, thence, the goals they endeavour to pursue (Roccas, Sagiv, Schwartz and Knafo, 2002).

Culture constitutes the social context in which activities occur. Culture is a group construct, commonly defined as 'the collective programming of the mind which distinguishes one category of people from another' (Hofstede, 1994). Culture is analysed at the levels of the society (national) and the organisation; organisational culture is acknowledged to be embedded in the national culture. Hofstede's five dimensions of national culture are Power Distance, Collectivism/Individualism, Masculinity/Femininity, Uncertainty Avoidance, and Long-Termism / Short-Termism; the six dimensions of organisational culture are: Process – Results Orientation, Job – Employee Orientation, Professional – Parochial, Open – Closed System, Tight – Loose Control, and Pragmatic – Normative (see Hofstede, 2001).

Both Denison (1997, 2009) and Cameron and Quinn (1999) employ competing values frameworks to model organisational cultures. In Denison's (1997, 2009) model, flexibility and stability are juxtaposed along one dimension with organisational focus – internal juxtaposed to external – on the other dimension. The resultant quadrants comprise mission, consistency, involvement and adaptability. In Cameron and Quinn's (1999) model, 'flexibility and discretion' is juxtaposed to 'stability and control' on one dimension with 'internal focus and integration' and 'external focus and differentiation' juxtaposed on the other. The resultant model comprises four quadrants, each denoting a type of organisational culture – Clan, Adhocracy, Market, Hierarchy.

Handy (1985) suggests a typology of organisational cultures. Power culture is depicted as a web with the major power at the centre, emphasising control over subordinates and external agents (suppliers etc., and nature). A role culture focuses on functions/professions which provide support to top management; emphasis is on rules, hierarchy and status through legality, legitimacy and responsibility. In a task culture, jobs or projects are the major foci; an organisation is regarded as a net (as in a matrix organisation); structures, functions, and activities are evaluated in respect of their contributions to achievement of the organisation's objectives. In a person culture, people interact and cluster freely and emphasise meeting the needs of members of the organisation through consensus. Handy considers that the main factors influencing which organisational culture develops are: goals and objectives, history and ownership, size, technology, environment, and people. Williams, Dobson and Walters (1989) advance categories of 'Power', 'Role', 'Task', and 'People' which correspond to Handy's (1985) typology.

Hall and Hall (1990) employ the concept of high context / low context to analyse cultures. In a high-context culture, there are many contextual elements that help people to understand messages, behaviour and other manifestations of the culture. Meaning must be derived from the message itself and the prevailing circumstances/situation – much intuition is necessary together with a thorough understanding of both the language and the society. In a low-context culture, very little is taken for granted. Thus, much more content is needed but the resultant message is precise and explicit in its meaning and so, there is a low chance of misunderstanding; thus, people can be quite confident to interpret messages at 'face value', although such direct and obvious expression can be offensive to people from high context cultures.

Hall and Hall's second dimension concerns how people perceive time along a dimension of monochromic / polychromic. Monochronic time means doing one thing at a time, often in a

predetermined sequence. In more complex situations (such as a construction project), it requires careful planning and scheduling to be carried out and is usually assumed/adopted in 'time management'. Monochronic people tend to be low context (high content). In Polychronic perceptions of time, human interaction is valued over time itself and material things. That generates a low concern for 'getting things done' – they get done, 'in their own time'. Polychronic people tend to be high context.

'Organizational Climate is a relatively enduring quality of the internal environment of an organization that (a) is experienced by its members, (b) influences their behaviour, and (c) can be described in terms of the values of a particular set of characteristics (or attributes) of the organization.' Tagiuri and Litwin, 1968: 27). Hence, the climate of an organisation distinguishes it from other, similar organisations. As organisational climate both reflects and shapes the work-experiences shared by members of an organisation, it indicates their perceptions about autonomy, trust, cohesion, fairness, recognition, support, and innovation and so, leads relative homogeneity amongst members through recruitment and retention.

Norms of acceptability and rules of human behaviour are often embodied in social institutions. Those institutions comprise both formal and informal organisations, including governments, firms, professional institutions, friendship groups. Social institutions include meta-organisations, such as an industry, and systems of organisations, such as an economy. Further types of social institutions are not organisations but are important influences on society and its constituents, such as a religion, and a language.

All those primary variables of human behaviour, group and individual, combine to determine actual behaviour in any given context/situation. Naturally, the variety of mixes of influence of the behavioural determinants lead to very different behaviours by people in a given situation – understanding, tolerance and consideration (towards others) are, therefore, important features of human interactions, together with subjective assessments of how others will behave proactively and reactively.

TRUST

Trust, the antithetical compliment of risk, is always an element in the decision to engage in a (business) relationship. Generally, trust is defined as 'Confidence in or reliance on some quality or attribute of a person or thing, or the truth of a statement.' (OED, 2009) or, in relationships, trust may be considered to be adequate confidence (on the part of the subject actor/participant) that the other participant(s) will not cheat – that the other will not behave to cause detriment to the actor. Perhaps the most widely employed definition is '…willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party' (Mayer, Davis and Schoorman, 1995). Thus, trust is an ***expectation*** of future behaviour rather than a certainty and so, incorporates a probability of betrayal (Zaheer, McEvily and Perrone, 1998). Trust may be unidirectional or mutual.

Trust may be classified in several alternative ways. For initial, or individual, encounters between actors, dispositional trust is appropriate (do the actors intuitively regard others to be trustworthy or are they cautious, wary of others and so, take precautions for their self-protection?). Additionally, trust may be based on the reputation of the other (reputational trust), which, then, operates to modify dispositional trust. For recurring encounters, trust may be based on experience (of others generally and of the particular others) – experiential trust. Trust may relate to individuals and to organisations (through their agents) – interorganisationally and between organisations and individuals (see, e.g., Lau and

Rowlinson, 2009). Bachmann (2001) classifies trust as relating to people (personal trust), institutions (as organisations) and the system (technical, political, social,economic and legal).

Zaheer *et al*. (1998) suggest that concepts of trust comprise components of predictability, reliability and fairness – which relate to others and their performance, both process and (especially) outcomes. Further, in addition to trust in the system, they consider the human facets of trust as cognition, behaviour and emotion (affect).

In a social context, trust is categorised as generalised (relating to trust exhibited by members of that society in its broad context) or particularised (between members of small communities who know each other and with strong social controls). Further, Arrow (1972) considers calculative (instrumental) trust which depends upon rational self-interest, whilst Bachmann (2001) finds that behaviour is determined by beliefs and knowledge rather than by explicit calculations regarding gains/losses.

Convergent interests between actors fosters trust (conversely for distrust). Further, continuing relationships leads to relational trust arising from experience of interactions between the particular actors. Interorganisational trust concerns the extent to which members of an organisation hold a collective view regarding the trustworthiness of the other organisation(s) (Zaheer *et al*., 1998). Hence, organisational culture and climate impact on perceptions of trustworthiness and trust behaviour between organisations.

Yamagishi and Yamagishi (1994) distinguish trust and (performance) assurance in that if one actor trusts another because the former has some provisions in place so that the latter has an incentive to cooperate, then that situation is one of assurance; trust exists when an actor believes that the other has an incentive to 'cheat' but does not do so – perhaps because of goodwill.

Hagen and Choe (1998) note that, '…a trust relationship in business involves an expectation of cooperation but not an expectation of altruism'. 'The Chinese system of networked transactions…is relatively uncodified, and it is based on trust and long standing personal connections' (Boisot and Child, 1996). Thus, social institutions give rise to differing levels of trusting behaviour through the required behavioural norms (and limits) and sanctions for transgressors (who are caught); those institutions also impact on trustworthiness of individuals and organisations and, hence, on apparent dispositional trusting behaviour.

'The relationship…in Japan is not built primarily on trust, but on the mutual interdependence enshrined in the agreed-upon rules of the game' (Womack, Jones and Roos, 1990:155). That is afforded more general applicability by Hagen and Choe (1998) who state that '…the institutionalized industry practices that we call 'institutional sanctions' in the context of societal sanctions, are key determinants of interfirm cooperation', as manifested as the deterrent based trust in Japanese industry.

Although trust and distrust are commonly viewed as opposite ends of a single dimension, that may not be appropriate (Lewicki, McAllister and Bies, 1998). Given that many business relations are multi-faceted, '…relationship partners might trust each other in certain aspects, not trust each other in other respects, and even distrust each other at times.' (ibid). That finding suggests the contingent nature of relationships together with the importance of culture and perceptions of cultures in determining behaviour. Likewise, trust comprises components of amount and scope (realms of trust and ways of trusting) (Rousseau, Sitkin, Burt and Camerer, 1998). Those aspects arise because, usually, relationships are multifaceted and those facets may be treated seapartely.

Thus, interorganisational relationships are complicated and, for each major componemt, amounts and types of trust and distrust are likely to differ.

Uncertainty and trust are the two primary constructs which affect relationships and their institutional arrangements (Sheth and Parvatiyar, 1992). Bachmann (2001) views trust and power as means for social control within business relationships. Those concerns are commonly manifested in the criteria for selection of participants and the establishment of safeguards against opportunistic behaviour; thereby increasing *ex ante* costs in the venture (Williamson, 1985). However, Baiden, Price and Dainty (2006) find that, in the usual processes employed for selecting participants on a construction projects, the vastly dominant criteria continue to be price and perceived technical expertise – the ability of participants to integrate and cooperate to deliver the project effectively and efficiently remains, largely, ignored.

MONEY

Traditionally, beyond a barter economic system, money is a system of tokens used to facilitate exchange, usually as coins and banknotes (narrow quantifications) but now includes significant extensions to include bank deposits and credit (broad quantifications). Today, even cash is not directly exchangeable for underpinning precious metal (gold) as the vast majority of the world's money supplies are 'fiduciary issue' – i.e., backed only by confidence (in governments and economies). Consequent potential problems due to ensuing fragility of modern money have been clearly demonstrated through recent (global) financial crises.

Money performs four major functions: a medium of exchange; a store of wealth; a unit of account; and a standard of deferred payment. People and organisations require (demand) money to effect transactions (whether cash or via credit), as a 'safety net' (precaution) for unforeseen expenditures (solvency and liquidity), and for speculations (as in much property development). On the supply side, at the macro level, an economy's money supply (the total amount of money in the economy and its rate of change) is regulated by government or, as in UK, the central bank. The money supply is controlled via (short term) interest rates plus open market operations, special deposits, reserve ratios and other means of control of 'money creation' by the banks. Normally, monetary control is used in conjunction with instruments of fiscal policy to effect management of the economy by government.

In construction, money is required to meet revenue (short term) expenditures (direct/prime costs) and for investment (long term). Those types of finance are obtained from different sources and, internally, are managed by different sections of the organisation. No finance (money) is free; its price is the rate of interest (real, foregone, or 'shadow'). A market (nominal) rate of interest, within the competitive market environment, has three components – inflation (simplistically assumed to affect everything equally), time/liquidity preference, and risk. People have liquidity preference and are risk averse – both to varying degrees but each requiring compensation through the rate of interest.

Cash flow models of projects are well known and are used to assist organisations to determine their financing requirements and costs. However, given the risk distributions and returns available, coupled with the widespread emphasis on capital price competition for work allocation, much effort is devoted to 'financial engineering' and power ploys for enhancement of own, individual profitability.

'The increased uncertainty of economic activity increases the information impactedness of parties and consequently increases the potential for opportunism in economic exchange' (Korczynski, 2000), thereby reducing potential trust and, consequently, performance of the processes involved – as in UK construction.

CONSTRUCTION (IN UK) SINCE 1983

Construction in UK is in the third phase of its contribution to the socio-economy. Having gone through emphasis on infrastructure provision and on new building, now repair, maintenance, and refurbishment dominate. Construction is also subject to privatisation, concerning both the public sector as client and as a supplier of construction realisation work. An important structural and systemic change is the (universal) adoption of total subcontracting for the execution of construction operations with 'main contractors' becoming, *de facto*, management contractors.

In 2007, the output of the UK construction industry contributed over 8% of gross domestic product (GDP) at market prices and almost 54 % of gross domestic fixed capital formation (GDFCF), which, itself, contributed over 16 % of GDP. The output was mainly produced by over 192,000 private contractors, which provided employment for almost 1.3 million people, of which ¾ million were operatives. Insolvencies of construction companies and partnerships, constituted over 14 % of the total but bankruptcies of individuals, self employed persons, etc. in construction had experienced a steady decline to only 3.5 % of the total (Office for National Statistics, 2009a; 2009b.)

The mix of output, by type of work, (2007) was about 58% new work (includes refurbishment etc.) and 42% repair and maintenance. Of the new work, just over 10% was infrastructure, 34.5% was housing (82.5% private), 21.5% private commercial and 7% private industrial; public housing and non-housing comprised almost 21% of total new work. Of the total repair and maintenance work (housing and non-housing), 67% was done by the private sector (Office for National Statistics, 2009a).

During the third quarter of the twentieth century the public and private sectors each commissioned about 50% of construction output. Given that (most) construction is a producer good, with stock far dominating annual (new) supply and that construction is a relatively independent industry regarding its inputs and outputs (expenditure on construction is 'postponable', at least in the short term), the operation of the Keynesian multiplier, coupled with successive governmental attempts at management of the economy, the industry was subject to cycles of 'boom and bust' (whether intentional or otherwise is contested – see, e.g., Hillebrandt, 2000: 23-28), the effects being magnified by the accelerator principle. Thus, turbulence forces in the environment over many years have shaped the industry culture of opportunistic behaviour.

Prior to Latham, a raft of reports presented analyses of facets of the industry and recommendations to enhance its performance; since Latham, the incidence of further such reports, with consequent initiatives for change, has intensified (see, e.g., Murray and Langford, 2003; Constructing Excellence, 2009). Essentially, Latham (1994) provided the foundations on which subsequent reports have built, notably, Egan (1998) but what remain largely omitted is the fundamental message of Latham (1993).

Latham (1994) articulated the impetus for 'partnering', asserting that such practices could achieve 30% saving in cost within five years(!) plus the significance of the client role; in respect of finance and cash flow, 'pay when paid' terms, extensive delays in making payments and 'bid shopping' were condemned. Four years later, Egan (1998), drawing on experiences in production industry and major construction clients, strongly advocated 'lean' production for the industry. Egan's perspective and performance change targets are shown in figure 1. Subsequently, additional reports etc. have developed the outputs of Latham and Egan – not just in UK but internationally; some countries have reinforced their desires for change with legislation.



Figure 1: *Achievements of UK Construction following Egan (source: Constructing Excellence, 2009:7)*

Constructing Excellence (2009) provides some salutary views on 'partnering': '…many so-called partners still seek to avoid or exploit risk to maximise their own profits, rather than find ways to share risk and collaborate genuinely so that all can profit…Companies who say that they partner will still seek to retain profit for themselves and pass risk down the supply chain…'. Further, '…we cannot assess how far the improvements in, say, profitability are attributable to favourable economic conditions…as opposed to process efficiency…'.

CIOB (2010) report a survey investigating what CIOB members of the UK construction industry regard as important issues in procurement. Amongst the issues are that clients are not sufficiently knowledgeable, 'suicide bidding' (leading to adversarial, opportunistic behaviour), and cover pricing. KPMG (2010) Global construction survey finds that margins are very tight, financing remains a big challenge for clients, competition is extensive, and 'red tape' is increasing. In accord with the findings of CIOB (2010), KPMG (2010) note that '…39 percent of the larger organizations said they were reducing prices to near break-even…Some are hopeful of making up such shortfalls further down the line through change orders and greater internal efficiency, and by demanding lower sub-contractor pricing'.

DISCUSSION

Mayer et al. (1995) develop a model of trust in which a trustor examines a potential trustee's technical ability, benevolence, and integrity to determine that trustee's trustworthiness which is, then operationalized into trust by the trustor, as moderated by the trustor's propensity to trust. Thus, trust occurs between actors and depends on purpose, context and time. Trust may occur between individuals and organisations but only the potential for trust, as in propensity to trust, seems to be applicable to a society as a generic feature/dimension. That conceptualisation, raises concerns over whether and, if possible, how Latham's assertion of too little trust within and relating to the construction industry may be addressed.

Literature suggests that there is a fairly strong relationship between interorganisational trust and performance, relating to interorganisational exchanges, negotiations, and conflict (Zaheer *et al.*, 1998); the longer relationships have endured, the greater the trust is likely to be. However, a caution involves 'contractual trust', which is assurance rather than trust *per se* and may be appropriately considered as reliance which operates as '…institutionalised standards to reduce potential risks…manifested in legal agreements…' etc. (Jiang, Henneberg and Naudé, 2010). Reliance, implies dependence – which seems a more appropriate

conceptualisation of relationships between participants in the realisation of construction projects, while relationships with other stakeholders may be more trust oriented.

'…when contingencies arise, such as unexpected costs…or unanticipated design changes, high levels of interorganizational trust enable the parties to address the contingencies without resort to legalistic remidies…the parties will tend to direct their efforts toward determining how best to reach mutually beneficial solutions' (Zaheer *et al*., 1998). However, due to the nature of the temporary multi organisations (TMOs), which are assembled bespokenly for each project, Korczynski,'s (2000) finding is apposite, 'In situations of power imbalance there is a temptation to enforce cooperation through power rather than trust'. That finding is reinforced by Bachmann (2001), 'In the British…business system, the risk of trust often seems intolerably high, and businessmen in many situations can find good reasons to consider their sources of power'.

Duarte and Davies (2004) note a positive relationship between trust and cooperation (although the causal relationship sequencing is contested), reduced conflict and increased commitment; they also discuss the empirical results which indicate satisfaction to be a consequence of trust. That perspective is detailed by Kwon and Suh (2004) '…a firm's trust in its supply chain partner is highly associated with both sides' specific asset investments (positively) and behavioural uncertainty (negatively). It is also found that information sharing reduces the level of behavioural uncertainty, which, in turn, improves the level of trust. A partner's reputation in the market has a strong positive impact on the trust-building process, whereas a partner's perceived conflict creates a strong negative impact on trust….the level of commitment is strongly related to the level of trust.'

Those findings support 'relational contracting' in its various guises. Unfortunately, empirically based findings regarding behaviour in the UK industry (e.g., Baiden, *et al*., 2006) demonstrate absence of the fundamentals and emphasis on uses of power for self-gain.

The issues of lack of trust and consequent behaviour spawn financial problems for the industry – the extensive uses of market power to allocate work and drive down prices, low profitability prompting investment difficulties, including securing finance to supply projects, opportunistic behavious to reduce costs and enhance cash flows, etc. The resultant risk distributions and performance concerns exacerbate the self-reinforcing cycle such that clients have problems in securing finance for construction too and so, prompt the cycle further. Indeed, major clients who have extolled the mutual virtues of partnering to construction have been found to practice in their own industries the very behaviours which they condemn in construction!

CONCLUSIONS

Construction is an important but relatively independent industry which may serve to enhance the turbulence of its activities. Given risk aversion, it is hardly surprising, therefore, that the industry operates opportunistically for its self-protection and survival of individual firms as well as having strong preference for the *status quo* and reluctance to invest. The industry, in addition to its many well-known caricature descriptors, may also be denoted as being suspicious and wary of suggested initiatives, hence, not prepared to trust and of questionable trustworthiness – both applying inwardly and outwardly.

By definition, the culture of the industry is deeply ingrained and very difficult to change – and that, only in the long term through enduring means which convince participants to change. Latham's concerns for trust and money, and the many reports and initiatives subsequently, have failed to address the fundamentals as well as the more superficial

behavioural cycles involving trustworthiness, trust behaviour, performance and finance. Indeed, it seems that research is required to identify the cycle and its cause-effect linkages as, only with such understanding, can real opportunities for improvement change be identified.

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THE LEVEL OF COMPLIANCE WITH THE PUBLIC PROCUREMENT ACT (ACT 663) IN GHANA

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Abstract

The Public Procurement Act (Act 663) 2003 was introduced in Ghana to streamline the anomalies in public procurement. The objective of the law is to promote fairness, transparency and ensure that public procurement is non-discriminatory. The implementation of the Public Procurement Act 2003 (PPA) has been quiet challenging coupled with a number of inefficiencies. The aim of this study is to observe and compare the extent to which selected public procurement entities have complied with the processes and requirements of the Law during the year 2008. The entities were chosen from the Ashanti and Brong Ahafo regions of Ghana. Structured questionnaire and face-to-face interviews were used to obtain data for this study. The overall compliance levels in the Ashanti and Brong Ahafo Regions lies at 19.58% and 17.8% respectively. This indicates low compliance levels of public entities. The study confirms that the Public Procurement Act 2003 (Act 663) is observed to proffer solutions but not without challenges. In the pursuit to improve compliance with the Act the study recommends that public entities recruit procurement personnel and organize intensive and regular procurement training for the personnel handling public procurement especially in the area of procurement processes.

Keywords: Ghana, Public Entities, Public Procurement, Public Procurement Act, Compliance

INTRODUCTION

In Ghana, the Public Procurement Act (Act 663) 2003, was enacted to harmonize public procurement processes in the public service, secure judicious, economic and efficient use of state resources, and furthermore, ensure that public procurement is fair, transparent and non discriminatory (Ministry of Finance, 2001). This new Act, was constituted after years of foul play and abuse as far as procurement was concerned in the country. This necessitated a thorough review of the existing procurements regulations. The enactment of the law in 2003 further

ensured that modern trends in procurement was adopted to bring about the much needed sanity to local procurement system which had been flawed by bad procurement practices such as corruption and other malfeasances (Osei-Tutu *et al*., 2010).

In Ghana, public procurement accounts for 50%-70% of the national budgets (after personal emoluments), 14% of GDP and 24% of imports. Implicitly, public procurement therefore has both social and economic impact on the country (World Bank, 2003a).

Assessment of Public Procurement Entities

Increasing the effectiveness, efficiency and transparency of procurement systems is an on-going concern of governments and the international development community. All countries have recognized that increasing the effectiveness of the use of public funds, including funds provided through official development assistance (ODA) requires the existence of an adequate national procurement system that meets international standards and that operates as intended.

The regular and continuous assessment of procurement entities in countries of their national procurement systems with regard to their compliance with the procedures, rules and regulations setup in the Public Procurement Laws has been embraced worldwide.

The baseline indicator assesses the strengths and weakness of National Procurement Systems. The indicator covers the legal and regulatory instruments from the highest level (national law, act, regulation, decree, etc.) down to detailed regulation, procedures and bidding documents formally in use. These indicators can be broken down into eight sub-indicators which are individually scored. These are: Scope of application and coverage of the legislative and regulatory framework, Procurement Methods, Advertising rules and time limits, Rules on participation, Tender documentation and technical specifications, Tender evaluation and award criteria, Submission, receipt and opening of tenders and Complaints (OECD-DAC/World Bank, 2006).

Performance indicators includes: Implementing regulation that provide defined processes and procedures not included in higher-level legislation, Model tender documents for goods, works, and services, Procedures for pre-qualification, Procedures suitable for contracting for services or other requirements in which technical capacity is a key criterion, User's guide or manual for contracting entities and General Conditions of Contracts (GCC) for public sector contracts covering goods, works and services consistent with national requirements and, when applicable, international requirements (OECD-DAC/World Bank, 2006).

For a public entity in a developing country to conduct procurement performance assessment, there are numerous challenges that are encountered. Notably among them are: i) there are many ways of measuring that may be in use, ii) most measures are irrelevant iii) there is no way of standardizing the measurements and iv) conducting performance measurement is costly (Kakwezi & Nyeko, 2010) .

Performance/Compliance of Procurement Entities

The Public Procurement Authority in its review in 2006 identified the weakness in the public institutions that need urgent attention. These are: Lack of qualified procurement personnel, incorrect interpretation and application of some provisions of the procurement Act, slow pace in regularizing the Draft Regulations, lack of clear procedures for Emergency Procurement, lack of Training Avenues or Institutions, poor Record Management (scattered files), poor handling of Suppliers' Complaints, poor Procurement Planning, Mobilization & Implementation, poor Contract Management and high cost of Advertisement (PPA, 2007).

Country Procurement Assessment Report (CPAR), prepared by a team of Government officials, World Bank and donor staff, and national consultants, reveals substantial inefficiency in public procurement and concludes that the principle of "value for money" is not achieved. This is true for both governments financed and donor financed procurement. The main findings of the 2002 Country Portfolio Performance Review of World Bank projects also reviewed slow project implementation and disbursement among other factors due to, a large extent of inadequate procurement planning, non-transparent procurement procedures and poor contract management. A review in 2002 of 132 works contracts which constitute an important part of public expenditure indicated that about 84% incurred cost-overruns of up to 30% of the initial amount (World Bank, 2003b). Similar findings of public procurement weaknesses were recorded in the 1996 Country Procurement Assessment Report (World Bank, 1996).

Successive waves of management and financial reforms have, inter alia, focused on improving public procurement efficiency, effectiveness and outcomes (Calendar & Matthews, 2002). Requirements for greater performance produce a refocusing of procurement management away from accountability for compliance through rule-bound codified processes (McCue & Pitzer, 2000) towards accountability for outcomes.

Public Procurement Law and Implementation Challenges

In most developing countries, the procurement function is transitioning from a clerical non strategic unit to an effective socio-economic unit that is able to influence decisions and add value (Knight et al, 2007). Developing countries in one way or another have reformed their public procurement regulations. The reforms have not been limited to regulations only; they have included public procurement process, methods, procurement organizational structure, and the workforce. The reforms have been as a result of joint efforts with various development partners like the World Bank, International Trade Centre, WTO, and UNCTAD varying from country to country.

In addition, public procurement is faced with the challenges imposed by a variety of environmental factors (external factors) such as market, legal environment, political environment, organizational and socio-economic environmental factors. Regardless of the effort by the central government and its related agencies and the acknowledgement that the procurement department is capable of adding value to the organization, still a large number of the internal customers act on their own and more frequently bypass the procuring department

(Schiele & McCue, 2006). This problem requires establishment of clear procurement procedures and performance standards. Performance when adopted will provide the decision-makers in the procurement department with unbiased and objective information regarding the performance of the procurement function (Knudsen, 1999).

Several countries have instituted reforms in their public procurement processes (Hunja, 2003). This is aimed at purging the public procurement sectors, encouraging competition, transparency, efficiency and ensuring accountability. These reforms have not come without difficulties (Hunja, 2003). The challenge include poor dissemination of the procurement law (Azeem, 2003), lack of proper training for the managers of the procurement process (Forgor, 2007).

The Country Procurement Assessment Report of Ghana in 2003 revealed that most Ministries, Departments and Agencies (MDAs) and District Assemblies (DAs) staff responsible for procurement were not procurement-proficient, even though they have been trained. The report contended that, application of the PPA and the Standard Tender and Contract Documents will not be successful without broad training and "refresher" programs and encouragement of officials in charge of procurement. In view of this, the PPA initiated a training programme in 2007 throughout the country with the aim to build the capacity of personnel responsible for the management of procurement in various institutions. This exercise unfortunately could not be sustained due to financial difficulties thereby leaving most Procurement Managers completely ignorant in the application of the law.

Building the capacity of service providers has been identified as one of the success factors of public procurement reforms. Many bidders are limited in various capacity issues including: lack of basic knowledge in the law, inadequate capacity to appreciate the standard tender documents, poor access to tender information and insufficient technical and managerial skills to be competitive in the tendering process (ODPP, 2007).

Political interference with the procurement process is also a big challenge to the implementation process and public procurement reforms. A good number of politicians think that they have the right to intervene in the procurement procedures thereby leading to a capricious procurement decisions (World Bank, 2004b).

The lack of career development path and low salaries of procurement personnel also militates against procurement reforms implementation (World Bank, 2003a). Poor records keeping (World Bank, 2003a), (ODPP, 2007) and delays in payment of contractors and suppliers have also been cited as some of the crucial factors that challenges the procurement reforms implementation (Azeem, 2007).

Corruption and Inefficiencies in Public Procurement

It is vital to make a distinction between instances of corruption and cases of inefficiency or lack of competence. While these problems occasionally go hand-in-hand, and some solutions are helpful in all areas, there are also trade-offs. For example, choosing to speed up a Procurement process might condense its transparency, making it very efficient but more prone to corruption. Moreover, it is important to realize that there is no single solution to the problem. Procurement processes need to be permanently monitored. Supervision and control play a key role since good

rules are necessary but not always enough to curb corruption. It is also important to have clear and publicly available procedures and to have regular audits by external parties.

Also, the 2009 Corruption Perception Index (CPI) released by Transparency International (TI) shows Ghana not making progress in the fight against corruption through passing of legislations. The country maintained its 2008 score of 3.9 in the 2009 CPI report. Ghana's score in the Transparency Internationals report, points to the fact that corruption is still deeply rooted in the country's procurement process (Transparency International, 2009). For example, a 2002 internal audit report revealed significant procurement irregularities in some of the major hospitals in Ghana.

There is a knowledge gap on how the procurement assessment can contribute to improved performance of the procurement function in developing countries. Only when the procurement function is well planned, that it is easy to identify areas where it is performing well, and where there is need for improvement (Kakwezi & Nyeko, 2010). Organisations which do not have performance means in their processes, procedures, and plans experience lower performance and higher customer dissatisfaction and employee turnover (Artley & Stroh, 2001, Amaratunga & Baldry, 2002 and CIPS Australia, 2005).

Thus the objective of the study was to find out the level of compliance of public procurement entities in Ghana with the Procurement Law, which was instituted to address some of these observed anomalies.

RESEARCH METHODOLOGY

The methodology for assessment of national procurement systems jointly developed by the Organization for Economic Co-operation and Development (OECD)/Development Assistance Committee and World Bank has been adopted in this research.

The methodology presented herein includes a numeric scoring with defined criteria that will enable the monitoring of indicators providing a qualitative scoring of the procurement system in place in procurement entities.

The indicators are intended to provide harmonized tools for use in the assessment of procurement systems. Although the indicators are designed for use in the assessment of the central government or national procurement system in a country, they can be adapted for use in sub national or agency level assessments. There are two parts of the indicators: baseline indicators (BLIs) that deal with the formal and functional features of the existing system; and compliance/performance indicators (CPIs), that deal with monitoring performance data to determine level of compliance with the formal system. The CPI's associated with the baseline indicators have been adopted since the authors intend to determine the level of compliance with the Procurement Law.

The suggested Compliance/Performance Indicators (CPIs) used has been summarized in Table 1 below. The CPIs help identify those areas where compliance or performance is weak. Based on review of the CPI data, analysis and findings were recorded.

The authors adopted four main Compliance Areas in the study. Indicators that designated compliance were also used. Specific information or records that designated the indicators were also identified and rated on a scale of 0 – 5; "0" rating indicates absence of the required information whilst "5" indicates that the information available is satisfactory.
The analysis was carried out by aggregating the statistics obtained from the rating. In all instances, a minimum of 20 contracts were sampled to enable subsequent analysis. Analysis of the data helped to determine the degree of compliance, measured in terms of percentage, within a given compliance area. Obtaining a 100% would imply that the entity fully complies with requirements of the procurement law in the particular area.

Four main compliance areas were adopted for determination of the compliance levels. Compliance levels in the areas were assessed based on certain indicators, which were used as sub-criteria for assessing the four main compliance areas adopted. Specific information were included in the questionnaire to aid in the assessment of the indicators. In developing countries, Ghana not being an exception, data on the baseline information are not available. Hence, the authors restricted themselves to assessing compliance levels based on the four main compliance areas.

Sampling Procedure and Data Collection

A purposive sampling was adopted for the survey. The study purposively targeted public entities in the categories of local government, education and health as representation of procurement activities of the regions for the financial year 2009. The simple method of calculating averages was employed in the computations. The ratings of the performance under each procurement area were done by the authors using a predetermined key Compliance Indicators (KCI's). In all a total key of 85 and 61 entities were assessed in both Ashanti and Brong-Ahafo Regions respectively.

Main Compliance Areas	**Key Compliance Indicators**	**Information rated on a scale of 0-5**
MANAGEMENT SYSTEMS	Effectiveness of Leadership	• Training programme(s) in place • Seeking technical support from the body with oversight role • Carrying out internal procurement auditing • Good record keeping
	Human Resource Development	• Having Staff with professional procurement qualification • Putting internal auditors in place and giving them procurement training • Evaluation of performance of procurement staff
	Monitoring and Control Systems	• Putting proper payment systems in place for every contract • Capturing procurement transactions in Cash budgets • Putting in place quality control mechanisms for contracts • Effective use of available procurement information dissemination systems
	Compliance with ethics and regulatory framework	• Appropriate use of procurement plans and contract documents • Use of Standard Tender Documents (STD) and Manuals • Use of right procurement methods • Anti-corruption measures put in place
	Complaints system, structure and sequence	• Fairness and transparency in resolution of cases within the terms established in the legal framework
INFORMATION AND COMMUNICATION	Procurement Information searching and Dissemination	• Awareness of use procurement website, procurement internal notice boards and newspapers • Capacity to use and using the procurement information dissemination systems

COMMUNICATION	Interaction with the marketplace	• Having knowledge of and interacting with the marketplace • Interacting with all procurement stakeholders
PROCUREMENT PROCESSES	Procurement Planning	• Having an adequately defined procurement plan • Posting plan on the net
	Procurement Publicity	• Advertising tender invitations • Sending information for placement in procurement bulletin • Using internal notice boards to display procurement information
	Bid Preparation and Invitation	• Use of STDs • All bid documents containing same evaluation criteria • Stating reasonable date and time for bid opening
	Submission, opening and evaluation of bids	• Stating date, time and venue for bid submission • Stating date, time and venue for bid opening • Having secured tender box in place • Having tender opening register • Keeping minutes of bid opening including all opening records • Evaluating tenders in accordance with tendering requirements
	Award of Contract	• Notifying Winner of Contract • Publicizing contract awards • Notifying losers of bid
CONTRACT MANAGEMENT	Project Planning and Mobilization	• Taking Works Programme from executers • Taking Advance payment Guarantees for advance payments made
	Project Implementation and Supervision	• Preparation of project monitoring reports • Organization of project progress meetings • Comparing and analysing planned progress against actual
	Inspection and Inventory control	• Preparation of Handing over certificates • Preparation of completion or delivery reports • Use of appropriate stock control record system
	Disposal	• Forming the required membership of Board of survey • Keeping minutes of meetings of Board of survey • Keeping records of items disposed

Table 1: *Rating of Compliance Indicators*
Source: Adopted from World Bank/OECD/DAC, 2004

Structured questionnaire were used to obtain the data required for determining the compliance levels in all the compliance areas. To obtain further data on the actual practices and challenges encountered in applying the procurement law, the key personnel members responsible for procurement were engaged in face-to-face interviews for all the entities.

ANALYSIS AND DISCUSSION OF RESULTS

The aggregated compliance levels of all the entities obtained under the main compliance areas are as presented in tables 2 and 3 below:

MAIN COMPLIANCE AREAS	LOCAL GOVERNMENT (%)	HEALTH (%)	EDUCATIONAL (%)	OVERALL (%)
MANAGEMENT SYSTEMS	35.00	31.58	15.56	27.38
INFORMATION AND COMMUNICATION	20.54	10.53	1.39	10.82
PROCUREMENT PROCESS	37.50	23.95	5.83	22.43

CONTRACT MANGEMENT	41.07	9.21	2.78	17.69

Table 2: *Compliance level of Public entities in Ashanti Region*

MAIN COMPLIANCE AREAS	LOCAL GOVERNMENT (%)	HEALTH (%)	EDUCATION (%)	OVERALL (%)
MANAGEMENT SYSTEMS	22.61	22.67	28.18	24.49
INFORMATION AND COMMUNICATION	8.69	18.33	18.64	15.22
PROCUREMENT PROCESS	17.39	10.67	5.91	11.23
CONTRACT MANAGEMENT	45.65	11.67	3.41	20.24

Table 3: *Compliance level of Public entities in Brong Ahafo Region*

In both regions, compliance levels observed were very low as indicated by the percentages obtained in tables 2 and 3. The procurement entities had comparatively better procurement management systems in place when compared to the other three main compliance areas. However, the compliance levels of all the three sectors were below average as none was able to attain 50% in all the four main compliance areas.

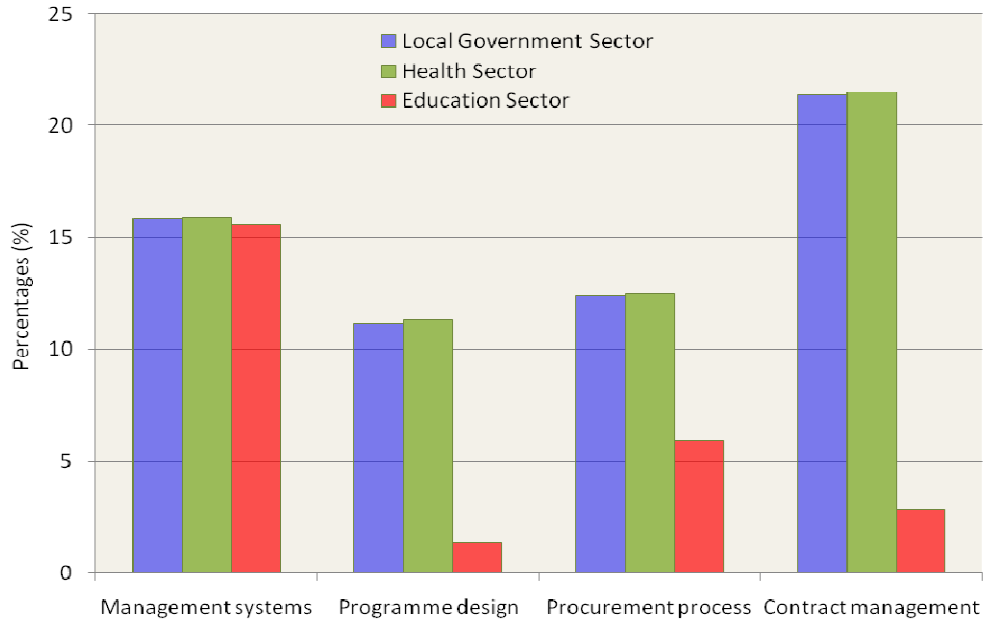


Figure 1*: Compliance level of the three sectors (Ashanti Region)*

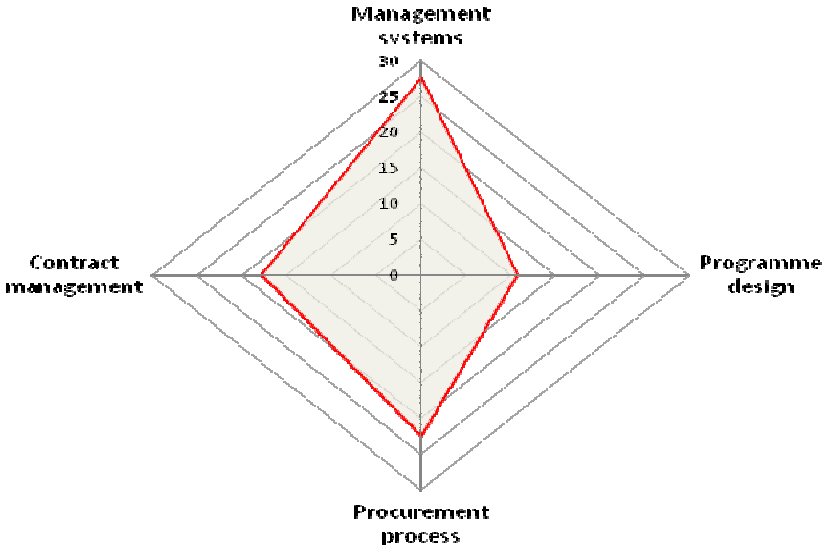


Figure 2: *Compliance levels under the Four Main Compliance Areas (Ashanti Region)*

Overall Compliance Level

The local government sector had a comparatively higher compliance figures as compared to the other sectors. The personnel at the Metropolitan, Municipal, and District Assemblies (MMDAs) are well familiar with contract management as most of the government construction projects are executed through the local government. Some supply contracts such as supply of school tables and chairs are also executed through the district assemblies. Contracts involving construction of hospital buildings are occasionally executed through the MMDAs.

Overall Compliance Level

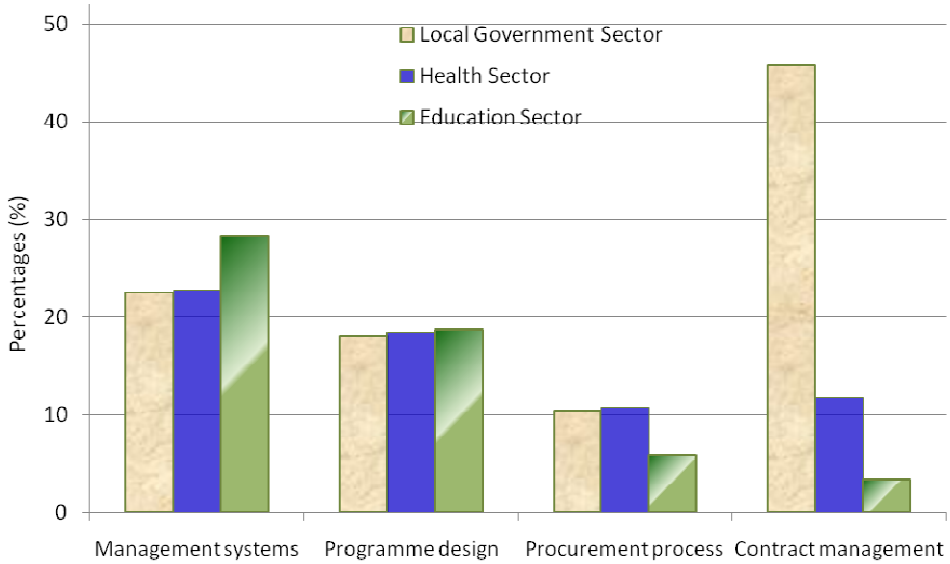


Figure 3: *Compliance level of the three sectors (Brong Ahafo Region)*

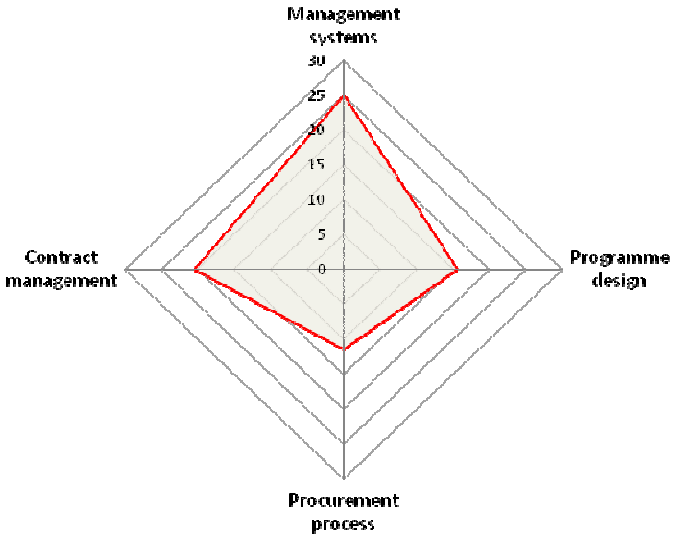


Figure 4: *Compliance levels under the Four Main Compliance Areas (Brong Ahafo Region)*

Moreover, it was found out that most of the staff members under the local government sector had the opportunity of participating in the first organized procurement training by the PPA. Hence, most of the procurement staff members are more familiar with contract management procedures resulting in better compliance level. This notwithstanding, the compliance level for this sector is found to be below average.

The health sector complied relatively better than the education sector (see figs.1 and 3). This is due to the fact that, most of the procurement undertaken by the schools (mostly second cycle and few tertiary institutions) dealt with the supply of low value procurement (perishables like tomatoes, okro, etc). In most cases personnel available were not procurement-proficient. This was evident where heads and their accountants and matrons double as procurement officers one time or the other. The procurement staff in most of the second cycle institutions complained of difficulty in following required procurement processes when dealing with such kind of procurements. This is evident by the compliance levels of 5.83% and 5.91% obtained by the education sectors in the Ashanti and Brong Ahafo regions respectively. Suggestions about developing peculiar procurement guidelines for the second cycle institutions came up in most cases.

Generally, the compliance levels of the entities under the area of procurement information and communication were on the lower side as overall percentages obtained fell at 10.28% and 15.22% for the Ashanti and Brong Ahafo regions respectively. This is probably due to the absence of access to Internet facilities in most of the district capitals. Also the authors identified that due to the absence of regular procurement training for staff of most of the procurement entities, there was lack of know-how with regards to the use of the Internet to post plans, retrieval of procurement information and other standard documents from the Internet and even the use of internal notice boards to disseminate procurement information.

Figures 2 and 4 indicate the overall compliance levels obtained by the entities with respect to the four main compliance areas. The average overall compliance level of entities in the Ashanti and Brong Ahafo regions were 19.58% & 17.80% respectively.

Under each of the four main compliance areas are key compliance indicators. Improving the management system in a public entity requires effective leadership i.e. putting in place training programs and seeking regular technical support from apex bodies. It was observed that there was lack of continuous staff capacity improvement in the procurement processes. For instance, it was found out that most of the staff in charge of procurement were not procurement proficient and have little or no knowledge of the existence of standard tender documents to be used for a given procurement as required by the Procurement Law.

Compliance with the public procurement Act, is anchored on how entities are able to conform with the outlined processes in the Act. There is a general outcry about the delays in the award of contract due to lengthy procurement processes. It is observed that, most entities are unable to award contracts on time due to inadequate planning of the procurement processes. World Bank, (2002) intimated that "misapplication of the procurement procedures and delays is as a result of uneducated procurement staff.

Generally, low compliance with some of the processes including notifying successful bidder, publicizing contract awards, notifying unsuccessful bidders, using internal notice boards to display procurement information and the use of standard tender documents is attributed to inadequate capacity of procurement personnel. In March 2005, The Paris Declaration on Aid Effectiveness highlighted the need to develop the procurement capacity of developing nations (OECD, 2005). Training of procurement managers in public entities should be on top of the agenda in the bid to ensure compliance with the law.

Contract management recorded a very low compliance level. It was observed that most entities take contract management for granted and thus are not enthusiastic at the contract management stage as compared to the award stage. There is a complete lack of information on ongoing contracts. Reports expected from procurement managers like project implementation and supervision reports, project monitoring reports, delivery reports, keeping of records of items disposed of and the use of appropriate stock control record system were generally not adequate in most of the institutions surveyed.

CONCLUSIONS

Based on the four main compliance areas adopted in this paper, the overall compliance levels in the Ashanti and Brong Ahafo Regions lie at 19.58% and 17.8% respectively. The study confirms the low level of compliance as indicated in earlier reports by the World Bank and the Public Procurement Authority. This paper affirms these findings and concludes that there is generally low compliance with the Public Procurement Act 663. The Local government sector however had higher compliance level compared to the other sectors. The Education sector has relatively low compliance level which is attributed to the kind of supplies this sector deals with. It was discovered that the sector deals with perishables and also lack storage facilities to encourage bulk purchase, hence the poor compliance level. The paper argues that the generally poor compliance with the law is due to lack of procurement proficient personnel to man public procurement, lack of resources to purchase in bulk, lack of understanding of the law, lack of Internet facilities to facilitate accessing of information from PPA and also to post adverts and procurement plans.

It is recommended that specific procurement guidelines tailored to suit the nature of procurement commonly carried out in the second cycle institutions should be developed to enable smooth compliance, frequent assessment of all entities, engaging of procurement professionals by all entities and encouraging entities to organize in-house procurement training to specifically address their peculiar needs.

The study confirms that the Public Procurement Act 2003 (Act 663) is observed to proffer solutions but not without challenges. It pencils out weaknesses and threats of the various sectors. In the pursuit to improve compliance with the Act the study recommends that public entities have to recruit procurement personnel and organize intensive and regular procurement training for the personnel handling public procurement especially in the area of procurement processes.

The paper has implications for policy makers in an attempt to strategize to improve the overall compliance level with the public procurement law. Complete conformance to the recommendations of this paper would guarantee maximum adherence to the law, enhance efficiency in Public Procurement, increase public confidence in the procurement process, the protection of public resources and grant equal opportunity for all. Though, the paper admits that its findings cannot be generalized due to the limited nature of the sample size, it also believes that the recommendations can be benchmarked to improve on the compliance level in the nation as a whole.

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INNOVATIONS WITHIN DBFMO PROJECTS FROM A MAINTENANCE AND ENERGY-USE POINT OF VIEW

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Abstract
In most literature integrated contracting and procurement is assumed to result in more innovative solutions as a result of the intended process integration. This paper explores Design Build Finance Maintain Operate (DBFMO) cases in the Netherlands on resulting innovations focusing on maintenance and energy-use. It is assumed that in DBFMO contracts innovations on these aspects are of direct benefit for the contractor and thus the most easy to detect.
Two DBFMO office projects were compared with five traditionally build office projects. Applied research methods are explorative interviews with clients and contractors about DBFMO-contracting, case-studies focusing on maintenance costs and energy-use calculations and expert interviews with contracting parties.
Within the DBFMO cases four design choices can be considered to be innovations on maintenance and energy use. Out of the expert interviews it has been identified that four design choices of the two DBFMO cases are new solutions directly related to the way the projects were procured. The innovations detected in the case studies can be considered as the successful transfer of knowledge between departments of one contractor that would have worked independently in case of a traditional procured project.

Keywords: DBFMO, PFI, PPP, innovation, maintenance, energy-use, performance specifications

INTRODUCTION

Bundling design, construction, maintenance and operations (DBFMO) is strongly advocated by the Dutch government to improve the performance of the construction industry. The overarching term for this construction organization is Public Private Partnership (PPP) or Private Finance Initiative (PFI).
In the discussion on the benefits of these projects, the private financing is often seen as a

condition to execute the projects with assumed large advantages for public clients. Besides this several other benefits are often assumed, with regard to these project types as listed by Blayse and Manley (2004), Akintoye et al.(2005) and Leiringer (2006): lower project cost (Haynes and Roden, 1999), shorter construction time (Tiffin and Hall, 1998), competitive advantage (Lemos et al., 2003), higher overall quality of the end product (Regeringskansliet, 2000) and benefits accruing from letting the private sector be innovative in its solutions (Construction Industry Council, 1998).

Conditions for better DBFMO project outcomes

In the PPP literature some arguments are presented for the supposed conditions to achieve innovations within DBFMO projects compared to traditional projects. The first one is the integration of activities and therefore a more collaborative environment. Secondly, the demand of the client is described in performance specifications (output specifications). The third argument is the possibility of optimizing through long life cycle commitments. The last argument is about the risk transfer from public to private parties. These issues will be further discussed, because they appear not to be as obvious as they might look at first sight.

The first argument is about the collaborative environment. One provider (mostly a contractor) is responsible for the delivery of several activities over a relatively long period (20-30 years). Therefore a common view is that this could lead to better collaborative working between the different disciplines involved. In practice a special unit (special purpose vehicle) is established which is concerned with the bidding. This special unit will not execute the work themselves, but is subcontracted to other departments within or outside the providers company, like construction and maintenance. Leiringer et. al. (2009) present a case study of a large construction firm that works with PPP projects. The case study clearly illustrates how managers responsible for service operations struggle in having any real impact on key design and construction decisions. Even within PPP projects there might be struggles between the construction department and the departments responsible for operations like maintenance and facilities management. The different activities are often subcontracted separately by the special purpose vehicle, resulting fragmented interests and non-collaborative working as in traditional projects.

The most common way to formulate the accommodation demand within PPP projects is by performance specifications. Whereas the traditional approach focuses on detailed description of the building, the performance approach only focuses on performances in relation to a certain use. A provider can therefore choose solutions that are able to deliver the performance in the most efficient way (e.g. Sexton and Barrett, 2005). In a publication of the Dutch Regieraad Bouw (2005) it is claimed that formulating the demand in performance specifications is an important stimulant for letting a provider be innovative in choosing a solution. However, Leiringer (2006) suggests that due to the performance approach a provider will likely choose a solution that fits best to the existing knowledge and available techniques within their organization instead of choosing new or unique innovative solutions.

The third argument is about the possibility to optimize on life cycle costs due to longer commitments. In case of DBFMO projects multiple activities of the construction process are outsourced for a longer period to one contractual partner, namely the special purpose vehicle and the demand is formulated in performance specifications. The focus within DBFMO projects is more on the use in form of accommodation services and less on the physical building as a product delivered at a certain moment in time. Due to the longer obligations it can be suggested that a DBFMO provider focuses more on life-cycle costing by optimizing

initial investments and operational costs. Leiringer et. al (2009) claim in their case study that there is little contact between the maintenance and construction department and therefore the possibility to influence the design is minimal: “Such decisions remain dominated by an institutionalized mindset that prioritizes traditional cost cutting over any consideration of through-life operational value”.

The last argument is about the risk transfer from the public side to private parties. This can be beneficial to a public client because the chances for budget overruns are smaller (HM_treasury, 1999). Whether a larger risk transfer to private parties will lead to innovative solutions is questionable (Leiringer, 2006). Especially the development and application of innovative solutions entails additional risk, therefore the doubt in the previous mentioned reasoning seems logical.

It might be concluded that there are different opinions and types of reasoning whether or not a DBFMO provider will be innovative in its solutions to deliver the accommodation services asked for.

This study is focused on finding empirical evidence for innovations on maintenance and energy-use in DBFMO office projects in comparison with traditional office projects. The main research question is: Can innovations be detected in case a DBFMO construction organization is applied instead of a traditional construction organisation? Two DBFMO cases in the Netherlands are explored on resulting innovations focusing on maintenance costs and energy-use. It is assumed that in DBFMO contracts innovations on these aspects are of direct benefit for the contractor and thus the most easy to detect.

THEORETICAL FRAMEWORK

First the context of DBFMO projects is discussed. The second part explains how innovations on maintenance and energy-use can be defined and how they can be measured. In the last part the conceptual model used within this research is described.

DFBMO context

When a DBFMO construction organization is applied, the client is demanding an accommodation service instead of a building delivered as a product at a certain moment in time. Within a predetermined performance specification a client buys, usable space or functionality for a certain period. This is in sharp contrast with the traditional construction organization where an amount of square meter floor area is bought as a building. A provider of a DBFMO project delivers the accommodation services through a model consisting of process parts and physical parts. The process parts consist of different activities that have to be performed during the contract period like designing, building, maintaining and operating the physical parts.

Based on decomposition models for design decision making, as described by for instance Prins (1992) and Leupen (2005), in the theoretical framework a building is decomposed in physical parts in terms of single components, component compositions) and ensembles. Components and their aggregations must have meaning in terms of usage, construction and/or their life-cycle, and as such are meaningful for design decisions as well as maintenance and operations.

The influence that can be exercised on the initial investment and operational costs is the highest in the design phase. According to Kohnstamm and Regterschot (1996) the influence in design phase is 30% for the investments costs and 65% for the operational costs. However these figures that often can be found in the literature do not make clear in which proportions the different costs per activity (design, build, operations) are represented. Evans et al. (1998) give the ratio 1:5:200, where 1 represents the cost for construction, 5 the costs for maintenance and building operations and 200 the business operating costs. However this ratio seems to be highly questionable, because no data can be found in the original study on which the numbers are based (Hughes et al., 2004). One generic ratio seems also debatable because every structure or building is (relative) unique. A building as a whole is unique due to a one-off composition of spaces, materials and products. At a lower level e.g. building materials or construction methods a building often is relatively less unique. E.g. a floor finishing will not differ that much between buildings.
The process parts were not investigated within this research, because it is not clear how the process parts influence exactly the design decisions and whether they stimulate innovations. So it is assumed that all the supposed advantages of the integrated process parts have to work out on the physical parts of the structure (components, component compositions and ensembles).

Innovation on maintenance and energy-use
The term innovation is in many ways ambiguous and its wide applications has led to many definitions depending on how innovation as a phenomenon gets meaning in a variety of contexts. Definitions can be found in for instance Rogers and Schoemaker (1971), Slaughter (1998), Kleinknecht (2000), Aa and Elfring (2002) and, Garcia and Calantone (2002). Most of the definitions found contain uniqueness of new developed inventions in terms of products, markets, systems and technology combinations. In case of determining project based innovations on DBFMO construction projects these definitions aren't applicable and can't be made operational.

In order to get a better understanding of innovations from a maintenance and energy-use point of view, explorative interviews were held with staff members of a large construction firm, an architect's firm and a client who were involved in DBFMO projects. In total 11 people were asked the following questions: (1) How to define innovation on maintenance and energy-use within a context of DBFMO projects? And (2) how to detect and to measure innovations on maintenance and energy-use in case of DBFMO projects? Ten respondents stated on the first question that innovations are mostly seen as the application of life-cycle costing. The application of products and solutions that in a traditional setting are considered to be too expensive, can be seen as innovative. The majority of the interviewees answered on the second question that innovations can be detected in the design process in terms of low life-cycle cost solutions and on the physical parts of the structure due to the uniqueness of product choices and materials.
Based on the outcomes of the explorative initial study innovation on maintenance and energy-use is defined as: A better performance compared to similar traditional build projects on maintenance and energy-use by developing and applying new and improved products and solutions on the physical parts components, component compositions and/or ensemble level, which are integrated into a structure and delivering accommodation services at an agreed level for a predetermined period.
Innovation according to this definition is not a goal on itself, but has to contribute value to the accommodation services. Innovation is measured via the so-called object method. This means that innovations themselves are investigated and not the company that creates the

innovations (Archibugi and Sirilli, 2001). The possible innovations are classified into project bounded and project unbounded innovations, due to the 'relative' unique nature of structures and buildings.

Conceptual model

As argued before it might be assumed that by both the integration of the process activities design, build, maintain and operate as well a the open solutions space by specifying the demand in performances, a provider of DBFMO constructions can offer accommodation services in a more efficient way especially in terms of life-cycle optimizations. If the structure is performing better on maintenance and energy-use by developing and applying new and improved products and solutions on the physical parts in comparison to traditional projects, it is an innovation within the context of this research. This has been visualized in a conceptual model, as depicted in Figure 1.

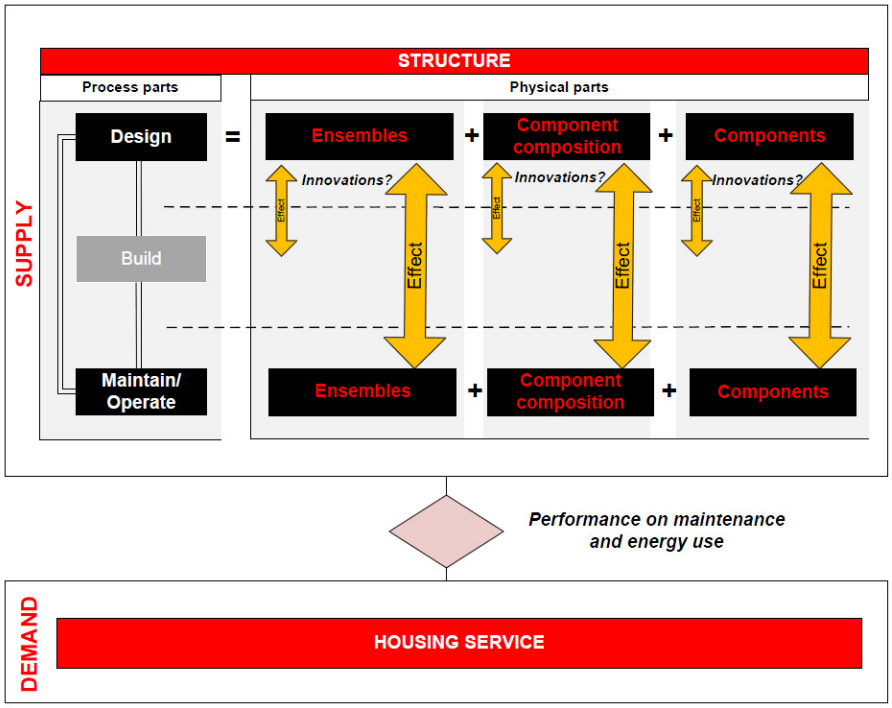


Figure 1: *Conceptual model*

RESEARCH METHODOLOGY

The research is focused on finding empirical evidence for the assumption that DBFMO projects stimulate innovations within maintenance and energy-use on the physical parts of a structure. A qualitative case study method was adopted as part of an engagement with a construction company, which has executed a large number of PPP projects in the Netherlands. This company is a leading PPP contractor at the Dutch market and has provided the data that was needed to conduct this research. The case study research consists of two components. First the 'better performance' on maintenance and energy-use had to be

determined. Second the solutions were assessed in order to determine if the better performing solutions could be classified as innovations according to the applied definition.

Case studies

In this research two DBFMO projects from a large contractor in the Netherlands are investigated. These two cases are compared with the traditional projects by means of long-term maintenance plans and expected energy consumption in order to identify possible innovations. The traditional projects were selected based on criteria for their properties in terms of comparability. Data of the traditional projects was received from maintenance consulting firms and facility management organizations. In Table 1 the different characteristics of the cases and projects studied as well as the methods used for data retrieval are shown.

Project criteria	**Case DBFMO 1**	**Case DBFMO 2**	**Project trad 1**	**Project trad 2**	**Project trad 3**	**Project trad 4**	**Project trad 5**
Information source	Strukton	Strukton	X	X	X/RWS	RWS	Tax departm.
Location	The Hague	Groningen	X	X	X	Middelburg	Apeldoorn
Function	Office	Office	Office	Office	Office	Office	Office
Building type	low-rise	high-rise	low-rise	low-rise	high-rise	low-rise	low-rise
GFA (m2)	68.000	47.731	12.500	25.000	50.328	11.872	13.845
Building layers	5	24	5	5	23	5	5
Quality of maintenance	3	3	3	3	3	-	-
Consideration period (y.)	25	20	40	25	30	-	-
Operation time (hours p.d)	14	13	NA	NA	NA	NA	NA
Price level	dec-05	mai 07	march 09	apr-03	aug-03	NA	NA
Available data							
Maintenance (S,B en T)*	S, B and T	S, B and T	S, B and T	S, B and T	S, B and T	-	-
Energy use (E)	E	E	-	-	E	E	E

* Structural, Building services and Tangible assets

Table 1: *Indicative properties per case/project*

Maintenance costs data-analysis

In order to determine a –potential- better performance on maintenance long-term maintenance plans of two DBFMO projects were compared with long-term maintenance plans of traditional projects.

Comparing buildings on maintenance costs is difficult due to the unique nature of buildings as a whole. “Every building is affected by its location, height, composition, energy consumption and a plethora of other differentiation points – all of which make each building unique” (Hughes et al., 2004). When a building is decomposed to smaller parts e.g. elements, the uniqueness is more relative. Maintenance costs are generally found in practice, related to a classification in elements. The maintenance costs were not re-classified and aggregated to components, component compositions and ensembles. Besides practical reasons for not doing this, it was not a necessity because the cost analysis is used to get an idea where possible innovations on components or their aggregations could be found. Also according to the applied definition it might be assumed that components and their aggregations are project specific and cannot easily be compared.

According to Daly et al. (2003) a number of factors have a strong influence on the maintenance costs. To compare different buildings on maintenance costs the following factors are identified, see Table 2 and Table 3. These factors wee used, given the characteristics of the two DBFMO cases, for the selection of traditional build projects getting comparative data and to correct the data by differences in building characteristics.

Function	Offices
Construction year	> 2001
Project size	> 10.000 m2
Floors	Indicative
Quality maintenance	Quality (Conditieniveau) equal to or higher than the traditional projects

Table 2: *Factors that must be equal*

Gross floor area	Cost and consumption is expressed per m2 GFA
Price level	Corrections using the BDB index
Consideration period	Equeal consideration period
Operating time	Corrections if possible

Table 3: *Factors that must be corrected*

A long-term maintenance plan is in essence an activity planning where dissimilar sequences of costs are modelled for a certain period. In the different maintenance plans different types of maintenance are identified. In the analysis the following types of technical maintenance are taken into account: preventive maintenance, corrective maintenance and replacements. In order to compare different sequences of costs the net present value was calculated, due to the time value of money. Besides the net present value the nominal value was calculated. The nominal value does not take time influences and price increases into account. The net present value method seems suitable because identical project lives are taken into account in the comparison. The maintenance costs are shown per element in €/m2 gross floor area (GFA).

Within structural maintenance the elements floor finishing and ceiling finishing are good comparable because they are almost equal to the gross floor area of a building. Elements like façade finishing and roof finishing can result into disturbing outcomes due to different shape factors. An example of the disturbing effect of shape differences in buildings on the maintenance cost for roof finishing is shown in Table 4. When the maintenance costs are calculated per m2 GFA, building one seems to be the most cost efficient. When the costs are calculated per roof surface the costs are equal, due to different building typologies. Building one is a high rise typology and building two can be seen as low rise typology.
For the building services the following elements seem to be comparable: heat generation, cold generation, ventilation and lighting.

Influence shape factors	**Building 1**	**Building 2**
GFA	50.000	12.000
Roof surface	1.000	2.400
Maintenance cost roof per year	€ 6.500	€ 15.600
Maintenance costs per m2 GFA	**€ 0,13**	**€ 1,30**
Maintenance costs per m2 roof	**€ 6,50**	**€ 6,50**

Table 4: *Influence of shape factors on maintenance cost per m2/GFA*

Energy-use analysis

The energy consumption of a building is also related to a number of factors, which are mostly unique per building. In the research the energy performance is expressed in consumption per Mega Joules instead of costs. Energy costs are affected by the oil price which can give a disturbing effect in a comparison. According to a publication of SenterNovem (2007) the

following factors can be distinguished that influence the energy consumptions in buildings: function, project size, year of construction and the operating time. With regard to energy consumption the use of gas and electricity were taken into account and are diverted into the unit Mega Joules (MJ) per year per m2 gross floor area.

Innovations?

Indications from the previous analysis of a better performance by lower maintenance costs of elements or lower energy use were discussed by means of expert interviews. The interviews (seven in total) have been held with staff who where involved in the design phase of the DBFMO cases. Per better performing element on maintenance costs or a better performance on energy consumption the interviewees have been asked the following questions: (1) Is the motivation for the application direct or indirect?; in other words is the design solution focused on reducing maintenance costs and/or energy-use, or is it a secondary advantage? (2) Can the applied solution be seen as innovative as defined in this research? (3) Is the solution project bounded or project unbounded? This framework of analysis has been visualized in Figure 2.

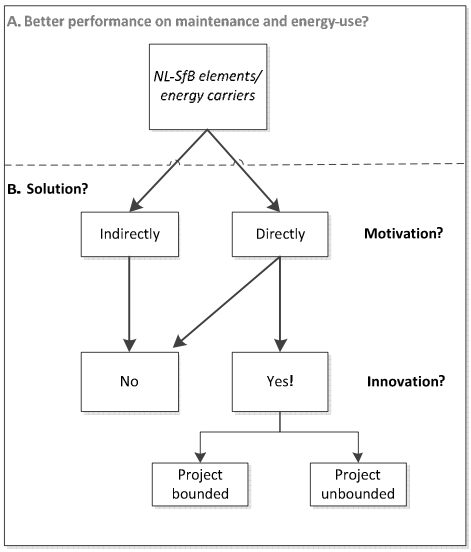


Figure 2: *Analysis framework for the expert interviews*

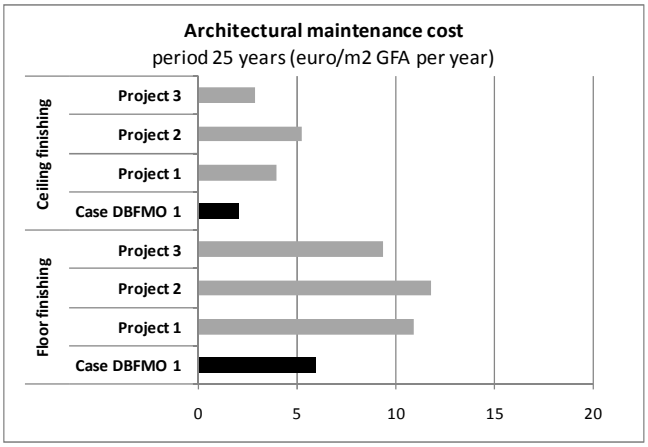
5. FINDINGS

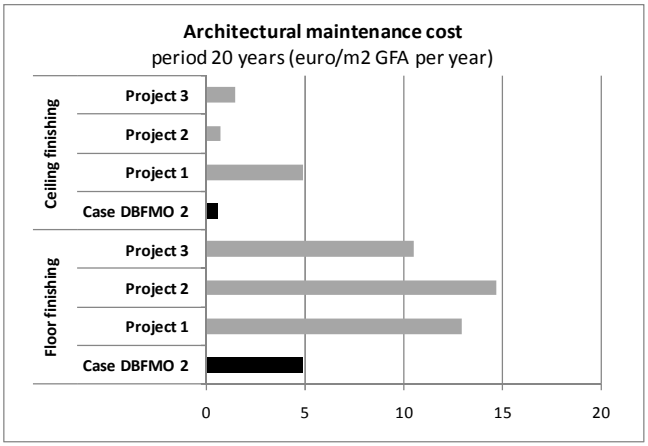
The findings are presented by type of analysis: maintenance costs, energy-use and expert interview, and by case.

Maintenance costs performance

For case one only the structural (architectural) maintenance costs could be analysed because the cost data for the building services maintenance was not available. The values shown in Figure 3 are nominal values because the net present values showed a similar trend as the nominal values. The absolute values as shown in the graphs are fictitious, the relative differences are real.

The graphs show significant lower cost levels for the DBFMO cases.





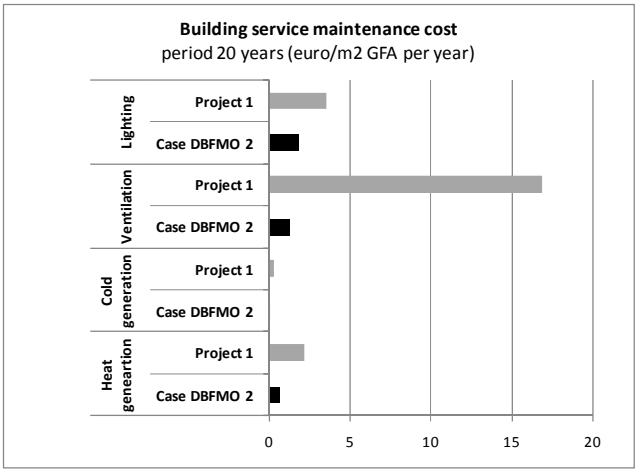


Figure 3: *Maintenance costs performance of the case studies*

Energy-use analysis

It was not possible to compare the energy consumption at element level because the data was only available per energy carrier (gas and electricity).

Figure 4 shows that the DBFMO cases are performing better than the traditional cases even without corrections for longer opening hours for the DBFMO cases.

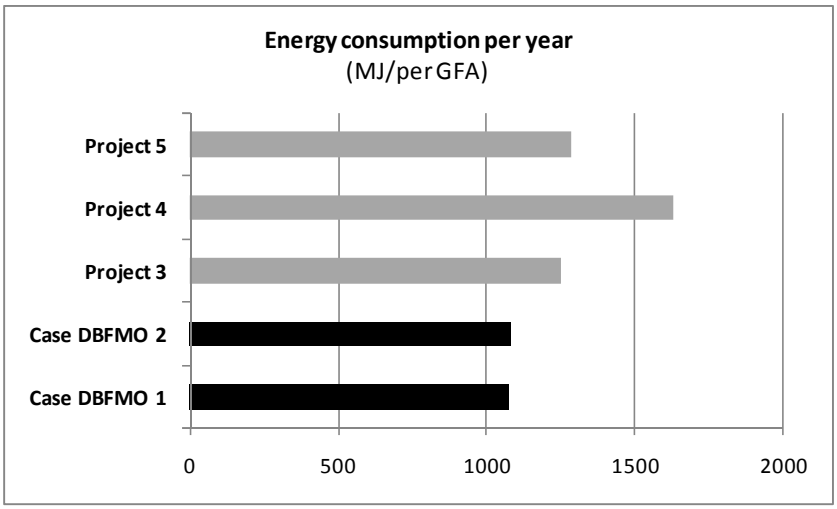


Figure 4: *Energy-use as analysed within the cases*

Expert interviews

In the interviews with experts the results of the data analysis were discussed, including the researchers ideas on innovations found within the cases according to the constituted definition within this research. The analyses of these interviews have resulted in the following findings.

Innovation on maintenance

Floor finishing: Carpet is the dominant floor finishing in the two DBFMO cases. In case one a carpet tile is applied. During the design phase a specific carpet tile was developed by the architect, contractor and supplier, resulting in seven different tiles differing in colour, weaving and pattern. The tiles are randomly produced, packed and mounted in the structure. Because of these special developed carpet tiles it is less visible when a single tile has to be replaced. The new tile does not stand out as a new tile in a 'carpet' with the old tiles. Therefore fewer replacements are expected to take place during the operational phase. This solution can be seen as an innovation on the ensemble because this solution has been developed and improved the use of a carpet tile. The carpet tile itself is not an innovation; the pattern that is developed that only works when seven or more tiles are placed together, can be seen as an innovation.

Ceiling finishing: The solution for the ceiling as applied in the DBFMO cases have an indirect link with maintenance. The choice for a climate sealing in case DBFMO 1 is based on energetic considerations. The advantage for the maintenance can be considered as indirect. The ceiling finishing for case DBFMO 2 is also based on energetic considerations and therefore it is not an innovation on maintenance.

Heat generation/cold generation: In case DBFMO 2 a heat pump is applied to warm and cool the structure. Out of the analysis a better performance can be discerned. However the interviewees refute this outcome. The heat pump is according to a number of interviewees more expensive on maintenance than a traditional heat system but has energetic advantages. In contrast with the data analysis the interviewees cannot see any advantages with regard to maintenance. Therefore the heat pump cannot be seen as an innovation on maintenance.

Ventilation: The choice for the ventilation concept of case DBFMO 2 is driven by a maintenance point of view. The fresh air is blown in the room via a raised floor and the exhaust air is collected in the room and exhausted via a central duct. This solution entails no ventilation ducts within the office spaces. Less ventilation ducts means less maintenance. The contractor and advisors developed this design solution in the design phase. Therefore this solution can be seen as an innovation on maintenance.

Lighting: Due to lower lighting level demand less lighting elements are installed, which are compensated with individual desk lights. Interviewees could not explain the better performance that came out of the maintenance costs analysis. It can be argued that less base lighting result in less maintenance. However interviewees argue that this is compensated by the extra individual desk lightning. So this aspect can't be seen as an innovation on maintenance.

Innovation on energy-use
Façade concept: The façade concepts of both DBFMO cases are not commonly applied solutions. First the façade concept of case DBFMO 1 will be explained. This case is in essence a renovation project. The existing structure was posing a problem for the transportation of exhaust air within the building and large thermal bridges were present. In order to overcome these two design issues, a double skin façade is applied to reduce the thermal bridges and to transport fresh and exhaust air in the façade. The individual elements cannot be seen as innovations. However, the solution as a whole is an innovation on ensemble level, which enables a reduction in energy consumption. The façade concept of case DBFMO 2 is specially developed with regard to sun influences. The façade consists of a fin, which differs in length and height to optimize sun radiation and light entry in all seasons of the year. In this way a reduction of energy consumption is expected because less heating, cooling and lighting has to be applied. This second façade concept can also be seen as an innovation on ensemble level.

Heat/cold generation: In both DBFMO cases the heat and cold generation is produced by a heat pump. This system can generate more efficiently heat or cold in relation to traditional heating systems. Interviewees conclude that it is a fairly normal system within offices. Therefore this is not classified as an innovation within the context of this research.

CONCLUSION AND DISCUSSION

Within the DBFMO cases four design choices can be considered to be innovations on maintenance and energy-use (two per case). See Figure 5. The design choices perform better on maintenance costs or energy use than the traditional projects selected for comparison. The four design choices on the physical parts are applied new and improved products and solutions related to the way the project was procured (DBFMO) and how parties involved collaborated to provide qualitative solutions.



Figure 5: *Innovations on maintenance and energy-use (www.mvsa.nl (2011) and Strukton (2008))*

The conceptual model, where a classification of design choices is introduced in components, component compositions and ensembles proved to be useful to identify innovations. For example, the carpet tile floor finishing itself is not an innovation and is done for decades. However, using the conceptual model the use of carpet tiles could be analysed as an innovation on ensemble level.. The pattern of the tiles is developed in collaboration between architect, the tile supplier and the maintenance specialist. Together they found a concept of seven tiles, which visually worked satisfactory after random replacement of tiles. The floor finishing contributes to the overall architectural expression of the interior of the building, and is aiming to reduce maintenance costs substantially over time. The ventilation concept is an innovation on component composition level. In this solution less components are used, because the raised floor is used to transport fresh air. In this way less maintenance costs are expected due to less applied components that require maintenance. Both façade concepts of the cases are innovations on ensemble level aiming to minimize energy consumption, but also contributing significantly to the architectural expression of the exterior. A larger case environment is needed to strengthen the applicability of this method for identifying innovations on project level.

Considering the findings of the research the DBFMO construction organization has a positive influence on the development of innovations on maintenance and energy-use. A number of conditions are described in the introduction that could be of influence on an innovative environment of DBFMO projects: the collaborative environment, the use of performance specifications, optimising life-cycle costing and risk transfer between public and private partners. Which relations exist between the conditions and the innovations is not explicitly investigated in this research, although some explanations are found based on the expert

interviews held after the data analysis. The innovations found in the case studies can be considered as the successful transfer of knowledge between departments that would have worked independently in case of a traditional procured project. Besides innovations found on the physical parts, other small incremental innovations on service delivery by the DBFMO-contractor were mentioned in interviews, dealing with the conditions of life-cycle costing and performance specifications, e.g. monitoring the condition of building components in-situ.

In the research only two DBFMO cases were investigated due to limited number of DBFMO projects in the Netherlands, making the conclusions difficult to generalize for all DBFMO projects. In general the conditions of DBFMO projects shape an innovative environment.

The performance data of the DBFMO cases on maintenance costs and energy-use is based on expected results, as the delivery dates were too recent for reliable actual cost data. The data used are provided by the contractor, which has made the calculations of the maintenance costs and energy-use on the basis of the preliminary designs. In this research it has been assumed that this data should reflect the real costs rather accurately, because risk-averse parties like the contractor in case are liable for these expected costs over up to two decades. The maintenance data and expected energy-use performance is calculated based on confidential data sets, therefore the validity could not be determined.

Comparing buildings on costs in general is rather problematic due to their unique character. It was not possible to get identical projects with regard to the case characteristics. In terms of case selection often the researchers were faced with limited available data on life-cycle costs, long-term maintenance plans and energy consumption performance. Instead of comparing buildings as a whole it proved possible to compare a number of elements. The maintenance costs and energy consumption analysis was about detecting possible innovations and not to compare similar solutions on cost or energy consumption efficiency.. However, on their contribution to the total life-cycle cost performance conclusions cannot be drawn.

Further research should be conducted on three areas: (1) The contributing issues why exactly innovations are arising in this type of construction organization; (2) The study has to be repeated with more cases and should be based upon actual cost data and real energy performance data for better validity; (3) A new study could focus more on the life-cycle cost efficiency of whole projects related to innovations detected.

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CHAIN COLLABORATION BETWEEN A HOUSING CORPORATION AND TWO GENERAL CONTRACTORS, THE FIRST STEPS

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Abstract
Several housing corporations in the Netherlands have realized they cannot do it alone if they want to renovate their housing stock faster, cheaper and with a higher quality. More and more of these corporations are forming strategic alliances with contractors and other partners to reach these goals. They are applying principles of supply chain integration and lean on the total process of the building lifecycle, under the umbrella concept of Chain Collaboration (Ketensamenwerking in Dutch).
This article draws from active research executed on two projects which started in 2010 and are still under development. It focuses on the definition and design phase and describes the approach applied to implement the chosen strategies.

Keywords: supply chain integration, lean, strategic alliance, housing corporation

1. INTRODUCTION

Under pressure of the current credit crunch and a decreasing need for new homes the coming ten to fifteen years, housing corporations (HC's) in the Netherlands are facing a market where higher quality at a lower price is requested by home buyers and tenants (Wal van der, Arts & Beijer, 2009). The cost HC's make for the production and maintenance of their houses will have to decrease dramatically in order to keep houses affordable (De Wildt and Luijkx, 2011). Faced by these challenges the HC's are looking for ways to produce more value to the end user at a lower price level.

In order to produce more value at a lower price level, HC's are abandoning the traditional design-bid-build approach. HC's are exploring different strategies, most of them under the umbrella concept of Chain Collaboration (*Ketensamenwerking* in Dutch).

The HC subjected to research in this case is applying the following strategy:

- integrating supply chains, with main contractors, subcontractors and suppliers;
- forming strategic alliances and alliance culture;
- applying lean principles and tools in the definition, design and realization phases.

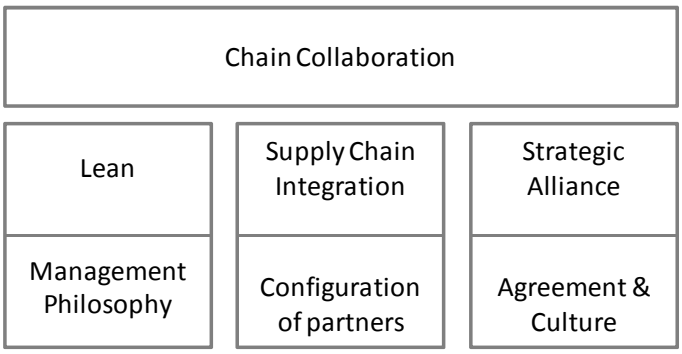


Figure 1: *Strategies part of Chain Collaboration*

In this article two cases of one Dutch HC are presented. The cases consist of two strategic alliances formed by one HC with two different general contractors. The general contractors also forms strategic alliances themselves with several subcontractors.

One alliance is formed for large maintenance projects of low rise houses. The other alliance is formed for the upgrading of apartments so they become more suitable for the elderly (55+). The research is done by action research and focuses primarily on the definition and design phase.

2. METHODOLOGY

This article draws from active research done during the formation of two strategic alliances between a HC, two main contractors and several subcontractors which started in 2010 and is still ongoing. The main goal of these alliances is, by the integration of the supply chains, to develop a faster and cheaper maintenance and upgrading process for existing houses.

This project consists out of two parts. The first part focuses on the definition and design phase. The second on the realization phase. This paper focuses primarily on the first part. Within this part, the traditional process is re-designed to converge to the main goal.

The development of each strategic alliance is managed by two change agents. One agent form the HC and one from the general contractor. Each of the two alliances has its own agents. The change agents work directly under the board of their company.
The change agents are guided by a team consisting out of two consultants and one researcher (the author). The development of the alliances is monitored for two hours a week during the guiding-sessions for a full year. A logbook of these sessions has been kept for ex-post research.

The researcher is actively involved in the process under study in order to identify, promote and evaluate problems and potential solutions. As stated by Fellows and Liu (2008) active research ‘is where the research actively and intentionally endeavors to effect a change in a system. Knowledge is used to effect the change which then creates new knowledge about the process of change and the consequences of change (as well as the change itself). In programmes of action research, the usual cycle of scientific research (problem definition – design – hypothesis – experiment – data collection –analysis – interpretation) is modified

slightly, by purpose of the action rather than by theoretical bases, to become 'research question – diagnosis – plan – intervention – evaluation', the 'regulative cycle'.

The main research question for this project is: How should the process of the definition and design phase be redesigned in order to (1) incorporate the know-how of the several alliance partners and (2) filter out the waste, in terms of lean, from the definition and design phase?
The method applied to diagnose the situation is value stream mapping (VSM) (Hines and Rich, 1997). At first the 'current state' of the (traditional) definition and design phase, together with the underlying process characteristics (lead time, process time,etc), was defined. This was done by the guiding team together with the change agents, the projectmanagers of the HC and general contractor, architects and other advisors. For both alliances a current state has been described.
Based on this value stream map possible interventions for filtering out waste and the integration of alliance-partner knowledge where identified. At the time of writing this article, the possible interventions where defined, but not fully developed.

In the follow up, which falls outside of the scope of this paper, the initiatives will be further developed in smaller teams and implemented into the process following a standard DMAIC-method (define, measure, analyse, improve, control). When an initiative is implemented, a new process map can be drawn up making the future state (or new current state). After this, new initiatives can be defined and developed, and the cycle starts again. The use of the VSM is further explained in chapter 4.

3. STRATEGY APPLIED BY THE HOUSING CORPORATION

This section will describe the three strategies used for the development and implementation of Chain Collaboration as presented in the first paragraph.

3.1 Supply chain management and relations

The supply chain has been defined as 'the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer' (Christopher 1992). Instead of looking at just the next entity, the concept of Supply Chain Management (SCM) looks across the entire supply chain and aims to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries (Cooper and Ellram 1993). According to Koskela and Vrijhoef (1999) the actors in the supply chain are dependent on each other for implementing the supply chain methodology successfully.

Supply chain relations are often described in terms of the level of integration, interconnectedness, or interdependence among trading partners within the chain (Lockamy and Smith, 2000). The level of partnership is, for example, identified by Cooper et al. (1997) and Tyndall et al. (1998). They identified four levels of partnership.
At the lowest level, the trading partners rely on what Tyndal et al. (1998) calls open market negotiations characterized by arm's length transactional business practices. The competitive imperatives, not management initiatives, determine the nature of the relationship.
In the next level Tyndall et al. (1998) trading partners formalize their cooperation. They construct specialized transactional processes that better serve their needs. To secure the benefits, partners enter into long term agreements and they commit to sharing information

about the volume and timing of product and service. This to further reduce uncertainty in their relationship.
The third level of partnership aims to create relationships rich enough to support joint efforts to simplify supply chain operations. Coordinated efforts are deployed to, for example, reduce inventories or the amount of transaction.
The fourth level is where partners reach the collaboration stage. In this stage partners engage in joint efforts to develop and improve products and in joint efforts to enhance the value and satisfaction provided by customers. In this stage, management devotes considerable energy to building trusting supply chain relationships and to negotiating equitable arrangements for sharing the risks and rewards of supply chain improvements.

According to Handfield and Nichols (2002) integrating a supply chain, as in level 4, represents a major change in the way companies do business. In creating integrated supply chains, companies must rethink how they see their customers and suppliers. They must concentrate not just on their own profits, but also on how to maximize the success of all organizations in the supply chain. When the organizations involved focus on these goals, they may discover the need to re-design the entire structure of their supply chains.

3.2 Strategic alliance agreement

Arrangements that counteract adversarial relationships with each other are needed to enlarge the magnitude of Supply Chain Management (Koskela and Vrijhoef,1999). Similar conclusions can be drawn from Khalfan and McDermott (2006) which conducted multiple case studies on long term framework arrangements applied in construction.
In this case the partners are aiming for a level 3-4 of supply chain relation (see paragraph 3.1 for explanation) where a contractor and subcontractors become involved in the early design stages of a project. The strategic alliance agreement between the HC, general contractors and sub-contractors therefore forms the fundament for the collaboration effort.

There are many definitions of ‘partnering’ and ‘alliancing’ (Barlow et al., 1997). The strategic alliance subjected to research in this case is a long term contractual agreement between the client, general contractor and several strategic partners (suppliers and subcontractors). According to Doz and Hamel (1998) such an alliance would be called a non-equity alliance.
The features of this strategic alliance are that the collaborators work together on multiple (housing) projects, towards joint goals, sharing parts of the projects risks and profits. The joint goals in this case are to produce more value to the end user at lower cost and at a higher speed. The performance is measured through performance indicators. An aligned development process, unanimous decision making, open book accounting, a fair payment, and trust are the basis of the arrangement.

The compensation model the partners are developing for these alliances is target costing based on a cost-plus pricing system. There are several approaches possible. For further reading about these approaches, the author suggests to read Lockamy and Smith (2000). The Target Costing approach falls outside the scope of this paper.

3.3 Lean

Koskela (1992) states that the traditional way of managing is essentially based on a conversion view on production, whereas Supply Chain Managment is based on a flow view of production. The conversion view suggests that each stage of production is controlled independently whereas the flow view focuses on the control of the total flow of production (Koskela, 1992).
There is a large toolbox of methods available to analyze various issues in order to integrate and improve the performance of the supply chain (Vrijhoef and Koskela 1999). For this case the lean philosophy and tools where used for the redesign, control and improvement of the supply chain.

Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) and identified as "Lean" in the 1990s. The term was first coined by John Krafcik in a 1988 article, "Triumph of the Lean Production System," published in the Sloan Management Review (Holweg, 2007).

Lean stresses a supply chain perspective, seeing the internal production operations as a part of a value stream from the sub-suppliers to the end customer (e.g. Rother & Shook, 1998; Jones & Womack, 2002). This perspective fits the highly fragmented AEC industry (Arbulu & Tommelein, 2002).
Lean considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for.

The first step in lean is to understand what value is. The second step is to understand what activities and resources are absolutely necessary to create that value. Once this is understood, everything else is waste. According to Monden (1993) waste can be categorized into:

- non-value adding
- necessary but non-value adding
- value adding

The original Toyota seven wastes are defined by Shingo in 1989 (see table 1 below).

The seven forms of waste	
Overproduction	Producing more than is needed or before it is needed
Motion	Any wasted motion to pick up parts, stack parts, wasted walking
Correction	Rework or Repair
Waiting	Any non-work time, waiting for tools, supplies, drawings, parts, etc.
Processing	Doing more work than is necessary
Inventory	Maintaining excess inventory
Conveyance	Wasted effort in transferring goods etc.

Table 1: *the seven forms of waste (Shingo, 1989)*

Many other wastes have been added since Shingo defined the first seven (Bicheno and Holweg, 2009).

For many, Lean is the set of "tools" that assist in the identification and steady elimination of waste. As waste is eliminated quality improves while production time and cost are reduced. Examples of such tools are Value Stream Mapping, Five S, Kanban (pull systems), and poka-yoke (error-proofing). In this case Value Stream Mapping has been used to diagnose the situation and to plan further action.

4. METHOD FOR DIAGNOSES: VALUE STREAM MAPPING

The method used in this case to assess and redesign the activities and resources, in order to create value is value stream mapping (VSM).

VSM was created by practitioners at Toyota to "make sustainable progress in the war against muda" ('muda' is the Japanese word for 'waste') (Rother and Shook 1998). VSM includes creating a map of the complete value adding (and nonvalue adding) process, from conception of requirement back through to raw material source and back again to the consumer's receipt of product. A current-state map of in-company value streams then serves as the basis for developing future-state maps that leave out wasted steps while pulling resources through the system and smoothing flow (Arbulu and Tommelein, 2002). In a CS-map all steps that are performed to complete the work as it is operating in todays environment as well as the issues and performance (metrics) of the process are mapped. The difference between the current state and potential future states provides a road map to start the implementation of performance improvements.

A value stream perspective should look across individual functions, activities, departments, and organizations, and focus on system efficiency rather than local efficiency within any one of these (Arbulu and Tommelein, 2002).

When setting up a VSM, a product family has to be defined and then map its current-state value stream before analyzing production data and metrics. A product family is a group of products or services that pass through similar process steps. In this case two product families of this HC where defined:

- large maintenance projects of low rise houses which where build in the 70's and 80's;
- (rather small) upgrading of existing apartments from the 70's and 80's so they become more suitable for seniors (55+).

Although every project in construction has its own dynamics and characteristics, the projects that are part of this 'product family' can be seen as comparable. The data is gathered through VSM-workshops with the change agents, the project managers of the HC and general contractors, architects and other advisors, all having experience with projects belonging to these product families. The data gathered therefore provide approximate durations instead of measured durations.

The scope of the VSM (current state) is restricted to the HC and it's first tier suppliers who are involved in the definition and design phase of a traditional project. This paper presents a current state maps of both projects and considerations for supply chain performance improvement (interventions).

5. CASE ANALYSIS

This section will describe the VSM's of two cases that have been produced through the VSM workshops.

5.1 Case 1: Large maintenance project of low rise houses

Using VSM the current state (CS) of the definition and design phase was drawn (see figure 2).

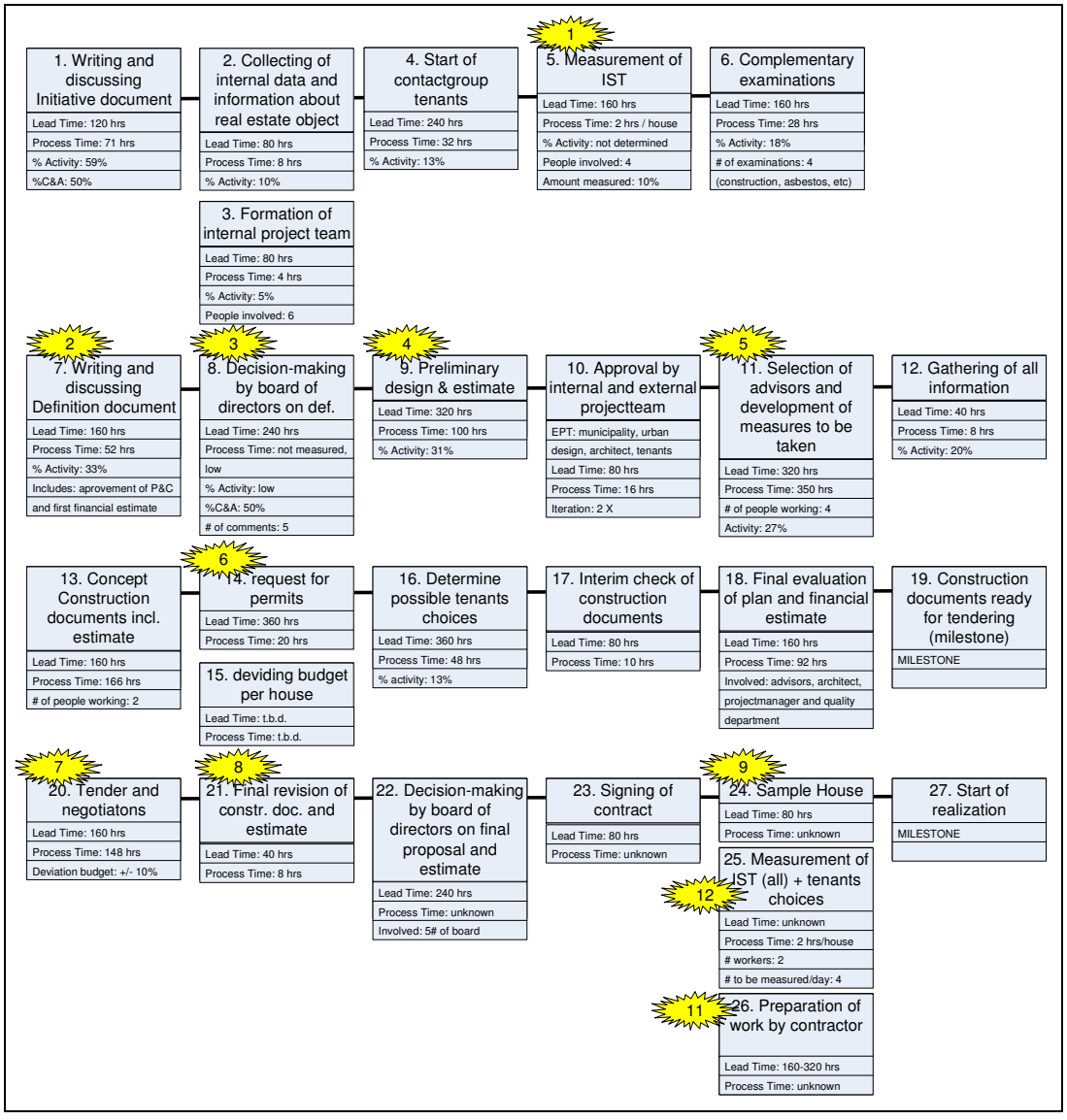


Figure 2: *Current state map of a large maintenance project*

The CS starts with the initiative document in which the projectmanager defines the global goals and targets of the project. With this document the projectmanager acquires a budget for the development of the design en research of the situation. From the initiative document the

global process steps are analysis (measurement IST, examinations), design development, permits, tender and negotiations to start of realization (see figure 2).

When looking at the CS waste becomes visible and possible initiatives (see figure 2, bursts) from the view of Chain Collaboration, can be defined:

- The percentage of activity in comparison to lead time on almost every steps is low. A lot of time in the overall process is going to waste as a result of waiting. Waiting for decisions, approval, meetings and documents. For every step further research should be done to minimize, at least, waiting time.
- The percentage complete and accurate (%C&A) for more than one step is 50%. This means one out of two of these steps have to be redone, resulting in extra waiting time and work. Further investigation what causes this low percentage of complete and accurate is needed.
- The decision-making by the board processes in general take a large amount of time (approx. 6 weeks per decision). One major cause for the delay is that project managers have to hand in their project plans 4-6 weeks before the board meeting. The responsibility for taking decisions could also be transferred to the head of the department when the project is still within scope and budget. This could lead to much faster decision-making process.
- The decision by the board, for most projects, are taken for one project at a time, while there are multiple ongoing projects which belong to the same product family. Combining projects can save time.
- There are steps that seem to be double. The measurement of the IST is done in step 6 and step 25. For a traditional design-bid-build project, this is understandable due to the split between design and realization, but within an alliance where client, designers and contractors work together it looks like one step to many.
- The tendering of the projects takes five weeks (step 21 and 22) when all goes well and the tender price is within budget. Step 22 represents a revision of the construction documents as a result of this tendering step. When working in an alliance, developing the design and estimates together, these steps should become obsolete. A process like Target Value Design (*The American Institute of Architects*, 2004), or another Target Costing mechanism, has to be implemented.

The initiatives are presented in the next figure (3, see next page), making a first idea for a future state map.

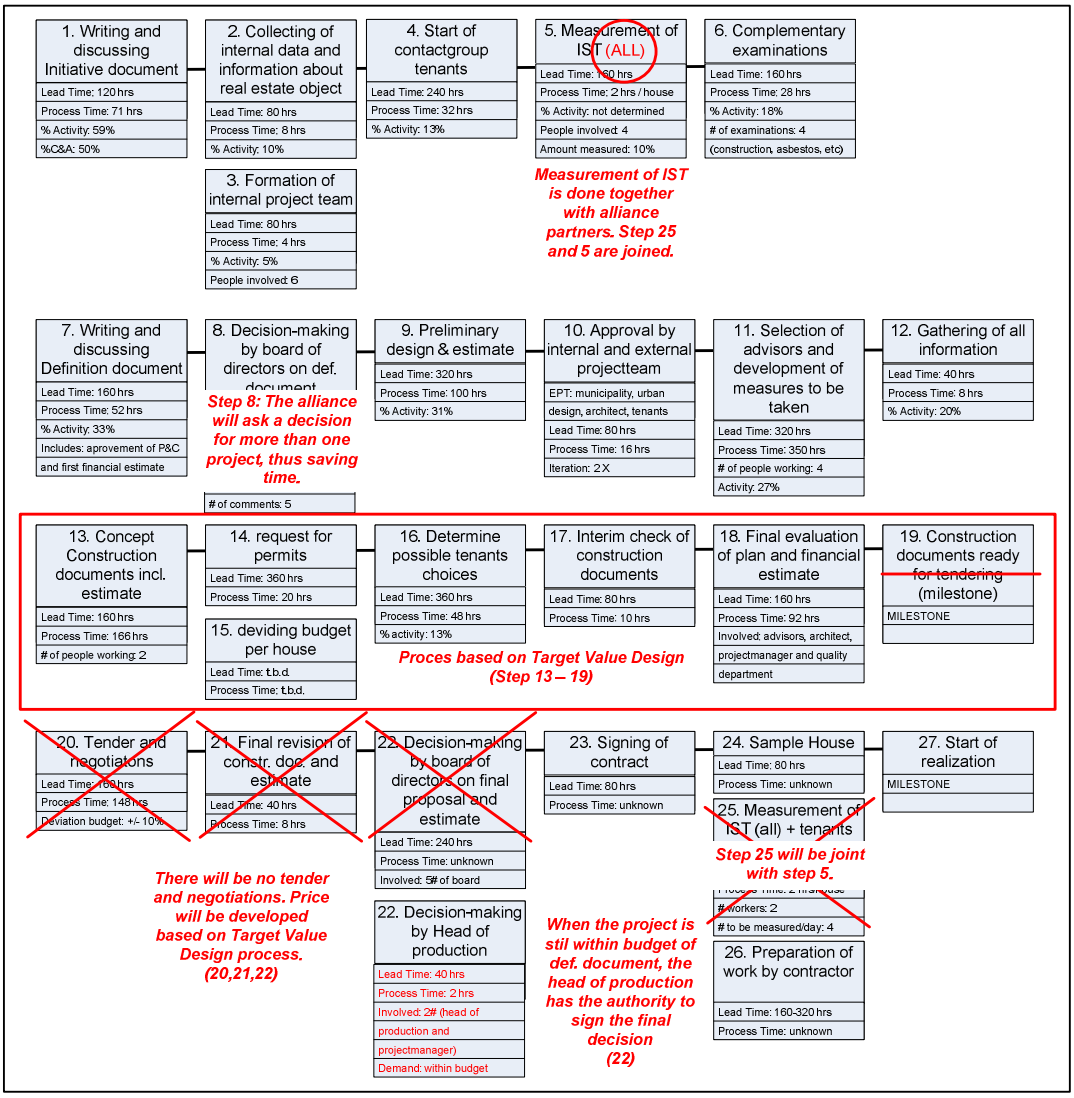


Figure 3: *First idea for the future state map of a large maintenance project*

5.2 Case 2: Upgrading of existing apartments

Using VSM the current state (CS) of the definition and design phase of the upgrading of existing apartments was drawn (see figure 4, next page). At the time of writing this article, the metrics for this project where not fully developed yet, therefore they are not presented.

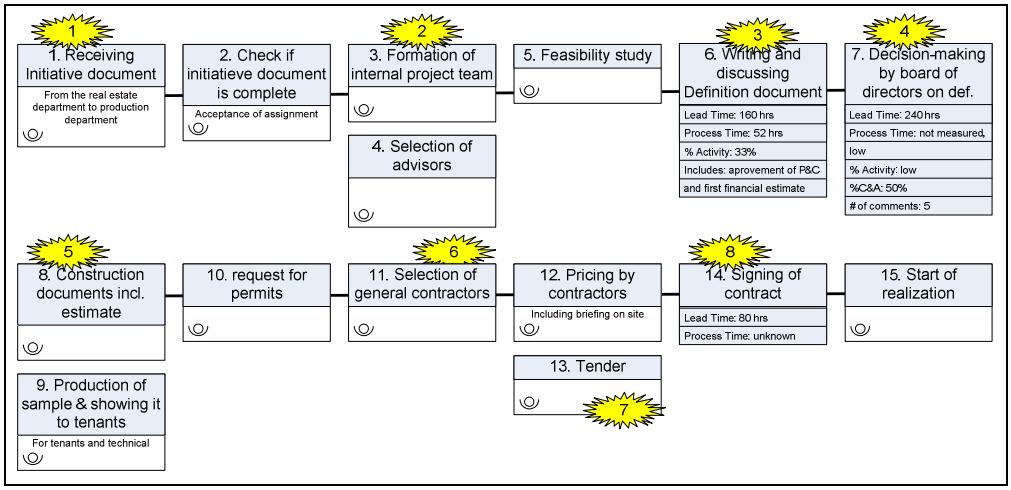


Figure 4: *Current state map of an upgrading of existing apartments project*

The CS map of the upgrading projects is shorter than the CS op a large maintenance project. This is due to the lower level of complexity of these projects.

The CS starts with the initiative document in which the projectmanager defines the global goals and targets of the project. The initiatieve document forms the assignment for the projectleader of the production department. This projectleader checks if the document is complete. When the project is accepted the projectleader sets up an internal team and selects advisors for a feasibility study. Based on the feasibility study the projectleader writes definition document on which the board decides. When the board approves the construction documents are produced and a sample is produced for testing. When the permits are requested, possible contractors are selected. These contractors can start pricing the project. After the tender one contractor is awarded the project and the project start.

When looking at the CS waste becomes visible and possible initiatives (see figure 4, bursts) from the view of Chain Collaboration, can be defined:

- Every projects starts with an initiative document (step 1). Part of this document is a program (an analysis of current situation and possible actions plus estimates). The program is drawn up for every single project. This initiative (burst 1) contains the development of a standard program document. Based on this program, all projects (25) can be analyzed and roughly estimated. This will be done by the advisors, general contractor and subcontractors which are part of the Chain Collaboration. By using this standardized program and the knowledge of the Chain Collaboration partners the speed and accuracy of the analysis will become much higher than current practice.
- The steps 3 and 4, formation of an internal project team and the selection of advisors (and possible contractors), will be eliminated due to Chain Collaboration.
- The writing of a definition document can be shortened using the standardized program (step 6).
- The decision-making by the board (step 7) can be shortened and multiple projects can be decided on instead of one which is current practice.
- The construction documents (step 8) can be simplified, only defining the information that is needed.

- Due to Chain Collaboration the general contractor is already selected. The selection step (11) can be deleted from the current map.
- There will be no tender (step 13).
- The signing of the contract will be replaced by a final check on the price and documents. The boards will sign a standard project agreement.

The initiatives are presented in the next figure (5), making a first idea for a future state map.

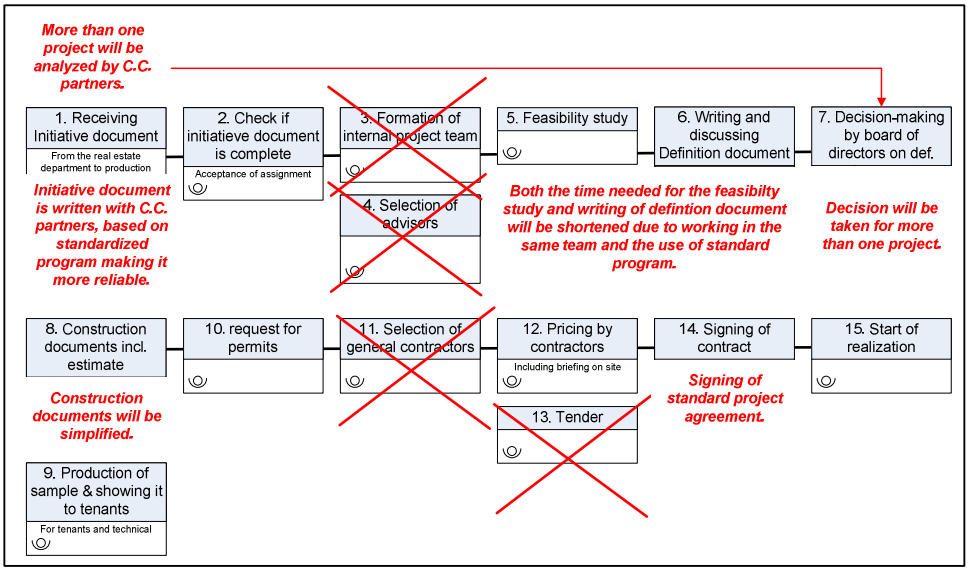


Figure 5: *First idea for the future state map of of an upgrading of existing apartments project*

6. CONCLUSIONS AND FINAL REMARKS

It seems that the combination of strategies, applied by the HC under the umbrella concept of Chain Collaboration, makes it possible not only to filter out waste from the traditional (design-bid-built) way of working by the use of lean principles, but also to alter the complete development and design phase. The reason for this is mainly the formation of a strategic alliance. The strategic alliance makes it possible to:

- research and develop (invest) a more efficient way of working;
- work as one integrated supply chain based on one joined process;
- utilize contractor's knowledge on design, construction and costs in the early stages of design, this making the whole process more predictable;
- filter out non-value adding steps (tender, negotiations, revisions of documents);
- join steps because the justification for two separate steps has disappeared;
- make steps simpler and less time consuming.

This first step in this Chain Collaboration effort looks very promising, but it's also clear that the future will tell us if the several initiatives can be implemented and what their effect will be. Only then can the actual performance be measured.

Parallel to this development are many other aspects that have to be tackled which have not been part of this paper. Personal issues, issues between team members, another way of working, mixing cultures, etc can all become bumps along the way. Next to this, the 'pattern

of payoff' and 'the shadow of the future' (Axelrod et al., 1985) will pay an important role in keeping the alliance working.

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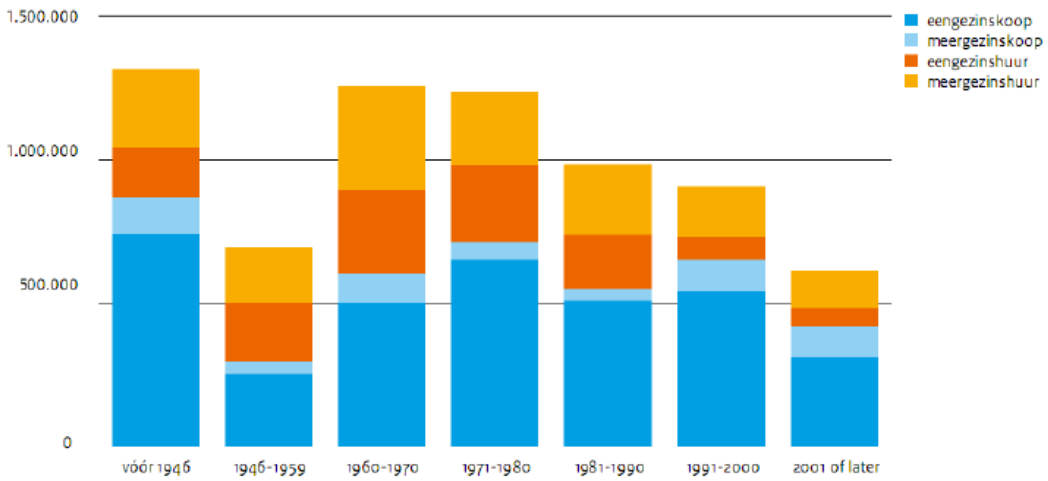
APPROACHES TOWARDS A SMART & SPEEDY IMPROVEMENT OF THE IN SERIES DEVELOPED POST WAR HOUSING STOCK

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Abstract
One third of the current housing stock in The Netherlands dates from the sixties and seventies and a large part of these dwellings are fairly similar (because they were built in series). There is a high need for smart and speedy renovation methods, to improve technical, energy and cost efficiency of renovation projects as well as to limit inconveniences to residents. A considerable number of professionals in the Netherlands currently are making a combined effort to improve these methods and their implementation, in an initiative called Smart & Speedy ('Slim & Snel' in Dutch). This article describes this initiative, some results till now and an inspiring already realized renovation project that illustrates the goal of the Smart & Speedy approach.

The large part of all Dutch houses is built after World War II. Almost a third between 1960 and 1980 (VROM,2009b). The calculated economical lifespan of dwellings in the Netherlands is fifty years. However, in practice houses stand much longer. Even before the economic crisis in the Netherlands only 0,25% of existing homes were replaced every year. Based on this information existing houses are expected to last six to eight times their economic life span (Van Hal, 2008).

In general, the quality of these houses is very low as a result of the shortage of both building materials and experienced constructors in the years of their construction (Andeweg 2009). Also, due to the increase of welfare of the population and many technical developments the use of dwellings and the wishes regarding living quality have changed a lot (Vreeze, 2001). Improving these houses in a smart and speedy way to make them more attractive for today's residents, has already been an issue high on the agenda of the government, housing associations and other parties of the supply chain, for a long period of time.



Figuur 1: Samenstelling woningvoorraad (Blijie, 2009)

Figure 1: *Compilation of the housing stock (Blijie, 2009).*

THE IMPORTANCE OF A FOCUS ON ENERGY EFFICIENCY

In the Netherlands one third of the CO_2 emissions, amounting to over 60 million tons per year, is related to energy usage in buildings. 53% of this emission is caused by the housing stock (Ecofys 2005). The energy efficiency of homes built before 1975 is lower than realized in housing stock built more recently. To a large extent this is due to the fact that legislation on energy efficiency was only implemented after 1975. Before there were no norms that prescribed insulation and the installation of high yield condensation boilers. Due to the fact that many homes were built in the period between 1945 and 1970, a large part of the total housing stock has a relatively low quality in terms of energy efficiency.

For a long period of time most energy reducing initiatives were focused on new housing. However, as a result of the crisis of 2008-2011 in the Dutch construction industry the focus changed from new housing toward the existing housing stock. In a short time energy efficiency in the existing housing stock became a big issue (Nieboer, Van Hal , Dulski, 2011). Due to the rise of the energy prices the living costs of residents increase as well. Figure 2 shows that the energy costs have been doubled since 2000.

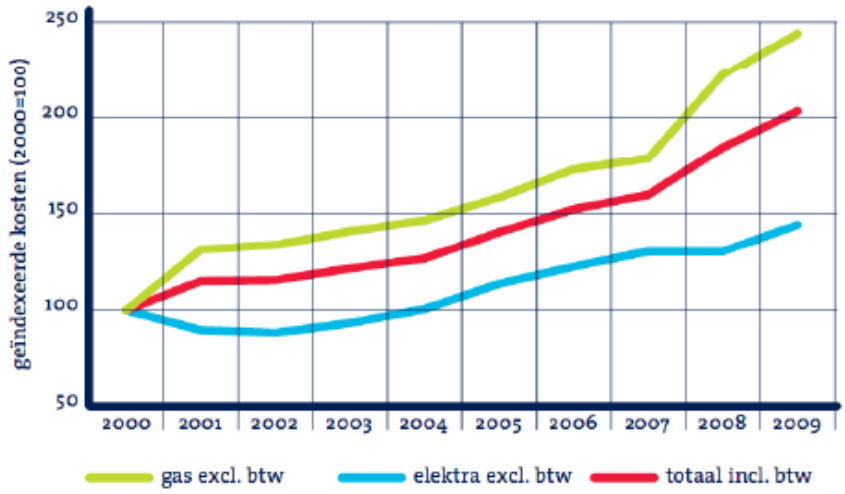


Figure 2: *Developments for energy costs of households since 2000 in the (Luijten, 2010).*

SOCIAL HOUSING

The Netherlands is unique because of the large percentage of social housing: 32 percent (between 2.2 and 2.3 million homes) of the total housing stock. With over 4.1 million homes the owner-occupied dwellings cover 55.9% of the total housing stock in the Netherlands (CBS, 2010). Over the past five years there has been a shift towards the owner-occupied market (CBS, 2010). Virtually all social housing (more than 99 percent) is procured and managed by social housing associations, which are private organizations operating under a range of public regulations that aim to ensure that a number of social tasks, such as housing lower-income households, are fulfilled. Large housing associations manage over 100,000 houses, whereas the majority of the housing associations manage less than 5,000, making the operational scope and influence of housing associations wide ranging. The remaining half percent of the social housing stock is owned by municipalities (Nieboer, Van Hal , Dulski, 2011).

Housing associations in the Netherlands are taking the energy challenge seriously. They signed an ambitious agreement with the government in which they promised to lower the energy use of their housing stock within a short period of time. The agreement was signed by the national association of housing associations AEDES.

It is the aim of the Smart & Speedy initiative to improve the large part of the housing stock built in series. To make an effective start on a broad scale the project is (at least initially) primarily focused on dwellings owned by housing associations.

THE CONCEPT OF THE SMART & SPEEDY PROJECT

Several parties have been approaching building and construction differently for quite some time. For these relatively small parties, it is difficult to really make a difference in the field. Housing associations, looking for suppliers and constructors, are cautious and often do not dare to opt for a new party on the market, especially not when that party operates differently to the usual. Often, after a long period of preparation and many meetings, they still chose a traditional party.

By joining forces and operating on a large scale, the project Smart & Speedy wants to bring movement to this static situation. The aim is to obtain concepts for serially built housing of the sixties and seventies that may reduce energy use by at least 45% at an affordable rate and without much hinder for the residents. One of the conditions is that the residents will not need to leave their house for longer than five days, whilst the preference goes to avoiding necessary vacation entirely.

The project consists of several elements that intertwine; a network, a field program and an extensive research program. Members from the construction chain that are involved with the sustainability of housing of the sixties and seventies, but also financial experts and parties from the energy field, work together in this network. Currently more than 20 companies are involved. The network members pay a fee per year for three years and thus create a joint capital that enables oriented research and the development of activities.

The network is involved on many fronts, for example as sounding board for the field segment of Smart & Speedy. This part is financed by the government and is part of the Energy Jump Program (EnergieSprong) of the SEV (Stuurgroep Experimenten Volkshuisvesting). Through field experiments the SEV aims to greatly increase energy reduction in the built environment. In the field program, Smart & Speedy realizes four projects, each with a minimum of 400 houses. These projects will start within a year and be completed within 3 years, but more importantly, will create concepts that may be repeatedly applied to comparable housing in other parts of the country.

The field program is experimental in the sense that in a totally new manner, consortia of rivaling market parties, in cooperation with the (coalition of) awarding corporations, develop supply ánd demand. Currently housing associations are approached and requested to take part and soon the search for supplying consortia will also start. They will be challenged so that they do not come forward with a solution that consists of piling measures such as double glazing and extra insulation, but with an integrated concept that may be applied to a large part of the housing of the sixties and seventies. The SEV provides an intensive process management to ensure these solutions become reality.

Of course, realizing these ambitions in the field is not just a technical issue. On the contrary. Besides the conservative reaction of awarding authorities already mentioned, there are more reasons that prevent ambitious plans from becoming reality. Therefore, preliminary to the field program, an extensive research was started with the aim to chart all possible opportunities and obstacles. Each opportunity and obstacle is displayed as a knob that may be turned, resulting in a concept with the working title ‘the control panel’. Who and when should turn which knob which way, differs per situation. These situations are charted as scenarios. During the program the results will be calibrated yearly.

Finally, three institutes of knowledge are connected to Smart & Speedy; Nyenrode Business University , Delft University of Technology (TUD) and Hogeschool Utrecht (University of applied sciences Utrecht). It is intended that a PhD candidate will monitor the whole project. Graduation students will focus on parts of the project.

BOTTLENECKS AND OPPORTUNITIES

The willingness of housing associations to invest in energy reduction used to be low. The interest among housing associations in the first years of the century was limited because of

low demand from residents and expected high costs of energy reducing measures. The introduction of the energy labels in 2008 may have changed the picture. Van Hal et al (2009) conducted an explorative study to see if this supposition is right. They made an inventory of the potential financial benefits of energy reducing investments, resulting or not in a higher energy label. They also conducted a survey of 15 housing associations to assess the impact of these benefits on the willingness of housing associations to invest in energy reduction.

The survey about the willingness of housing associations showed that they agree upon the urgency of the matter: energy reduction is necessary and is a task for housing associations. Compared with the first part of the decade the opinion of housing associations changed.

Van Hal et al conclude that housing associations are willing to invest in energy reduction. However, there are three obstacles for housing associations to do so:

- the 'split incentive' problem. When housing associations invest in energy reduction, they have to carry the load of the investment, the costs. The benefits - lower energy costs and more comfort - land with the residents. (When the majority of the residents do not agree with the investments they do not have to pay a higher rent (see below).) The split incentive problem is also related to the problem that the energy performance has a relatively small weight in the Dutch rent setting system.
- the diverging development of rents and energy costs. The energy costs are growing much faster than rents and are not leveled off by the housing allowance.
- the requirement that 70% of the tenants of an estate have to agree with investments and corresponding rent increase. If they do not agree the investments are possible but the increase in rent cannot be enforced.

Several housing associations tried, in creative ways, to avoid these obstacles. For example by starting an energy company, by investing in a long turn relationship with their tenants (tenants do support the initiatives of a housing association more easily if the relation is based on trust), by investing without a rent increase (in those cases the rent will only be raised after moving of the tenants) and several other initiatives. However; a definitive solution has not bene found yet. There are still a number of obstacles to remove to reach the goal of an energy efficient housing stock (Flier, v.d. and Van Hal, 2010).

Recent discussion amongst the members of the network Smart & Speedy show the same results. In this network one of the main concerns is related with the willingness of residents to cooperate and pay the raise of rent that goes with the energy efficient retrofitting. For years there have been attempts to get Dutch citizens enthusiastic to invest in improving the energy efficiency of their homes. Looking back, one can only conclude that the results are disappointing this far. A lot of money has been invested in information campaigns and specific motivational programs, but the overall results are minimal. Herein the Dutch are not unique. The American environmental psychologist Dough McKenzie-Mohr already stated in 1999 the example of an electricity company in California in his book 'Fostering Sustainable behavior'. This company had spent more money on advertising about the benefits of an energy-saving system in a specific type of dwelling, than the costs would have been had they implemented the system in the dwellings for free. In the Netherlands there are no official figures in this field, but it is not inconceivable that a comparable situation sometimes arises here.

An important cause seems the fact that too little is learned from earlier experiences. It is difficult to find projects whose effects have been analysed on the basis of a thorough benchmark and a final study. Developers of campaigns just do 'what seems sensible'. Partly due to this, project descriptions from years ago show strikingly few differences with descriptions of present projects, despite the fact that they were not successful. Another reason for the repeated mistakes seems to be the fact the main focus with the startup and realization of Dutch motivation campaigns often stays limited to the technique and financial consequences. Knowledge of the behavior of the target groups (fields of study such as psychology, sociology, behavior-economy and marketing) was usually not considered (Boerbooms, Diepenmaat, Van Hal, Kansrijke aanpakken, 2010).
The Smart & Speedy initiative shows the following elements to be of great importance too:

- The ratio of sold and rented houses
- The specific circumstances of the renovation project (kind of neighborhood, technical condition, etc..)
- Energy prices
- Public opinion regarding sustainability topics
- Policy of the national government
- European regulation
- Employment rate in the building industry
- Pull or Push market
- Market demand
- Vision of the construction industry on cooperation (willingness to cooperate)

Research carried out for the Smart & Speedy initiative has resulted in determining the following main focuses for action: cost reduction, meeting the needs of the residents, increasing the interests of housing associations, improvement of the position of the supply side, optimization of the effectiveness of governmental influences, development and optimization of effective technology, improvement of cooperation, a focus on the neighborhood scale too, and improvement of communication.

PROMISING APPROACH: THE CASE OF ROOSENDAAL

In neighborhood the Kroeven in Roosendaal 264 dwellings are being renovated in a way that can be described as smart and speedy. The project is realized according to the 'passive house' principle. This project is unique because in the Netherlands traditional rental terraced houses are never renovated to passive house level on this scale. Furthermore, besides the high energy ambition, the project is spectacular as the whole renovation is realized in occupied state, for which a relative fast realization and rigid planning are necessary.
In conjunction with the residents' committee, the choice was made to renovate to passive-house level as a response to the fast rising energy prices. Since the first plan to renovate these houses normal maintenance had been put off. Unfortunately, it had taken years before the project was started. This diminished the residents' trust in the housing association, making it difficult to get the required 70% approval. In the end, the necessary approval was obtained by a guarantee for the coming five years that the rent increase will be compensated by the decrease in energy costs.

In the passive-house concept, optimal insulation is used in combination with the sealing of chinks causing the dwelling to have a maximal heat demand of 25 kWh/m^2 (against 65 kWh/m^2 for a newly built dwelling). In this project, this leads to a decrease in average use of natural gas from 2500 m^3 to 700 m^3. The energy label of the houses improves from an F/G label to A++. Two approaches are used for the renovation of the houses. The first 110 dwellings are renovated in a more traditional way on the outside as well as on the inside. The installation systems needed for a passive house are installed separately. The other approach makes use of prefab elements and one integrated passive house heating and ventilation system.

The second approach, with prefab elements, leads to higher quality, shorter construction time, no delays and less complaints of inconvenience. In this renovation method the outer cavity wall is removed first. Next, the ground floor is insulated. On the fifth day the door frame, the window frames and the roof are removed and replaced with new prefab façade and roof elements. These elements are already provided with windows and a solar boiler. The total renovation takes no more than fifteen days. The tenants are given the option to include an internal renovation of their dwelling. If the kitchen or bathroom are old, they can be replaced during the renovation. Additionally, the residents can choose convenience improvements, like a larger bathroom or a luxurious kitchen, in exchange for a rent increase.

In spite of the improvement in quality and the short turnaround, the reactions of the residents are not always favorable. At the start of the project, some of the tenants are dissatisfied when they do not qualify for a free new kitchen or bathroom, when others do. During the renovation there are complaints about the workmen working inside the house, not tied to any specific job. The renovation is a large infringement of the residents' privacy.

However, there is a different between the two renovation approaches. The approach with the prefab elements takes no more than fifteen days. This seems to be the maximum amount of time people can bear with this inconvenience. The more traditional approach takes four to five weeks. This causes a lot more complaints about the duration of the renovation. When the renovation is done, the residents are not always satisfied with their 'new' dwelling. They have to get used to using new heating strategies and to the lingering warmth. Some complain that the dwelling is too warm and there is some distrust of the new (mechanical) ventilation system regarding the indoor air quality.

CONCLUSIONS

There is a great urgency to refurbish the existing serial built housing stock in a smart, speedy and energy efficient way. New approaches, strategies and more extensive implementation are necessary which ask for a combined effort of stakeholders. Bottlenecks to realize these renovation projects in practice have to be tackled. Apart from speeding up technical and process innovation (and sharing knowledge) expanding the possibilities for financing energy efficient renovations is crucial. One of the main issues is to address the split incentive phenomena. To be able to do so, in the Netherlands also cooperation of residents is of major concern. One of the main bottlenecks is the lack of enthusiasm amongst residents. Meeting the needs of residents should be the number one concern of all parties involved.

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