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Complexity is in the Eye of the Beholder

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Complexity is in the Eye of the Beholder

Dissertation

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by

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Summary

English Summary

The Information Communications Technology (ICT) industry has been identified to have poor project outcomes (NATO Science Committee, 1969; Standish, 2016). ICT Project complexity has been reported by suppliers and clients as a cause of the poor project outcomes (Sauer & Cuthbertson, 2003; Whittaker, 1999). As the ICT industry becomes more integrated into society through technological advances and automation, firms require approaches and solutions to handle project complexity in order to stay in operation (Bakhshi et al., 2016; Ireland, 2016; Qureshi & Kang, 2014; Ramasesh & Browning, 2014)

Literature in project complexity revealed that there is no generally accepted definition (Vidal & Marle, 2008). Project complexity was initially defined to be centered around the project itself by factors involving its size, variety, uncertainty, dynamics and socio-political complexity (Baccarini, 1996; Shenhar & Divir, 1995; Maylor et al., 2008). Recent literature has provided definitions which have gravitated around the individual or team performing the project, defining project complexity as the difficulty to deliver the project (Tie & Booluijt, 2014; Vidal et al., 2010; Xia & Chan, 2012).

Literature has identified various project complexity factors, of which each factor has a different weighting (Dao et al., 2016), prioritization (Xia et al., 2012), and correlation amongst other factors (Qureshi & Kang, 2015). However, literature has not provided an all-inclusive framework to measure project complexity or handle the effect of project complexity on project outcomes. Research in project complexity appears to still be at a theoretical and conceptual state and has not yet reached a sustained and lasting practical level to the industry.

The supplier's expertise has been suggested as a key factor in handling the effect of project complexity on project outcomes (Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014). Yet, little is known about the extent of impact of the supplier's expertise. Our research aim is to develop an enriched conceptual model by better understanding the "impact of expertise on the effect of complexity on project outcomes". The main research question (MRQ) to be explored is: Can supplier expertise impact the effect of ICT project complexity on project outcomes? The main research question is then broken down into sub research questions (SRQ) as follows: SRQ1: What factors define ICT project complexity? SRQ2: What are characteristics of an expert supplier delivering ICT projects? SRQ3: How does supplier expertise influence the effect of project complexity factors on project outcomes?

To answer the main research question and sub-research questions we applied a multi method approach (Venkatesh et al., 2013). First, to answer SRQ1 a literature study was conducted analyzing 19 project complexity publications by the identification of project complexity factors. Second, to answer SRQ2 we conducted a case study to identify characteristics of an expert supplier delivering ICT projects. We validated the supplier as an expert through their project portfolio and embedded cases. After which we analyzed their organizational structure and project implementation methodology to identify specific characteristics of the expert supplier. Third, to answer SRQ3, a survey was conducted with 97 ICT practitioners. The survey research was conducted by asking practitioners to rate 22 project complexity factors' effect on project outcomes in two situations, with an expert supplier and with a nonexpert supplier. Statistical tools were then used to analyze the impact of the supplier's expertise. Lastly, interviews with 15 ICT practitioners were held to further elaborate on the research findings of the case study and survey to answer the main research question.

To answer SRQ1, the literature study identified 22 project complexity factors that influence the degree of project complexity. These factors can be divided into two main components of a project, namely stakeholder related factors (8) and scope related factors (14).

To answer SRQ2, the case study research identified seven characteristics of an expert supplier delivering ICT projects. Furthermore, the case study validated the supplier as an expert with project outcomes higher than the market reported outcomes. The case study findings were used to create two propositions that were tested in the next steps of our research:

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.
- Proposition 2: An expert does not perceive projects as complex.

To answer SRQ3, the survey research identified in the case of all 22 factors, expertise to reduce the effect that the project complexity factor had on project outcomes. Based on the survey findings Proposition 1 was strengthened, Proposition 2 was adjusted, and we identified two new propositions (3 and 4).

- Proposition 2 (Adjusted): Experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex.
- Proposition 3: Expert's challenges that relate to project complexity factors correspond to project stakeholder factors.
- Proposition 4: Nonexpert's challenges that relate to project complexity factors correspond to project scope factors.

The interviews provided elaboration on the case study and survey findings which strengthened all four propositions. Additionally, the interviews provided new insights as to the contribution and limitations of an expert with respect to project complexity factors relating to project stakeholders. Experts were identified to mitigate and handle project complexity factors which are within his/her control. Stakeholder related factors were identified to be outside of the expert’s control and unless the stakeholders utilize the expert’s expertise, the expert is unable to influence the effect of those factors on project outcomes.

Based on our research findings we conclude that the supplier’s expertise impacts the effect of ICT project complexity on project outcomes. Specifically, we found that the expertise of a supplier reduces the effect of ICT project complexity on project outcomes. Although an ICT project might be complex by nature, when applying the lens of expertise, an expert supplier will be able to reduce the effects of project complexity on project outcomes. In context, the supplier’s reduction of the effect of complexity on project outcomes is contingent on the client stakeholders’ willingness to release control and as such utilize the expertise of the supplier.

The aim of this research was to develop an enriched conceptual model by better understanding the “impact of expertise on the effect of complexity on project outcomes”. The findings of our research contribute to project complexity theory and practitioners by explaining the role and value of expertise to project complexity. The findings suggest the need to adjust existing project complexity models to incorporate expertise and further develop criteria to measure the expertise of suppliers. Based on the findings, practitioners are suggested to change their selection model, organizational structure, and project implementation methodology to center around the identification and utilization of expertise.

Nederlandse samenvatting

De Informatie Communicatie Technologie (ICT) industrie staat bekend om de slechte resultaten van projecten (NATO Science Committee, 1969; Standish, 2016). Leveranciers en opdrachtgevers benoemen de complexiteit van ICT-projecten als oorzaak van deze slechte resultaten (Sauer & Cuthbertson, 2003; Whittaker, 1999). Nu de ICT-industrie meer geïntegreerd raakt in de samenleving, onder andere door technologische vooruitgang en automatisering, hebben bedrijven voor hun continuïteit methoden en technieken nodig om tegenwicht te kunnen bieden aan de toenemende complexiteit in ICT projecten (Bakhshi et al., 2016; Ierland, 2016; Qureshi & Kang, 2014; Ramasesh & Browning, 2014).

Literatuur over projectcomplexiteit geeft geen algemeen aanvaarde definitie (Vidal & Marle, 2008). Complexiteit van projecten werd aanvankelijk gedefinieerd rond het project zelf door factoren die betrekking hadden op de grootte, variëteit, onzekerheid, dynamiek en socio-politieke complexiteit (Baccarini, 1996; Maylor et al., 2008; Shenhar & Dvir, 1995). Recente literatuur vult hierop aan met definities waarin de uitvoerenden in een ICT project centraal staat en wordt complexiteit van projecten gedefinieerd als de moeilijkheid om het project op te leveren (Tie & Booluijt, 2014; Vidal et al., 2011; Xia & Chan, 2012).

Uit de literatuur komen verschillende factoren van complexiteit, waarvan elke factor een andere weging heeft (Dao et al., 2016), een andere prioritering (Xia & Chan, 2012) of een andere correlatie tussen de factoren (Qureshi & Kang, 2015). De literatuur biedt echter geen allesomvattend model om de complexiteit van projecten te meten of het effect van complexiteit op de resultaten van het project te beïnvloeden. Onderzoek naar complexiteit van projecten lijkt zich in een theoretische en conceptuele fase te bevinden en heeft nog niet een praktisch toepasbaar niveau bereikt voor de ICT-industrie.

De expertise van de leverancier wordt gezien als een sleutelfactor bij het verklaren van het effect van complexiteit op het resultaat van een project (Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014). Toch is er weinig bekend over de impact van de expertise van de leverancier. Het doel van het onderzoek is om meer inzicht te krijgen in de impact van de expertise van de leverancier op de relatie tussen de complexiteit van ICT-projecten en de resultaten. De hoofdonderzoeksvraag van het onderzoek is:

- Heeft de expertise van een leverancier impact op het effect van complexiteit op de resultaten van een ICT-project?

Deze hoofdonderzoeksvraag is onderverdeeld in de volgende drie sub-onderzoeksvragen:

- Subvraag 1: Welke factoren bepalen de complexiteit van ICT-projecten?
- Subvraag 2: Wat zijn kenmerken van een expertleverancier die ICT-projecten levert?
- Sublvraag 3: Hoe beïnvloedt de expertise van een leverancier het effect van factoren van complexiteit op de resultaten van een ICT-project?

Om de onderzoeksvragen te beantwoorden, is een gemengde onderzoeksmethode toegepast. Allereerst werd voor het beantwoorden van subvraag 1 een literatuurstudie uitgevoerd waarbij publicaties over complexiteit van projecten werden geanalyseerd om de factoren van complexiteit te identificeren.

Vervolgens hebben we voor het beantwoorden van deelvraag 2 een casestudie uitgevoerd, gericht op het identificeren van de kenmerken van een expertleverancier van ICT-projecten. We kwalificeerden de leverancier in de casestudie als een expert via hun projectportfolio en embedded cases. Daarna is de organisatiestructuur (van de leverancier) en de p implementatiemethode in het project geanalyseerd om specifieke kenmerken van de expertleverancier te identificeren.

Ten derde, om deelvraag 3 te beantwoorden, is een survey uitgevoerd onder 97 ICT-professionals. In de survey hebben we ICT-professionals gevraagd naar het effect van expertise van de leverancier op de factoren van complexiteit in relatie tot de projectresultaten. Statistische instrumenten zijn vervolgens gebruikt om de impact van de expertise van de leverancier te analyseren. Ten slotte zijn er interviews gehouden met 15 ICT-professionals om de onderzoeksresultaten van de casestudie en de survey verder uit te werken en zo de hoofdonderzoeksvraag te beantwoorden.

De literatuurstudie identificeerde 22 factoren van projectcomplexiteit. Deze factoren kunnen worden onderverdeeld in twee hoofdcomponenten, namelijk stakeholder gerelateerde factoren (8) en project scope gerelateerde factoren (14). Daarmee is deelvraag 1 beantwoord.

Uit de casestudie werden zeven kenmerken van een leverancier die expert is op ICT-project geïdentificeerd. Bovendien valideerden de resultaten uit de casestudie de leverancier als een expert met projectresultaten die hoger waren dan de door de markt gerapporteerde resultaten. De bevindingen zijn gebruikt om de volgende twee proposities te creëren die werden getest in de volgende stappen van het onderzoek:

- Propositie 1: Expertise vermindert het effect van complexiteit op de resultaten van een ICT-project.
- Propositie 2: Een expert ziet ICT projecten niet als complex.

Uit de resultaten van de survey (antwoord op deelvraag 3 volgt dat expertise van de leverancier het effect van alle 22 factoren van complexiteit op het resultaat van het project vermindert. Op basis van de onderzoeksresultaten werd propositie 1 bevestigd, werd propositie 2 aangepast en presenteerden we twee nieuwe proposities (3 en 4):

- Propositie 2 (aangepast): Experts zien ICT-projecten niet als complex, terwijl niet-experts ICT-projecten als complex ervaren.
- Propositie 3: Uitdagingen van experts betrekking hebben op stakeholder gerelateerde factoren van complexiteit.
- Propositie 4: Uitdagingen van niet-experts met betrekking tot factoren van complexiteit, komen overeen met de scope gerelateerde factoren.

De interviews leverden dieper begrip op van de casestudie- en onderzoeksbevindingen van alle vier de proposities. Daarnaast hebben de interviews nieuwe inzichten opgeleverd over de bijdrage en de beperkingen van een expert met betrekking tot de factoren van complexiteit in relatie tot de stakeholders van het project. Een expert kan factoren van complexiteit binnen zijn/ haar invloed mitigeren en hanteren. Stakeholder gerelateerde factoren bleken buiten de invloedsfeer van de expert te liggen en als de stakeholders geen gebruik maken van de expertise van de expert, kan de expert het effect van deze factoren op het resultaat van het project niet beïnvloeden.

Op basis van de onderzoeksresultaten concluderen we dat de expertise van een leverancier het effect van complexiteit op de resultaten van ICT-projecten vermindert. Hoewel een ICT-project van nature complex kan zijn, zal een expertleverancier bij het toepassen van zijn expertise het ICT-project niet als complex ervaren. Met andere woorden, ‘complexity is in the eye of the beholder’.

In de context van ons onderzoek is de vermindering van het effect van complexiteit op het resultaat van een project afhankelijk van de bereidheid van stakeholders om los te laten en gebruik te maken van de expertise van de leverancier.

Het doel van dit onderzoek was om een beter inzicht te krijgen in de impact die de expertise van de leverancier kan hebben op het effect van de complexiteit op het resultaat van ICT-projecten. De bevindingen van ons onderzoek dragen bij aan de theorie over complexiteit van projecten en aan de praktijk door de rol en de waarde van expertise te relateren aan de complexiteit van projecten. De bevindingen adviseren om bestaande modellen over complexiteit van projecten aan te passen en expertise te integreren in de modellen en om criteria te ontwikkelen om de expertise van leveranciers vast te stellen. Op basis van de bevindingen wordt ICT-professionals geadviseerd om hun selectiemodel, organisatiestructuur en methodologie voor projectimplementatie te wijzigen in het kader van het identificeren en benutten van expertise.

1. Research Introduction and Design

1.1. Introduction

The Information Communications Technology (ICT) industry has been identified to have poor project outcomes. ICT Project complexity has been reported by suppliers and clients as a cause of poor project outcomes (Sauer & Cuthbertson, 2003; Whittaker, 1999). As the ICT industry becomes more integrated into society through technological advances and automation, firms require approaches and solutions to handle project complexity in order to stay in operation (Bakhshi et al., 2016; Ireland, 2016; Qureshi & Kang, 2014; Ramasesh & Browning, 2014). Over the years, expertise has been suggested as a potential solution to handle and mitigate the effect of project complexity on project outcomes (Arisholm et al., 2007; Bakhshi et al., 2016; Buckland & Florian, 1991; Francis & Gunn, 2015). The importance of the supplier's expertise in the delivery of projects has been researched at TU Delft as an overarching research strategy to improve the supply chain (Boer, 2012; Wiel, 2012; Kopecká, 2013; Smolders, 2019). We position our research to contribute to this body of knowledge through an exploration of the supplier's expertise in relation to the effect of project complexity on project outcomes.

This chapter forms the background to our study in the field of ICT project complexity. First, in Section 1.2 the research background regarding the importance of project complexity in relation to project outcomes is discussed. Then, Section 1.3 addresses how project complexity can be defined, how it can be measured and its effect on project outcomes. In Section 1.4 research concerning expertise and its impact on the effect of project complexity on project outcomes is explained. In Section 1.5 we present the research aim and questions that are used to guide our research. In Section 1.6 we define the research scope and subsequently, Section 1.7 describes the research approach in answering the research questions. Next, in Section 1.8 we address our research's contribution and finally, Section 1.9 presents the thesis outline.

1.2. Background

The Information Communications Technology (ICT) industry has had poor project outcomes for many decades. There are varying criteria which are used to report ICT project outcomes. We will consider the criteria 'on budget', 'on time', and 'client satisfaction' which are commonly used criteria in the industry (Al-ahmad et al., 2009; Dijk, 2009; Emam & Koru, 2008; Fenech & De Raffaele, 2013; Kappelman et al., 2002; Mckinsey, 2012; Proacaccino, 2002; Public Adminstration Committee, 2011; Standish Group, 2016). Other less-cited criteria for project outcomes include 'cancellation' (Schmidt et al., 2001), 'quality' (Emam & Koru, 2008), 'use of end product' (Proacaccino, 2002), and 'required features and functions' (KPMG, 2005).

Poor project outcomes have been identified as early as 1968 when in The North Atlantic Treaty Organization (NATO) software engineering conference, the so called “software crisis” was addressed (NATO Science Committee, 1969). The crisis arose due to the number of software projects failing to be finished on time, on budget, and which did not meet the correct specifications. At that time, based on the NATO conference findings, the proposed causes of failure included the complexity of projects and the lack of expertise.

These causes were addressed to be related to the technology and demands of the clients surpassing the suppliers’ available solutions. Due to client demands, suppliers offered solutions which were not tested, and accepted projects which had never been done before on a large scale. In this state, it was a concern that clients were losing confidence in the industry. The concluding guidance was to continue to improve current techniques and to not work outside the present state of technology (NATO Science Committee, 1969).

Since 1969, technology has advanced with various project delivery and management methods. Rivera (2017) studied the evolution of project management and nineteen different approaches including rapid application development, the V-model, spiral model, lean software development, and agile. Beulen and Ribbers (2002) developed a framework to manage complex ICT outsourcing partnerships including IT-strategy, information management, contracts, contract management, and availability of human resources. Van Oosterhout et al. (2006) have defined a framework for business agility, in order to better operate in highly uncertain conditions. Janssen and Kuk (2006) formed a structure to manage diverse, independent, and ICT related projects from the perspective of a complex adaptive system.

Even with these advancements in technology and project delivery and management methods, the “software crisis” may not have been resolved. A study published by the Standish group (1994) identified that 83.8% of ICT projects failed to be completed on time and on budget. ICT projects, which were completed by the largest American companies, had only 42% of their original features and functions. Recent reports by the Standish Group (2016) reported that on a global level 71% of ICT projects failed to be completed on time, on budget and with a satisfactory result to the client.

A company’s ICT projects are a crucial part of their ability to excel in the industry. Poor ICT project outcomes can lead to other serious issues including failure to use designed systems properly, failure to meet business needs, and the failure to meet expected benefits. Poor project outcomes can be serious enough to threaten the existence of the company. The Robbins-Gioia survey (IT-Cortex, 2016) reported that 46% of the respondents noted that while their organization had an ERP system in place, or was implementing a system, they did not feel their organization understood how to use the system to improve the way they conduct business. Hoffman (1999) surveyed more than 16,000 IT professionals at 6,000 companies in 28 countries. The results identified 85% of IT organizations in the US failed to meet their organizations strategic business needs. Whittaker (1999) surveyed chief executives of 1,450 public and private sector firms across Canada in the ICT industry. The findings identified that 45% did not produce the expected benefits. Budzier and Flyvbergij (2011) entry for the Harvard Business Review did an analysis of 1,471 ICT projects and reported 17% had a failure high enough to threaten the firm's existence.

The effect of project complexity has been identified as a recurring issue to ICT project outcomes. The Standish Group (2016) identified project complexity as one of the main reasons for project failure with 14% of "very complex" projects to be completed on time, on budget and with a client satisfactory result. Al-ahmad et al. (2009) indicated that failure of ICT projects can be attributed to complexity as one of six generic root causes (other factors include project management, top management, technology, organizational, and process). Sauer and Cuthbertson (2003) analyzed data collected from 1,500 practicing ICT project managers. Their study showed that an increase of the degree of project complexity resulted in lower project outcomes reflected in on time and on budget. Xia and Lee (2004) through an analysis of 541 Information System development projects identified project complexity to have a negative effect on project outcomes (delivery time, cost, functionality and user satisfaction). Studies in the public sector show comparable results. For instance, governmental studies in The Netherlands, United Kingdom, and Australia all identified ICT project complexity to be a key contributor to poor project outcomes (Legislative Assembly of the Northern Territory, 2014; Public Administration Committee, 2011; The House of Representatives of the Netherlands, 2014).

Bakhshi et al. (2016) identified that projects are becoming more complex and are considered to be an inseparable aspect of modern daily business operations. Bullock and Cliff (2004) described how ICT project complexity is unavoidable due to the transition from relatively isolated individual ICT activities to much more interconnected information systems (i.e. data, applications and ICT infrastructure). An example of such a transition is that companies today are globally connected in sharing and exchanging information. Additionally, technology has transitioned from isolated ICT activities to a centralized information system, which may support finance, marketing, facility management, project management, and communications. These increasingly complex information systems have been recurrently identified as a growing obstacle. Whittaker (1999) identified that the key users' misunderstanding of an ICT project's complexity is considered to be one of the major causes of project failures. Yeo's (2002) research ranked the underestimation of project complexity as number one of the top five causes of content driven issues, including incomplete specifications, inappropriate choice of software, changes in design specifications late in the project and a high degree of customization.

The ICT Industry has been experiencing poor project outcomes for years. Project complexity has been identified to contribute to poor project outcomes inclusive of the criteria ‘on budget’, ‘on time’ and ‘client satisfaction’. As technology progresses and ICT systems become more advanced, the ICT industry will require the expertise and means to handle project complexity in order excel and survive in the industry.

1.3. Project Complexity

A preliminary, explorative literature review was conducted in the field of project complexity to understand project complexity theory in terms of how it is theoretically defined, measured/modelled and related to the project outcome.

Schlindwein and Ison (2004) state that complexity has been understood in different ways and as such, grouped existing explanations into two distinct components: descriptive and perceived complexity. The authors explored the history and epistemology of both components. Descriptive complexity depends on the project itself regardless of the observer. In contrast, perceived complexity is dependent on the observer’s perception of the project. A distinction between the two components would make it difficult to understand complexity as it relates to both the perception of the observers of the project and the project itself (Casti, 1995; Ciurana, 2004). In defining project complexity, the descriptive and perceived components are integrated in the measurement of complexity through project factors and the weighted contribution of those factors to project complexity.

Literature provides multiple definitions of project complexity; however, there is not a generally accepted definition (Vidal & Marle, 2008). Geraldi et al. (2011) performed a systematic review of relevant literature to provide a framework to define project complexity comprising of four dimensions including structural, uncertainty, dynamic, and socio-political complexity.

Structural complexity (Baccarini, 1996; Williams, 1999) relates to the many-varied interrelated parts of a project. Structural complexity can be described by the attributes of size (number), variety and interdependence. Examples of factors of structural complexity include the number of stakeholders and their interdependency, financial scale of project, scope, number and diversity of inputs and/or outputs, and the number of separate and different actions or tasks to produce the end product of a project.

Uncertainty complexity relates to the current and future state of factors that make up a project (Dvir & Shenhar, 1998; Tatikonda & Rosenthal, 2000). Uncertainty includes the understanding of the current state; how current factors will interact and the impact of those factors on the future state of the project. Uncertainty factors can be described by the attributes of experience, novelty, ambiguity and availability of information (knowledge). Examples of factors include innovation, use of methods (contracting, project management, technology) with little or no previous experience, and ambiguity of performance measurements.

Socio-political complexity relates to the people within a project which have potentially conflicting interests and difficult personalities (Maylor et al., 2008; Rolstadas et al., 2017). Socio-political complexity can be described by the attributes of the stakeholders' project priority, support, and agreement/fit. Factors include support of senior management, appropriate authority and accountability, project goals aligned with the organization's strategy, and realistic expectations of timescale and budget.

Dynamic complexity relates to changes which occur in a project. Dynamic complexity can be described by the attributes of adaptability, flexibility and alteration. Factors include changes to the project conditions such as specifications, stakeholders, technology and goals.

Geraldi et al. (2011) analyzed project complexity using both 'descriptive' and 'perceived' components to measure complexity. They identified that how individuals perceive and respond to descriptive complexity is not fully represented in existing literature. Tie and Bolluijt (2014) identified that the project team is usually responsible to manage the project complexity. Based on this assumption, project complexity should not be solely defined based on the descriptive measurements of a project but include the individual's perception. Therefore, Tie and Bolluijt (2014, p. 248) defined complexity as the "…difficulty of delivering a specific project in a specific organization". Xia and Chan (2012, p. 11) similarly defined complexity as the "…degree of difficulty in delivering a project". Vidal et al. (2011, p. 719) defined complexity as the "…property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour".

For the purpose of our research we will draw on the definitions of Tie and Bolluijt (2014), Xia and Chan (2012), and Vidal et al. (2011) and define project complexity as "the difficulty in delivering a project". The difficulty in delivering a project fits within our research aim as we investigate the impact of the supplier's expertise on the effect of project complexity on project outcomes. This definition incorporates both the descriptive and perceived components to project complexity (Schlindwein & Ison; 2004) while building off findings from Geraldi et al. (2011). Our definition fits within the descriptive component as it utilizes factors to objectively measure complexity such as the number of stakeholders or the project budget. The definition also fits within the perceived component as the added "difficulty" of these factors can be based on the perception of each individual.

Project complexity has been measured through various contributing factors. Qing-hua et al. (2012) modelled project complexity through the measurement of 28 factors by using six criteria, namely: technical, organizational, goal, environmental, cultural, and informational. Their study resulted in a weight per factor by means of the Analytic Network Process which relied on the feedback of expert practitioners. The top five weighted project complexity factors included cross-organizational interdependence, multiple stakeholders, number of organizational structure hierarchy, project team's trust and diversity of technology in the project.

Xia and Chan (2012) created a ranking of top project complexity factors for building projects. The results identified six important factors that include: building function and structure, construction method , urgency of the project schedule , project size/scale , geological condition and neighboring environment.

Vidal et al. (2011), identified 17 project complexity factors each with an assigned weight of contribution to complexity. Unlike Xia and Chan (2012) and Qing-hua et al. (2012), Vidal et al. (2011) operationalized their framework to evaluate seven projects in the entertainment industry. The 17 factors were grouped subsequently:

- Project size represented by the number of stakeholders.
- Project variety represented by a variety of information systems to be combined, geographic location of stakeholders, and variety of the interest of the stakeholders.
- Project Interdependencies represented by dependencies with the environment, availability of people and material due to sharing, interdependence between sites, interconnectivity/feedback loops in the project networks, team cooperation and communication, dependencies between schedules, interdependence of information systems, interdependence of objectives, level of interrelations between phases, and specification interdependence.
- Project context dependence represented by cultural configuration and variety, environment organizational complexity, environment technological complexity.

Qureshi and Kang (2014) modelled project complexity through the measurement of 38 factors divided into five latent variables: project size, project variety, elements of context, interdependencies within the project, and project complexity. The results indicated that the only latent variable that did not directly affect project complexity related to the project context. This includes factors such as competition, environmental complexity, intuitional configuration, laws and regulations, and organizational degree of innovation.

Azim et al. (2010) analyzed project complexity through the measurement of 23 factors divided into three determinants: people, product/service, and processes performed by people. The results underlined the importance of the role of people to project complexity. Their study showed that people-related factors are ranked as the highest impact to project complexity, and next, processes and products. People-related factors include number and size of teams, technical knowledge and expertise, poor relationships, lack of senior management support, and lack of leadership.

There are factors which can be clearly measured with both the descriptive and perceived components. For instance, the factor of financial value can be measured by the observable contract value (e.g. one million dollars) or the perceived value of the project, such as small, medium and large. There are factors which unlike financial worth, are difficult to measure objectively such as poor relationships, trust in stakeholders and the technological degree of innovation. Tatikonda and Rosenthal (2000) measured the project complexity factors of technological difficulty, process technology novelty, technology interdependence, objectives novelty and project difficulty using a seven-point Likert scale. For instance, project difficulty was measured by 1 signifying no difficulty, 4 some difficulty and 7 great difficulty. Similarly, objective novelty was measured with 1 signifying no experience, 4 some experience and 7 great experience. Florciel et al. (2015), Tie and Bolluijt (2014) and Dao et al. (2016) similarly use Likert scales as a practical method to measure project complexity factors. We did not find evidence in literature that demonstrated that complexity could be understood without both descriptive and perceived components (Casti, 1995; Ciurana, 2004). Literature's identification of project complexity factors supports the practice of incorporating both descriptive and perceived components of complexity.

Various studies have built frameworks to model project complexity by establishing weights, prioritization and correlations between project complexity factors (Qing-hua et al., 2012; Xia & Chan, 2012; Vidal et al., 2011; Qureshi & Kang, 2014; Azim et al., 2010). Importantly, there is no consensus as to a preferred framework of measurement. Vidal et al. (2011) analyzed 42 existing project complexity measurements and identified that the different definitions and weightings of project complexity factors caused inaccuracy in measuring project complexity as a whole. The inaccuracies were attributed to (1) different perceptions of the definition of project complexity (2) difficulty for users to compute and implement the given factors as they are not intuitive to understand or user-friendly and (3) the selected measures are biased and often measure the project model and not project complexity.

What is complex to one person can be non-complex to another. Vidal et al. (2011) analyzed seven projects with five project team members which resulted in a different rankings of project complexity. In one case, four of the project team members ranked a project third in complexity while the fifth member rated the project as less complex. The project team members rated the same project factors but resulted in different scorings of project complexity. The difference in scoring was identified to be due to the difference in expertise gained through experience. The fifth member had already completed a similar project before, while the other four were performing the project for the first time. Ribbers and Schoo (2002) measured 15 projects comparing the computed complexity rating based on the factor's values and the subjective rating based on the program managers. The comparison identified that program managers rated their projects slightly higher than the computed scoring. Studies conducted by Ribbers and Schoo (2002) and Vidal et al. (2011) demonstrate that the determination of a project's complexity is based on both descriptive and perceived components.

The conclusion of the preliminary review of project complexity is that literature has not provided an all-inclusive framework to measure project complexity or reduce the effect of project complexity on project outcomes. Such a framework would include contributing factors to complexity, weighting/prioritization of factors and correlation between factors, that has been standardized and proven accurate through repeated testing. Literature has suggested that individual related factors affect project complexity significantly in which the aspect of expertise is perceived as important (Azim et al., 2010; Qureshi & Kang's, 2014; Tatikonda & Rosenthal, 2000; Antoniadis et al. 2011; Floricel et al. 2016). Next, we address the impact of expertise on the effect of project complexity on project outcomes.

1.4. Expertise

Qureshi and Kang's (2014) analysis of 38 project complexity factors suggested that handling the degree of project complexity mainly depends on the expertise of the project manager and entire project team. Putting it differently, it is suggested that the effect of project complexity relates to the observer's expertise and as such, their expertise may reduce the effect of project complexity. Buckland and Florian (1991) underpin the importance of expertise by analyzing the relationships between user expertise, task complexity and the scope for the use of artificial intelligence. The authors' study identified that the expertise of the user must match the task complexity. They argued that when the required expertise is insufficient, a company may either increase the level of expertise through education or simplify the system. Francis and Gunn (2015) studied the effect of expertise on auditors' quality of earnings amongst different industry groups. The results identified that the auditors' expertise may improve the quality of their earnings in complex industries. On the other hand, Francis and Gunn (2015) identified the auditors' expertise to be insignificant in non-complex industries. Arisholm et al. (2007) studied 295 ICT consultants in the programming of simple and complex information systems. Their study identified that the effect of information system complexity on the programmer's project outcomes was dependent on the programmer's expertise.

Literature shows various descriptions of expertise. Gobet (2015) noted that experience and the amount of time an individual has spent in a domain has been used as a definition. In contrast, experience and the amount of time is discouraged by Richman et al. (1996); as it is seen as a poor predictor of true expertise. Research indicates there is little empirical evidence to substantiate a correlation between the number of years spent in the field and expertise (Meehl, 1954; Campitelli & Gobet, 2004). Gobet (2015) noted that diplomas, including PhD's, honorary titles, and certificates from professional associations are unreliable due to the subjective varying criteria, testing of declarative knowledge, and the identification of expert individuals who do not have diplomas (Epstein, 1996). Outcome oriented metrics, specific to the domain, are often seen as more reliable (Gobet, 2015). For instance, financial management expertise can be identified by wealth accumulated to clients or expertise in science be identified by the accumulated number of citations and books sold.

In our research, we will draw on Gobet's (2015, p.12) definition of expertise 'knowledge and skills', with an expert being defined as 'somebody who obtains results that are vastly superior to those obtained by the majority of the population'.

This definition of an expert can be applied recursively to expertise, emphasizing both the individual's knowledge and the individual's skills. The application of this definition to skills is straightforward as the results of both an expert and nonexpert can be observed. Gobet (2015) noted that knowledge requires testing more than quantity but also the quality of knowledge, which can also be measured through observable results from an expert and nonexpert.

Our research herein, is performed within TU Delft, Industrial Design Engineering, where, amongst other fields, delivering projects in networks is studied. The research strategy of the chair of Marketing and Supply Management includes the use of expertise of suppliers within these networks as well as in inter-organizational (project) cooperation. Examples are:

1. Seneca's error, An affective model of cognitive resilience (Boer, 2012)
2. Learning to collaborate (Wiel, 2012)
3. Why didn't we ask the supplier ? (Kopecká, 2013)
4. How to achieve availability in the MRO&U triad (Kaelen, 2014)
5. Innovating across boundaries (Deken, 2015)
6. An action repertoire for the collaboration in innovation networks (Bergema, 2016)
7. Trust unraveled (Smolders, 2019)
8. Rules or Rapport? On the governance of supplier-customer relationships with initial asymmetry (Steller, 2019, to be published)

This research contributes to this body of knowledge through the exploration of the impact of the supplier's expertise on the effect of ICT project complexity on project outcomes. Suppliers' expertise has been suggested as a potential concept that may reduce the effects of project complexity on project outcomes. The extent in which expertise may impact the effect of project complexity on project outcomes requires further research.

1.5. Research Aim and Questions

ICT project complexity has been identified as a cause of poor project outcomes (Al-ahmad et al., 2009; Sauer & Cuthbertson, 2003; Standish Group, 2016). Research into project complexity appears to be at a theoretical and conceptual state and has not reached a sustained and lasting practical level in the industry. As research into project complexity is a long-standing issue, it is noted that the industry is having difficulties shifting from the theoretical to the practical state. Consequently, poor project outcomes may cause extended project lead times, increase project costs and may even harm a firm's business operations. Literature identified various conceptual models to operationalize project complexity in terms of factors which contribute to complexity (Qing-hua et al., 2012; Vidal et al., 2011; Xia & Chan,2012). Project complexity models have not provided evidence that claim the effect of project complexity on project outcomes can be handled by using a standardized project complexity model.

The supplier's expertise is perceived to be a potential concept to reduce the effect of project complexity on project outcomes (Arisholm et al., 2007; Bakhshi et al., 2016; Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014).

Although project complexity literature identified various complexity factors, research insights did not find an explanation of how to reduce project complexity or its effect on project outcomes. Little is known about the extent of impact that expertise may have on the effect of project complexity on project outcomes. We argue that it is necessary to study project complexity by studying the "impact of expertise on the effect of project complexity on project outcomes". This research avenue may open new insights to handle the effects of project complexity and consequently improve project outcomes.

The aim of our research is to develop an enriched conceptual model by better understanding the "impact of expertise on the effect of complexity on project outcomes". In order to achieve our aim, the main research question (MRQ) to be explored is:

> Can supplier expertise impact the effect of ICT project complexity on project outcomes?

The MRQ is then broken down into three sub-research questions (SRQ):

> SRQ1: What factors define ICT project complexity?
> SRQ2: What are characteristics of an expert supplier delivering ICT projects?
> SRQ3: How does supplier expertise influence the effect of project complexity factors on project outcomes?

The main research question represents the aim of our research. The sub research questions will guide our research in order to achieve our aim. The flow and reasoning of our research questions are described in the research approach shown in Section 1.7.

1.6. Scope of Research

The conceptual research design is illustrated in Figure 1. ICT project complexity is defined as "the difficulty in delivering a project" (Tie & Booluijt, 2014; Xia & Chan, 2012; Vidal et al., 2011). This definition is used as a guide in the analysis and compilation of factors which contribute to project complexity as identified in literature (see Chapter 2 for analysis). The supplier's expertise is used as the moderating variable for the effect of ICT project complexity on project outcomes. We drew on Gobet's (2015, p. 12) definition of expertise as "knowledge and skills", with an expert being defined as "somebody who obtains results that are vastly superior to those obtained by the majority of the population". Hence, the ICT project and the supplier (inclusive of their expertise) are separate variables. In other words, the characteristics which define an expert supplier (defined in Chapter 3) do not overlap with ICT project complexity factors (defined in Chapter 2). The criteria of on time, on budget and client satisfaction are used as a proxy to measure project outcomes. These three criteria have shown to be commonly used in the ICT industry (Al-ahmad et al., 2009; Dijk, 2009; Emam & Koru, 2008; Fenech & De Raffaele, 2013; Mckinsey, 2012; Proacaccino, 2002; Standish Group, 2016).

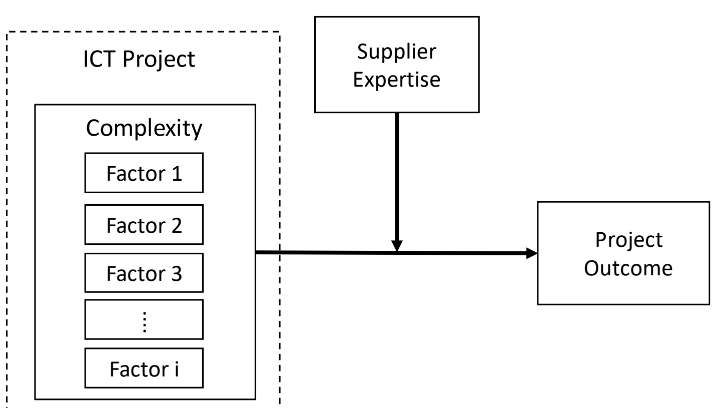

Figure 1: Conceptual Research Design

As our research focuses on the ICT industry in particular, an ICT project is identified as the unit of observation. The impact of the supplier's expertise on the effect of ICT project complexity on project outcomes is considered as the unit of analysis. Within the context of an ICT project the supplier is considered to be fully responsible for executing the project (product or service), which is defined by the client (McCarthy & Anagnostou, 2004; Tayauova, 2012).

A project life cycle has three main phases (1) creation of the project in terms of the scope (2) procurement of the project for the selection of a supplier and (3) the execution of the project by the supplier's project manager and project team. The scope of our research focuses on the project execution phase specifically as we are focused on the impact of the supplier during the execution of the project.

1.7. Research Approach

Research explaining the impact of expertise on the effect of ICT project complexity on project outcomes is suggestive and requires further theoretical substantiation. To answer the main research question and sub-research questions we applied a multimethod design to ensure that varying aspects are considered. The multimethod design allowed us to use data, methods, methodologies, and/or paradigms from both qualitative and quantitative approaches (Mingers & Brocklesby 1997; Teddlie & Tashakkori 2003, 2009). The use of multiple methods is identified to benefit research which requires a holistic view of circumstances which context is required (Venkatesh et al., 2013). Morse (2003) notes that the use of multiple methods allows for the compensation of weaknesses of both qualitative and quantitative techniques with their strengths. As such, research outcomes can be related to one another to create propositions (Creswell, 1999; Ostulnd et al., 2011). The multimethod design as applied in our research was adapted from Dul and Hak's (2008) structure for theory building. The multimethod was considered appropriate for our research as our objective is to develop an enriched conceptual model by understanding the concept, "impact of expertise on the effect of project complexity on project outcomes". The concept under study is not well understood in literature, dependent on circumstance and has an inherent perceived component to its measurement. Based on the listed criteria the research techniques used include:

1. Literature review
2. Case Study
3. Survey
4. Interview

For the Literature review, publications from multiple industries were considered due to the limited knowledge specific to the ICT industry (see Chapter 2.2 for further details). The geographical locations of the Netherlands and United States were selected as areas of focus for our case study, surveys and interviews. These countries were identified as applicable due to their history and investigation into both ICT project complexity and poor ICT project outcomes from a governmental perspective (The House of Representatives of the Netherlands, 2014; United States Senate Permanent Subcommittee on Investigations, 2014) and an industry perspective (Giarte, 2014; Standish Group, 2016).

Table 1 provides an overview of the research questions and the applied research methods.

First, a literature review was conducted as a suitable method to identify relevant factors by which ICT project complexity can be defined (SRQ 1). The objective of the literature review was to further develop an enriched conceptual model with regard to the identification of a comprehensive list of project complexity factors to measure ICT project complexity. The factors would be considered formative factors which contribute to project complexity. The preliminary literature review identified publications which have already defined project complexity factors using various research methods, such as workshops, interviews, surveys and literature reviews. By drawing on the previous publications instead of self-performing the identification of project complexity factors from scratch, we were able to strengthen the validity of the identified project complexity factors.

Second, case study research is used to investigate an expert supplier delivering ICT projects. The objective of the study was to further develop an enriched conceptual model with regard to the identification of (1) the project outcomes of an expert ICT supplier within an industry identified to have complex projects and (2) characteristics (organizational structure and project implementation methodology) of an expert ICT supplier. By using case study research, we gained a more in-depth, comprehensive understanding of an expert supplier including their project portfolio, organizational structure characteristics, and project implementation methodology characteristics (SRQ 2). For instance, by selecting a single supplier, we were capable to identify the actual project outcomes in contrast to the perception of the project outcomes performed through survey research. Additionally, we analyzed and identified specific characteristics which describe the expert ICT supplier. Based on theory building and the exploratory nature of the research, this level of depth and context was necessary to achieve the research aim.

Third, through survey research (SRQ 3) the results of the case study were further explored by analyzing the impact of the supplier's expertise on the effect that individual project complexity factors have on project outcomes. The main objective of the survey study was to further develop an enriched conceptual model with regard to the impact of expertise on the effect of project complexity (measured through individual project factors) on project outcomes. A secondary objective of the survey research was to identify underlying project complexity factors which affect the project outcome. In contrast to the case study, the survey gathered data from a larger number of respondents which strengthened the generalizability of our research findings.

Lastly, interviews were conducted to elaborate on the theory building findings of the case study and survey. Theory elaboration has been used as a basis for developing new theoretical insights (Lee et al., 1999). Fisher and Auginis (2017) identified that theoretical relations could be elaborated so that they accurately describe and explain empirical observations. The case study's limitation was that the findings only related to a single supplier. The survey research was objectively analyzed and drew from a larger number of respondents, which strengthened the generalizability of the case study findings. The survey research's limitation was that it lacked the exploration of the opinions, behavior, and experiences of the respondents. The purpose of the interviews was to compensate for the survey research's limitations and elaborate on the theoretical findings of the case study and survey findings.

By applying a multi method design, we were able to create a holistic understanding to answer the main research question (MRQ).

Table 1: Relationship Between Research Questions and Methodology

Framework	Literature Review	Case Study	Survey	Interviews (Elaboration)
Methodology: Multi methods Unit of Observation: ICT Projects Unit of Analysis: The impact of expertise on the effect of ICT project complexity on project outcomes	*SRQ1: What factors define ICT project complexity?*	*SRQ2: What are characteristics of an expert supplier delivering ICT projects?*	*SRQ3: How does supplier expertise influence the effect of project complexity factors on project outcomes?*	*MRQ: Can supplier expertise impact the effect of ICT project complexity on project outcomes?*

The research methods are further addressed in the next sections.

1.7.1. Literature Review

A literature review was conducted based on publications which studied project complexity factors. We used a wide range of academic journals, conference papers and books as well as industry magazines, websites, organizational documents and publications. The literature review was used to identify relevant factors which contributed to project complexity, to answer the first sub research question (SRQ1). This is consistent with the approach as explained by Dul and Hak (2008). The literature review is described in more detail in Chapter 2.

1.7.2. Case Study

By conducting a case study, we gained a deeper understanding of the phenomenon under study (Yin, 2009). More specifically, a case study was performed with an ICT supplier identified to be an expert to create insight into the characteristics of an expert supplier delivering ICT projects. The "supplier" was identified and selected to be an expert through comparative third-party reviews with other suppliers within the same area. The supplier's project portfolio (in terms of project outcomes) and embedded cases were then analyzed and validated the supplier as an expert. The supplier's organizational structure and project implementation methodology were then analyzed to identify characteristics which described an expert ICT supplier. This method is described in more detail in Chapter 3.

1.7.3. Survey

The survey method consisted of a questionnaire which included project complexity factors identified through the literature research (Chapter 2). Practitioners involved in the implementation of ICT projects from client and supplier organizations were then invited to participate in the questionnaire. The goal of the survey was to collect quantitative data to further explore the findings from the case study research (see Chapter 3). This was done by identifying the effect of ICT project complexity factors on project outcomes from the perspective of an expert supplier and a nonexpert supplier. The method is described in more detail at the beginning of Chapter 4.

1.7.4. Interviews

The purpose of conducting interviews was to deepen our understanding of the impact of the supplier's expertise on the effect of ICT project complexity on the project outcomes, gained from the case study and survey findings. Interviews were conducted with practitioners involved in the implementation of ICT projects. The interviews followed a semi structured design centered on elaborating on the key research findings from the case study and survey. The method is described in more detail in Chapter 5.

1.8. Research Contribution

Three main contributions of our study are the identification of (1) ICT project complexity factors, (2) characteristics of an expert ICT supplier and (3) the expertise of the supplier to reduce the effect of ICT project complexity on project outcomes, up to the limit that client stakeholders are willing to release control and utilize the expertise of the supplier.

From an academic perspective, the findings of our research contribute to project complexity theory. The identification of key ICT project complexity factors strengthens the theoretical framing of ICT project complexity. By better understanding the critical role of expertise to project complexity, existing project complexity models can be adjusted taking expertise into account. The adjustments include (1) the measurement of factors contributing to the level of expertise of the supplier executing the project, (2) the measurement of the stakeholder factors which prevent the utilization of the supplier's expertise and (3) the elimination of factors which do not pertain to the supplier's expertise or limit the supplier's expertise. The adjustments would reduce the number of factors to be measured, improve the accuracy of modelling project complexity and assist the theoretical modeling of project complexity move towards a more practical state.

The research findings contribute to practices by addressing the value of experts in dealing with ICT project complexity. Based on the findings, practitioners can use an ICT project complexity model that takes expertise into account to improve project outcomes. Understanding the role of an expert will allow practitioners to adjust their best practices.

Clients may begin by changing the procurement (selection) of suppliers and focus on criteria which include expertise. Selection criteria which may not be a reliable indicator can be eliminated. The adjustments to procurement may also affect the actual process of procurement. For example, some criteria, such as project planning and risk mitigation, have been suggested to be criteria of expertise. The research results may propose these functions be moved before the award of the project as a selective criterion of expertise. Clients can then begin to change their role within the execution of the project. To reduce the effect of project complexity on project outcomes, clients can reduce activities which prevent the supplier's expertise from being utilized. Next, Suppliers may change their organizational structure and project implementation methodology to allow the fostering, identification and use of experts within the organization.

The contribution of this research to project complexity theory has potential to improve modelling project complexity and industry practices.

1.9. Thesis Outline

Figure 2 identifies the outline of this dissertation. A summary of the chapters is also presented to help navigate through the chapters of the dissertation.

Chapter 1: Research Introduction and Design: This Chapter introduces the research topic of project complexity including its background, research aim, research questions, scope, approach and contribution to research and practitioners. In doing so, the research topic is designed inclusive of ICT project complexity and the supplier expertise.

Chapter 2: Literature Review: This Chapter describes a literature review which was conducted on project complexity publications focused on the identification of factors which contribute to project complexity. This Chapter answers the first research question.

Chapter 3: Case Study Research: A case study was performed as part of the multi method approach, with a supplier identified to be an expert. The supplier's organizational structure and project implementation methodology were analyzed to identify characteristics of an expert ICT supplier. Chapter 3 answers the second research question.

Chapter 4: Survey Research: This Chapter shows the results from the exploratory survey research done, to gain a better understanding of the impact of the suppliers' expertise on the effect of project complexity factors on the project outcome. Chapter 4 answers the third research question.

Chapter 5: Interview Research: This Chapter elaborates on the research findings from both Chapter 3 and Chapter 4 through interviews. The insights gained from these interviews are integrated with the research findings to answer the main research question.

Chapter 6: Conclusion: This Chapter summarizes the answers and results of each question identified in Chapter 1, and as such, to the main research question.

Chapter 7: Reflection: This Chapter concludes the research with a review of the research performed and its place within existing research by identifying its value, limitations and recommendations for further research.

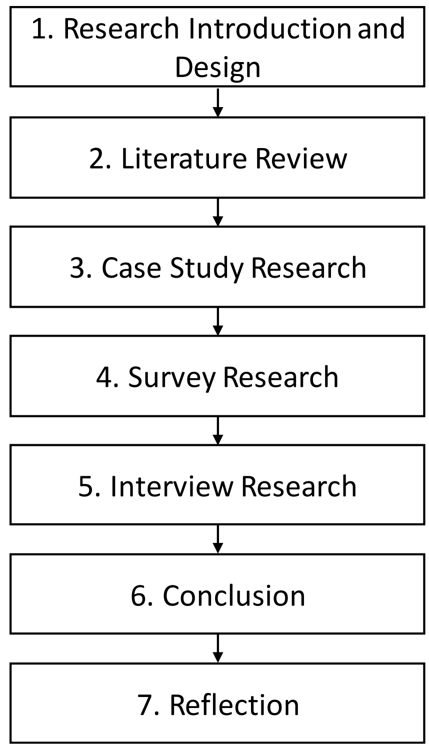

Figure 2: Thesis Outline

2. Literature Review

2.1. Introduction

This Chapter describes the literature review that was conducted to answer the first research question 'What factors define ICT project complexity?' The literature review drew from previous publications which have defined project complexity factors using various research methods. Section 2.2 describes the methodology followed including the identified search engines, publication selection and database structure to organize the data collected. Section 2.3 describes the analysis and coding of the data. The resulting factors which contributed to project complexity from the literature analysis are described in Section 2.4. Lastly the conclusions are described in Section 2.5.

2.2. Research Method

When performing the literature review, a structured methodology was followed to strengthen the reliability of the research. The methodology included the identification of four relevant search engines and a publication selection protocol with three criteria described in Section 2.2.1 and the creation of an excel database structure for documentation described in Section 2.2.2.

2.2.1. Search Engine and Publication Selection

Publications on project complexity and related factors were identified through four search engines: Engineering Village, Emerald Insight, ProQuest and Google Scholar. Engineering Village consists of 12 engineering literature and patent databases. In total, the database composed of more than 16 million records from over 68 countries and 1,000 publishers. Emerald Insight focuses on research in the practice of business and management. Emerald Insight manages a portfolio of nearly 300 journals, more than 2,500 books and over 450 teaching cases. ProQuest also focuses on research into business management, extending their database to include dissertations, news, and the latest working papers. Google Scholar is a broad search engine across many disciplines and sources: articles, theses, books, abstracts and court opinions, from academic publishers, professional societies, online repositories, universities and other web sites. Google Scholar ranks search results according to where it was published, who it was written by and how recently it was cited.

Engineering village was the first search engine used as it drew from the largest pool of publications based on the descriptions given by each database. The database covers a wide range of relevant subject journals to ICT project outcomes and complexity namely: computer science, business and management, decision sciences, psychology, and engineering. The remaining databases (Emerald, ProQuest, and Google Scholar) were used sequentially based on their descriptive size. The process of multiple selected databases sequentially confirmed the range, saturation and overlap of publications from different sources and fields. In doing so, we conducted a broad search to identify current research within the area of project complexity.

In the literature review for project complexity, the terms “project complexity” + “complexity models” + “complexity factors” were used as keywords. While conducting the search based on the identified keywords, we used a set process.

The keywords were searched in each of the four databases. Starting with the first database (Engineering Village), publications were searched in rounds of 100 publications. After each round was completed, the hit rate was based on the following criteria:

1. The publications had to be available in full text English.
2. The abstracts were reviewed and filtered based on the relation to project complexity factors (related).
3. The publications were fully reviewed and filtered based on the contribution of a unique list of project complexity factors (contribute).

The search was deemed sufficient (completed) when the round failed to identify any new contributing publications. For subsequent databases, the same process was repeated with a minimum number of rounds required equal to the first database (Engineering Village). A minimum number of rounds was used for subsequent databases to account for new contributing publications to be rarer, due to identification in previous databases. After all contributing publications were identified, the references of the publications were reviewed to identify additional publications which contributed to our research.

After the review of the first database, five rounds was the minimum number of rounds required for the three subsequent databases. The search resulted in the review of 2,000 publications’ abstracts of which 213 were identified as ‘related’ to our research and 19 publications were identified to ‘contribute’ to our research as they provided a unique listing of project complexity factors (see Table 2). Emerald Insight excluded 4 contributing publications due to overlap with Engineering Village, ProQuest excluded 3 contributing publications due to overlap and Google Scholar excluded 13 contributing publications due to overlap. After the third round of reviews there were not any new or overlapping contributing publications in the databases of Emerald Insight, ProQuest or Google Scholar.

Out of the 19 contributing publications, 17 are based on using the four search engines and two through references. The 19 were published through academic journals (14) and conferences (4) such as, Kybernetes, Project Management Institute, Wiley Interscience, Elsvier, Sciencedirect, Procedia Engineering, and System of Systems Engineering. One publication (The Global Alliance for Project Performance Standards, 2005) was identified through the references of four of the 19 academic publications (Azim et al., 2010; Floricel et al., 2016; Tie & Bolluijt, 2014; Xia & Chan, 2012). The publication was published in the private sector but due to its relevance within existing academic publications it was included.

Table 2: Summary of Literature Review

	Engineering Village		Emerald Insight		ProQuest		Google Scholar	
Range of Publications	Related	Contribute	Related	Contribute	Related	Contribute	Related	Contribute
1-100	25	8	15	1	5	0	40	2
101-200	30	2	20	0	10	0	10	1
201-300	20	2	8	0	4	0	7	0
301-400	8	1	6	0	0	0	3	0
401-500	0	0	2	0	0	0	0	0
Total	83	13	51	1	19	0	60	3

Literature Review Results	
Searched	2000
Related	213
Database Contribute	17
Reference Contribute	2
Total Publications Contribute (database and reference)	19

The literature results are summarized in Table 3. The selected publications range from 1969 up to 2017. The publications' ensured that both previous and relevant project complexity factors were considered. The industry publication distribution identified that project complexity is not solely limited to the ICT industry but considered as an industry wide issue. Out of the 19 publications, only two were specifically aimed at the ICT industry, complex software and information systems (Ribbers & Schoo, 2002; Xia & Lee, 2004). Other industry specific publications include four for the construction, and one for both product development and entertainment. The other 11 out of the 19 publications were labeled as general as they either did not specify an industry or included multiple industries. Of the 11 general publications, six included ICT projects within their multi-industry study, two did not include ICT projects and three did not specify the type of projects included. Due to the lack of research specific to the

ICT industry, this literature review was expanded to all industries, for the purpose of creating a holistic list of project complexity factors.

Table 3: Literature Review Results

Publication Year	Project Complexity
2016 - 2017	4
2011 - 2015	7
2006-2010	4
2001-2005	3
1969-2000	1
Industry	#
General (multiple industries)	11
Inclusive of ICT industry	6
Exclusive of ICT industry	2
Not specified	3
Single Industry	8
Construction	4
Entertainment	1
ICT	2
Product Development	1

2.2.2. Database Structure

The publications extracted from the project complexity literature were documented in excel, forming a master database for our research. The master database stored three central excel sheets which comprised the raw data. During the research period, the database was accessible to analyze the data. An example of the data structure is available in Appendix A and more details are available upon request.

Each of the 19 publications relating to project complexity were listed in an excel sheet (Appendix B: Complexity Publications) as its own row with the columns of data listing all critical pieces of information gained from the publications. This includes:

1. Background of the study, such as year of publication, source database, source type, location and industry

2. Key information including: the research method used to create the complexity model (survey, interview, case study, etc.), number of participants in the study, number of factors identified by the model, results of the model (tools, relation to performance, etc.), specific notes or unique qualities of study

In a third excel sheet, all project complexity factors that were found were listed as a separate row. Each column included a coding of that factor and the reference source. The creation of a database structure strengthened the reliability of our literature research.

2.3. Literature Analysis

When studying the 19 publications, we identified 623 project complexity factors. The factors were extracted from the individual lists of the 19 publications. Each of the project complexity factor lists (in their respective publications) were created through multiple research methods, such as workshops, interviews, literature review, and surveys. The publications' factors were refined through an exclusion/exclusion process explained in Section 2.3.1, followed by a coding process described in Section 2.3.2.

2.3.1. Inclusion and Exclusion of Factors

In determining the scope of project complexity factors to be included in defining ICT project complexity, we identified relevant perspectives such as the project itself, the organization, people, management, context and team. Kermanshachi et al. (2016) studied project complexity focusing on the project, which meant excluding contextual factors. In contrast, Qureshi and Kang's (2014) research focused on analyzing the organizational impact to project complexity, which included project context factors. Other researchers narrowed their scope to specialized areas within a project. For instance, Antoniadis et al. (2011) focused on measuring the organization and management of projects, limiting the scope of factors to people within a project including the team members and the management style adopted. Tatikonda and Rosenthal (2000) limited their scope of factors to product development excluding all factors outside of the project such as context and people factors.

As the aim of our research is to develop an enriched conceptual model by better understanding the "impact of expertise on the effect of complexity on project outcomes", we considered factors that fit the research aim, which relate to the project including project stakeholders and the project scope. Consequently, factors pertaining to the context of a project (not directly pertaining to the project) and factors which may relate to the supplier project team's expertise are excluded and therefore out-of-scope of our research.

Contextual factors (Qureshi & Kang, 2014, Vidal & Marle, 2008; Bakhshi, et al., 2016) include factors such as competition, institutional configuration, geographical conditions, cultural configuration, and the networked environment. The project team's expertise has been described by Azim et al. (2010) and Geraldi et al. (2011) through factors which described the people and the process or functions which they perform. Project team factors include the project team's size, location, cooperation, communication, knowledge, skill, and experience.

Lastly, factors which were ambiguous (not explicit) were excluded as the researchers did not have sufficient information to understand the factor's meaning. For instance, factors such as: attractors, group, non-linear, paradigm, priority, and trust did not provide enough background or explanation to be listed. In total, 25 factors were identified as ambiguous, 125 factors relate to the context of the project, and 94 factors were identified to be related to the project team.

Based on the above described analyses, we listed 379 factors in total. As a next step, we coded the factors in order to establish groups that can be studied in more detail.

2.3.2. Project Complexity Factor Coding

The difficulty with compiling the project complexity factors is that each model has framed a unique set of factors specific to the purpose and terminology of their given research. To analyze the factors, we build on Miles and Huberman (1994) by using a two-stage coding process to identify a broad range of "project complexity factors" as a proxy to measure ICT project complexity. Each stage was performed by means of iterative rounds and conducted by the consensus of three researchers to strengthen the reliability of our results. The consensus amongst the three researchers was done sequentially in stage one and two of the coding processes through workshops. The researchers first independently coded the 379 factors and then came to a consensus as to a final coding of each factor. This process was repeated for stage two of the coding process.

In the first stage of coding, the factors were clustered into two components of the project relating to the project stakeholders or project scope. This corresponds to Azim et al. (2010), which identified the distinction between project complexity factors which relate to the people component of the project (stakeholders) and the product/service (scope) being delivered. After the coding of data within the designated component, the second stage involved coding the factors into subgroups based on the similarity of wording and content to create a coherency.

2.4. Literature Analysis Findings

The two-stage coding process resulted in 22 distinctive factor groupings which contribute to project complexity. Each of the 22 groupings were then analyzed and given an overarching factor name to represent the grouping. The overarching factor name is based on our definition of complexity, defined as "the difficulty in delivering a project"; we used the structural, variety, pace and uncertainty of complexity as guiding principles (Geraldi et al., 2011). The overarching factor name identified to represent each grouping was selected from the factors within each grouping. In other words, we did not create any new factors through our coding process, but selected factors already identified through the 19 publications to represent each grouping. The 22 factor groupings included eight relating to the project stakeholders and 14 relating to the project scope. Table 4 summarizes the coding results including the number of publications and percentage of publications (out of 19) which describe the given factor grouping. The description of each factor grouping is given in Section 2.4.1.

The least cited factor grouping was namely: (1) a client with unrealistic goals. There were eight factor groupings which were cited by the majority of publications (more than 50%) including:

1. The interaction and interdependence between stakeholders
2. The client's project requirement is poorly defined
3. Largeness of scope
4. Availability of the people, material and of any resources due to sharing
5. Lack of senior management support
6. The size of the project budget
7. The integration between technology
8. The diversity of technology in the project

The purpose of our literature review was to determine a holistic range of factors which can be used to define ICT project complexity, not to determine priority or weight of such factors. Literature is at a theoretical state and the priority of project complexity factors is unclear. The number of publications which cite a specific factor does not necessarily determine the priority or weight of that factor. All 22 factor groupings demonstrated that multiple researchers have considered the factors within the grouping to be an aspect of project complexity. Based on these results, all 22 factor groupings were determined to be beneficial to include in defining ICT project complexity.

Table 4: Identified ICT Project Complexity Factors

#	Project Complexity Factor		Publications [out of 19]	
			#	% Frequency
1	Stakeholder	Lack of senior management support	11	57.9%
2		Appropriate authority and accountability	7	36.8%
3		The interaction and interdependence between stakeholders	13	68.4%
4		Multiple stakeholders	7	36.8%
5		Availability of the people, material and of any resources due to sharing	12	63.2%
6		Conflict between stakeholders	8	42.1%
7		The stakeholder's technical knowledge and/or experience	6	31.6%
8		Geographical location of stakeholders	6	31.6%
9	Scope	Largeness of scope	12	63.2%
10		The client's project requirement is poorly defined	10	52.6%
11		The project comprises a diversity of tasks	7	36.8%
12		The size of the project budget	13	68.4%
13		The length of the project's duration	8	42.1%
14		The information uncertainty in the project	8	42.1%
15		A client with unrealistic goals	3	15.8%
16		The project's alignment with the business goals and interests	4	21.1%
17		The number of decisions to be made on the project	10	52.6%
18		The integration between technology	8	42.1%
19		The newness/novelty of the technology	5	26.3%
20		The technology is continuously changing	8	42.1%
21		The diversity of technology in the project	10	52.6%
22		Highly difficult technology	4	21.1%

2.4.1. Project Complexity Factors' Grouping Descriptions

1. Lack of senior management support

When executing ICT projects, various issues may arise that influence the agreed project objectives. Geraldi et al. (2011) state that at a strategic level ICT projects have to be managed in a coherent manner as various aspects may influence the results. Examples relate to conflicting goals, unwilling stakeholders, an ambiguous project scope, and unclear financial consequences. Geraldi and Adlbrecht (2007) argue that dependencies between projects may affect project objectives, such as the required number of personnel, and specific skills and expertise to complete a project on time. These dependencies have to be managed adequately to avoid extended project lead times (Vidal et al., 2011).

If firms neglect these issues, problems or uncertainties may occur that may cause unexpected effects. Bosch-Rekveldt et al. (2010) argue that project issues may cause unexpected risk, such as an extension of lead times, and an increase of cost. This is consistent with the findings which the authors argue that negative effects of project implementation may result is poor project outcomes (Azim et al., 2010). In the end, expected project outcomes may be at stake. To avoid project issues at a firm's strategic level, senior management support is required to manage these issues adequately. Bosch-Rekveldt et al. (2010) and Geraldi et al. (2011) argue that senior management support is needed to deal with these issues. For instance, by developing strategies to overcome resistance, set priorities between deliverables, and manage resistance at an organizational level.

Based on our literature review and the factor grouping, we identified lack of senior management support identified in previous literature (Azim et al., 2010; Bakhshi et al., 2016; Geraldi et al., 2011) to be an essential project complexity factor.

2. Appropriate authority and accountability

Each stakeholder within a project has a role and function. The delegation of authority and accountability can be determined by the assigned roles within a project such as the role of product owner and the steering committee (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Geraldi et al., 2011). Maylor et al. (2008) identified that appropriate authority and accountability of stakeholders is crucial to manage the organizational complexity of a project. Without the appropriate authority and accountability, the stakeholders lack the power and direction to fulfill their designated functions including oversight, change control, approvals and decision-making (Azim et al., 2010; Kermanshachi et al., 2016).

Bakhshi et al. (2016) elaborates on authority and accountability in terms of the organizational hierarchy which may affect the degree of project complexity. Simple projects are those in which participants can respond to different situations by accessing the necessary information and use of that information (Bakhshi et al., 2016). In contrast, complex projects are those which participants do not have access to the proper information and power to use that information. The proper authority and accountability of participants corresponds with the necessary hierarchy of a project. Similarly, Geraldi et al. (2011) identified that when the fit and convergence of a project defined by the appropriate authority and accountability are not met, the dynamic and uncertainty in a project may increase due to the inability to access and use the proper information.

Based on our literature review and factor grouping, we identified that appropriate authority and accountability to be an essential project complexity factor (Bakhshi et al., 2016; Geraldi et al., 2011; Maylor et al., 2008).

3. The interaction and interdependence between stakeholders

Vidal and Marle (2008) identified that the interdependencies and interactions of a project are likely to be the greatest source of project complexity. Within a project the degree of interdependence between stakeholders may affect project complexity as each stakeholder will depend and influence the others (Calinescu et al., 1998). This finding is supported by research of Qureshi and Kang (2014) who identified that a project is considered to be a complex when the degree of interactions or interdependence between stakeholders becomes higher.

Bakhshi et al. (2016) identifies that the interaction and interdependence between stakeholders affect the ability of agents of the system to work together. The interactions and interdependence between stakeholders makes it more difficult to handle tasks that are affected by their predecessors or successors which adds to the complexity in projects. Interactions and interdependencies may include stakeholder schedules, objectives, interests, resources, tasks, and goals required for the completion of the project (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Qing-hua et al., 2012; Qureshi & Kang, 2014).

Based on our literature review and factor grouping, we identified that the interaction and interdependence between stakeholders to be an essential project complexity factor (Bakhshi et al., 2016; Geraldi et al., 2011; Maylor et al., 2008).

4. Multiple stakeholders

The total, number of stakeholders participating in a project is frequently cited as a factor of project complexity (Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Maylor et al., 2008; Qureshi & Kang, 2014; Tie & Bolluijt, 2014; Vidal et al., 2011). Literature shows various stakeholder roles and positions, such as contractors, vendors, client departments and units, government, investors, and partners (Bakhshi et al., 2016; Qing-hua et al., 2012; Vidal & Marle, 2008). As a result, the multiplicity of stakeholders, and their potential contrasting objectives, contribute to project complexity.

Hence, the number of stakeholders in a project increases the structural complexity of a project (Azim et al., 2010; Baccarini, 1996; Williams, 1999). Due to an increasing number of stakeholders, the size of a project increases which in turn contributes to project complexity. In addition, the interactions and interdependencies between stakeholders may cause project coordination challenges, which as an effect, may influence project outcomes (on time, on budget) (Vidal et al., 2011). Maylor et al. (2008), who measured the level of the interaction and interdependence through the number of stakeholders, suggested that high structural complexity may lead to the increase of sociopolitical complexity. The authors argue that project complexity increases due to the necessary contribution and function of each stakeholder.

Based on our literature review and factor grouping, we identified that multiple stakeholders contribute to project complexity and as such, are considered to be an essential project complexity factor (Qing-hua et al., 2012; Qureshi & Kang, 2015).

5. Availability of the people, material and of any resources due to sharing

Availability of resources (e.g. people and material) is critical to project complexity due to the autonomy amongst stakeholders (Azim et al., 2010; Qureshi & Kang, 2015; Vidal et al., 2011). For example, stakeholders are often required to share people and material, such as financial sources, subject matter experts, and equipment (Abdou et al., 2016; Bakhshi et al., 2016). The absence of resources may increase project complexity as people and material are not available in a timely manner (Geraldi et al., 2011).

Without access to the required project subject matter experts and their necessary training, experience, and skills or materials required to perform specific tasks, the degree of project uncertainty increases (Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Qing-hua et al., 2012). Uncertainty in project outcomes increases as the results are unpredictable in terms of the immediate work of unqualified people, which may result in rework, or delays which occur due to the unavailability of required materials.

Based on our literature review and factor grouping, we identified that the availability of resources (e.g. people, material) can be listed as an essential project complexity factor (Bakhshi et al., 2016; Qureshi & Kang, 2015; Tatikonda & Rosenthal, 2000; Vidal et al., 2011; Vidal & Marle, 2008).

6. Conflict between stakeholders

Antoniadis et al. (2011) investigated the complexity of interconnections (socio-organo complexity) and identified the importance of managing conflicts between stakeholders. Due to contrasting objectives between stakeholders, mismanagement of these interconnections may cause an increase of project complexity. Some characteristics correspond to emergence, nonlinearity, and instability. Consequently, mismanagement may result in conflicts between stakeholders, which in turn may affect a stakeholder’s status, internal competition and powerdependency challenges within a project (Bakhshi et al., 2016; Geraldi et al., 2011; Qureshi & Kang, 2015; Vidal & Marle, 2008).

Each stakeholder has different interests and objectives within a project. For example, senior management may be focused on profit while end users are focused on the functionality of the product/service. Employees on the other hand are interested in adequate working conditions. Bakhshi et al. (2016) argues that conflicts between stakeholders increases project complexity as an effect of contrasting interests. Projects that can be characterized as small and which are supported by a limited number of stakeholders have a higher chance of conformance and agreement compared to large projects (and multiple stakeholders). The latter relates to the variety of interests and perspectives of each stakeholder (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Qureshi & Kang, 2015; Vidal et al., 2011).

Based on our literature review and factor grouping, we identified that conflicts between stakeholders is considered to be an essential project complexity factor (Bakhshi et al., 2016; GAPPS, 2015).

7. The stakeholder's technical knowledge and/or experience

The stakeholders' amount and diversity of technical knowledge and experience have been repeatedly cited as a key factor in determining project complexity (Bakhshi et al., 2016; Geraldi et al., 2011; Vidal & Marle, 2008).

Geraldi et al. (2011) identified that the lack of knowledge and experience increases the uncertainty complexity of a project. The severity of increased complexity would be determined by the gap between the amount of information and knowledge required to deliver the project and what is available. The stakeholders are responsible for a variety of functions within a project including approvals, scheduling, and the sharing of resources. When stakeholders do not have sufficient technical knowledge and experience, they are unable to properly fulfill their responsibilities. Literature revealed that technical knowledge and experience can be measured through their attributes, predisposition from earlier experiences, and participation on similar projects (Maylor et al., 2008; Ribbers & Schoo, 2002). Geraldi et al. (2011) identified that stakeholders unconsciously may increase project complexity because they do not understand the impact of their decisions. Azim et al. (2010) identified that the technological complexity of a project will be affected by the knowledge and experience of the people involved. This is consistent with research of Kermanshachi et al. (2016) who addressed that the degree of project complexity may increase due to quality issues caused by the lack of knowledgeable craft labor.

Based on our literature review and factor grouping, we identified that stakeholder's technical knowledge and/or experience is addressed as an essential project complexity factor (Bakhshi et al., 2016; Geraldi et al., 2011; Vidal & Marle, 2008).

8. Geographical location of stakeholders

The geographical location of the stakeholders involved in a project has been identified as a factor of project complexity (Bakhshi et al., 2016; Qureshi & Kang, 2015; Vidal & Marle, 2008; Vidal et al., 2011). The geographical location of stakeholders affects the structural complexity of a project based on the variety/diversity it adds to the project. Qureshi and Kang (2015) identified a direct correlation between the project variety (inclusive of geographical location) and the project complexity characteristics of non-linearity, context dependence, uniqueness, uncertainty, trust, and capability. The geographical location of the stakeholders has an impact on the quality and ease of these interactions. Different time zones and locations may affect the frequency, availability and the quality of interactions. Due to geographically dispersed project stakeholders' additional attention has to be paid to coordinate tasks and align objectives. The severity of complexity can be determined in terms of their distance, numbers of different locations, and differences between locations (Vidal & Marle, 2008; Vidal et al., 2011).

Based on our literature review and factor grouping, we identified that the geographical location of stakeholders is considered to be an essential project complexity factor (Bakhshi et al., 2016; Qureshi & Kang, 2015; Vidal & Marle, 2008; Vidal et al., 2011).

9. Largeness of scope

Azim et al. (2010) identified that the scope of what is being offered in terms of the project outcome (e.g. product or service) is considered to be a key area to project complexity. Literature demonstrate that structural complexity relates to the multiple varied interrelated parts of a project specifically to the attributes of size (number), variety and interdependence (Baccarini, 1996; Geraldi et al., 2011; Williams, 1999).

Literature shows that the largeness of scope (size) is identified as a measure of structural complexity (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Vidal & Marle, 2008). The attribute of size increases complexity due to the number of elements and the intricacy in terms of the number of interdependent elements involved in delivering the project. Bosch-Rekveldt et al. (2010) measured size in terms of number of goals, number of tasks, and size in engineering hours. Bakhshi et al. (2016), extended previous research on the size of projects and measured the largeness of scope in terms of the number of activities, number of deliverables/disciplines, number of information systems, number of inputs and/or outputs, number of objectives, and scope for development. Other measures of the largeness of scope include: peak number of FTE participants during detailed engineering and design phase of the project (Kermanshachi et al., 2016), conversion effort in terms of the level of data misfit and number of systems to be replaced (Ribbers & Schoo, 2002), number of sub-systems and number of technologies (Azim et al., 2010), and product volume and systems to be replaced (Geraldi et al., 2011)

Based on our literature review and factor grouping, we identified that the largeness of scope is considered to be an essential project complexity factor (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Vidal & Marle, 2008).

10. The client's project requirement is poorly defined

In order to deliver a project, the requirements must be clearly understood as to its direction (Tie & Bolluijt, 2014). The project requirements can be characterized by its goals, objectives, scope, tasks, specifications and project outcome measurements (Bakhshi et al., 2016; Geraldi et al., 2011). Poorly defined project requirements are a common cause of complexity as it adds to the uncertainty of a project (Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Qing-hua et al., 2012).

Poorly defined requirements can be caused by undefined values or ambiguity of performance and success criteria (Antoniadis et al., 2011; Xia & Chan 2012). Geraldi et al. (2011) identified that the uncertainty of a project increases due to the absence of a clear way to determine the start or completion of project requirements. Uncertainty is caused by the lack of agreement on the current and future state. Importantly, the absence of clear project requirements causes additional coordination and management attention to create more clarity on the final project outcomes. Geraldi et al (2011) further identified that the uncertainty of project requirements can be minimized. Examples relate to a description of tangible benefits, create a better understanding on the project implications, improve and intensify communications and a create a shared understanding of project aims.

Based on our literature review and factor grouping, we identified that the poorly defined project requirements is considered to be an essential project complexity factor (Bakhshi et al., 2016).

11. The project comprises a diversity of tasks

Literature shows that the diversity of project tasks has been addressed as reoccurring factor that influences project complexity (Abdou et al., 2016; Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010). Jones and Anderson (2005) identified that the diversity in a project is closely associated with emergent properties and is therefore key in determining complexity. Emergent properties stem from what parts of a project do together that they would not do alone. As tasks of a project become more diverse, the uncertainty of their interdependence produces such emergent properties.

There are hundreds of diverse and varied tasks to completed in a project which are spread amongst multiple disciplines. Tasks may include activities such as: approvals, accounting, personal management, methods, logistics, utilities, hand-over, quality control, and documentation. Brockmann and Girmscheid (2008) identified that the diversity of tasks contributes to project complexity separating the disciplines into five areas, including: organizational planning, design planning, work preparation, installation and management. Qing-hua et al. (2012) identified that the diversity of tasks are needed in order to keep a balance with respect to the goals of a project. Geraldi et al. (2011) identified diversity of tasks as the number of separate and different actions or tasks to produce the end product of a project.

Based on our literature review and factor grouping, we identified that a project which comprises a diversity of tasks to be considered to be an essential project complexity factor (Bakhshi et al., 2016; Brockmann & Girmscheid; Geraldi et al., 2011; Qing-hua et al., 2012).

12. The size of the project budget

The financial resources of a project, in terms of size, have been identified by Qureshi and Kang (2015) as an influencing factor in determining the project's overall structural complexity. Financial resources are one of the major driving factors in project complexity. The size of the project budget has continuously been identified as a financial factor of project complexity (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Vidal & Marle, 2008). The size of a project budget may include largeness of capital investment, cost restraints, size in capital expenditures, unit cost objective novelty and financial scale of the project (Bakhshi et al., 2016; Tatikonda & Rosenthal, 2000; Tie & Bolluijt, 2014) ; Xia & Chan, 2012).

An increase in size of the project budget influences the structural (size/variety) and socio-political dimensions of complexity. For instance, as the size of the project budget increases, the financial resources required to fund the budget must increase as well. Bosch-Rekveldt et al. (2010) identified that the number of financial resources contribute to complexity. Moreover, Bakhshi et al. (2016) state that the variety of financial resources contribute to complexity and GAPPS (2015) identified that the overall expected financial impact (positive or negative) on the project's stakeholders has to be considered as a factor to complexity. The size of the project budget is a key indicator of the scale of a project (Maylor et al., 2008). This is consistent with research of Qureshi and Kang (2015) who argue that if the project scope increases (including the number of activities, number of groups to be coordinated, and the number of companies sharing their resources) the project budget increases too.

Based on our literature review and factor grouping, we identified that the size of the project budget is considered to be an essential project complexity factor (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Vidal & Marle, 2008).

13. The length of the project's duration

The duration of the project has been identified as a key factor of project complexity (Abdou et al., 2016; Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Tie & Bolluijt, 2014; Vidal & Marle, 2008). The duration of a project may affect various other factors due to the required cost of resources over time. For example, continuous maintenance of equipment, required coordination and management, and labor over time may increase project complexity. Abdou et al. (2016) argues that the duration of a project can be perceived as an operational complexity factor that is correlated with factors such as variety of tasks, strict quality requirements, and availability of financial resources.

An increase in the duration of a project may influence the degree of complexity as it corresponds to the project size and required project scheduling. Xia and Chan (2012) identified that the length of a project is intended to be aligned with the resources to deliver the project. Examples of resources include equipment, materials, and labor. Importantly, an increase of required scheduling of interactions between project stakeholders increases the uncertainty and as such the length of a project in terms of availability of resources and predictability of project outcome (Geraldi et al., 2011).

Based on our literature review and factor grouping, we identified that the length of the project's duration is considered to be an essential project complexity factor (Abdou et al., 2016; Bakhshi et al., 2016; Tie & Bolluijt, 2014; Vidal & Marle, 2008).

14. The information uncertainty in the project

Geraldi et al. (2011) argues that a project's success is determined by an understanding of the current conditions of the project. These current conditions may include factors such as the goals, requirements, duration, budget, and stakeholders. Based on the understanding of the current conditions, expectations of future conditions are created. Literature shows that a lack of project information or project information ambiguity may result in project uncertainty that in turn may affect project outcomes (Qureshi & Kang, 2015). Bakhshi et al. (2016) and Qing-hua et al. (2012) have identified that the degree of a client's information uncertainty is perceived as a factor of complexity.

Geraldi et al. (2011) identified that information uncertainty can be caused by unknown or inaccurate and unavailable information. For example, clients may not know specific details of integrating systems such as technical specifications or the number of man hours used to maintain a system. In other instances, clients may have the information however, due to the unavailability, or understandability of the information it still may lead to project uncertainties. Vidal and Marle (2008) identify that uncertainty propagates through the entire project. The uncertainty complexity of project stems from when task duration, quality of outcomes, and the budget become unpredictable.

Based on our literature review and factor grouping, we identified that the client's information uncertainty in the project is considered to be an essential project complexity factor (Bakhshi et al., 2016; Qing-hua et al., 2012).

15. A client with unrealistic goals

Linehan and Kavanagh (2004) study on project complexity demonstrate that projects are considered to be complex when the vision and understanding of clear project goals differ with reality. Bakhshi et al. (2016) also identified the gap between expectations and reality and labelled it as clients with unrealistic goals. Unrealistic expectations of stakeholders involved in a project increases the socio-political complexity (Geraldi et al., 2011). The socio-political complexity can be affected as stakeholder expectations are not met causing resistance, political pressure and power struggles within the project.

At some point in the project, stakeholder expectations and reality of the project goals must be resolved and corrected, which increases the uncertainty complexity in a project. Xia and Chan (2012) identify this correction in the context of the difference between the design work and the buildability of what was designed. Projects must be designed to fit within all the conditions of a project including the duration, budget, and resources available. Maylor et al. (2008) addressed issues with managing stakeholders to be problematic when there are uncertainties in the project goals and direction. Redefining a project to meet realistic goals can significantly change the cost, requirement and benefit each stakeholder initially expected. The uncertainty complexity of stakeholder responses and support of such changes leaves the future of the project at risk.

Based on our literature review and factor grouping, we identified that a client with unrealistic goals is considered to be an essential project complexity factor (Bakhshi et al., 2016).

16. The project's alignment with the client's business goals and interests

Bosch-Rekveldt et al. (2010) identified the project's alignment of goals as one of three factors which defined a project's goal complexity, the other two being the number and clarity of those goals. The client's organization chooses to be involved in a project as they believe that the overall outcome will benefit their business goals and interests. Bakhshi et al. (2016) labeled this form of alignment as connectivity. The project's connectivity is disrupted when there is a misalignment with the organization's goals and interests. As a result, this misalignment causes project complexity. (Williams, 1999; Baccarini, 1996; Thompson, 1967; Vidal & Marle, 2008; Geraldi & Adlbrecht, 2007). The disconnect can lead to increased lead time which translates to increased costs as the priority of the project is outranked by more aligned projects. Eventually the complexity caused by the misalignment can result in either project cancellation or a project end product or service never being used.

Based on our literature review and factor grouping, we identified that the project's alignment with the client's business goals and interests to be an essential project complexity factor (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010).

17. The number of decisions to be made on the project

Projects are delivered by people who, throughout a project, will be required to make decisions both small and large. The number of decisions has been identified as a contributing factor to project complexity (Bakhshi et al., 2016; Qureshi & Kang, 2015; Vidal & Marle, 2008). The decisions made on a project may have a positive or negative impact to project complexity. For example, Qureshi and Kang (2015) identified that the number of decisions as a factor which can affect the size, variety, and interdependencies within a project. Decisions could include which software to use, the addition of extra functions, and scheduling of key milestones.

Decision making increases the complexity by increasing the uncertainty complexity of a project. With each decision multiple courses can be taken, each with different consequences, making the project's predictability more difficult. Azim et al. (2010) identified that the uncertainty in each decision can exponentially increase as the number of options and variation of options increases. Danziger et al. (2011) argued that the complexity of each decision increases as number of decisions a person has to make increases. The complexity can be attributed to decision fatigue which is the deteriorating quality of decisions made after a long session of decision making (Baumeister, 2003).

Based on our literature review and factor grouping, we identified that the number of decisions to be made on the project to be an essential project complexity factor (Bakhshi et al., 2016; Qureshi & Kang, 2015; Vidal & Marle, 2008).

18. The integration between technology

Technology is critical to ICT projects. Abdou et al. (2016) along with other researchers (Baccarini, 1996; Williams, 1999) define technology as the transformation process involving conversion of inputs into outputs. The transformation can include the use of technology such as hardware, software, processes and methods.

The integration between different technologies is frequently cited as a project complexity factor (Bakhshi et al., 2016; Tatikonda & Rosenthal, 2000; Qing-hua et al., 2012). It is characterized by the necessary dependence and connectivity between technology, required to deliver the project (Bakhshi et al., 2016; Qing-hua et al., 2012; Vidal et al., 2011). The integration of technology includes the processes, systems, networks, phases, processes platforms and programs. Integrating technology can be human processes, for example two departments who both must approve project documents, requiring the integration between individual department approval processes. In contrast, integrating technology can be networks or databases which need to integrate into a singular software.

The integration of technology can increase project complexity. Examples refer to technical limitations of systems, the absence of technical norms and standards and lack of architectural guidelines. Moreover, a lack of project feedback loops affects the output of a project as insights are not fed back as input causing technology to improperly align or fail to meet the current needs of users. Literature identifies these feedback loops of technology to increase project complexity (Bakhshi et al., 2016; Qureshi & Kang, 2015; Vidal & Marle, 2008; Vidal et al., 2011). Each piece of technology has its respective limitations in terms of capacity and conditions of compatibility. Integration of various technologies must consider the emergent limitations of the system of technology as a whole (Bakhshi et al., 2016; Qing-hua et al., 2012). Emergent limitations may result in the replacement, adaptation and minimized functionality of technology which will increase project complexity.

Based on our literature review and factor grouping, we identified that the level of integration between technologies is considered to be an essential project complexity factor (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2010; Geraldi et al., 2011; Tatikonda & Rosenthal, 2000; Qing-hua et al., 2012; Vidal & Marle, 2008).

19. The newness/novelty of the technology

Azim et al. (2010) identified the newness/novelty of the technology may contribute to project complexity. Newness/novelty is an individual perspective. What is new to one person, may not be new to another. Tatikonda and Rosenthal (2000) described technology novelty by the familiarity with the given technology. The unfamiliarity with the technology increases uncertainty complexity as both the current state, how current factors will interact, and the final state of the technology is unknown for that respective individual. Saed et al. (2016) identified that technical complexity creates unknown and untried aspects to a project which create uncertain outcomes. Uncertain outcomes can include the performance of a product, acceptance level of a product within the organization, and project costs associated with maintenance of product.

Bakhshi et al. (2016) identified that the newness/novelty of technology is influenced by the demand for innovation and creativity. Geraldi et al. (2011) describes the demand for innovation as there are many ways to achieve a solution. Tatikonda and Rosenthal (2000) identified that this occurs when new products, processes, objectives, or time to market are needed. New solutions will always be required to stay competitive and progress on the micro levels of department success and macro levels of an industry.

Based on our literature review and factor grouping, we identified that the newness/novelty of technology is considered to be an essential project complexity factor (Azim et al., 2010; Bosch-Rekveldt et al., 2010).

20. The technology is continuously changing

Technology is continuously changing in order to deliver projects successfully. Changing technology can include different hardware, software, processes and methods. Geraldi and Adlbrecht (2007) identify the continual change in technology to effect project conditions such as team members, specification, functions, and standards. Continuously changing technology requires a mindset of project team members to cater for adaptability, flexibility and alteration. Consequently, project management and its methodologies have to deal with changing conditions (Cutter Consortium, 2008). These changes lead to higher levels of disorder, rework and inefficiency when not handled appropriately.

Ribbers and Schoo (2002) measured the changing technology by the required amount of redesign of an ERP software. The authors identified innovation requires technology to continuously change in order to pilot and evolve solutions. The complexity of continuously changing technology can have negative consequences as experienced resources and technology are in short supply. Project stakeholders can be a source of the increased complexity. For example, Geraldi et al. (2011) identified the stakeholders requests to customize and continually adjust the final product requires technology to continually adjust to meet those needs. Antoniadis et al. (2011) identified the effects of continuously changing technology within a project to impact the budget, schedule, contribution to the company, and level of use.

Based on our literature review and factor grouping, we identified that changing technology is considered to be a project complexity factor (Geraldi et al., 2011 ; Ribbers & Schoo, 2002).

21. The diversity of technology in the project

There are hundreds of diverse and varied technologies required to deliver a project. The Literature shows that diversity of project technology has been addressed as a factor that influences project complexity (Qing-hua et al., 2012; Vidal & Marle, 2008). Qing-hua et al. (2012) identified the diversity of technology to be the largest contributing factor to technology complexity, being prioritized over technological interaction, dependence and difficulty. Diversity of technologies includes areas such as project management methodologies, product components, networks, devices, and databases (Bakhshi et al., 2016; GAPPS, 2015; Qureshi & Kang, 2015; Vidal et al., 2011).

The more diverse technology, the greater the range and depth of knowledge is required. Geraldi et al. (2011) identified the lack of information in any of these areas of knowledge increases the uncertainty complexity of a project. Qing-hua et al. (2012) identified the diversity of a project to increase the structural complexity. The increase in both structural and uncertainty complexity in a project can lead to larger projects which require increased resources, duration and budget to maintain control of the project.

Based on our literature review and factor grouping, we identified that diversity of technology is considered to be an essential project complexity factor (Qing-hua et al., 2012; Vidal & Marle, 2008).

22. Highly difficult technology (hardware, software, processes or methods)

The difficulty of technology has been identified as a factor of project complexity (Bakhshi et al., 2016; Qing-hua et al., 2012; Azim et al., 2010). Tatikonda and Rosenthal (2000) who studied product development, identified that the difficulty in delivering a project is related to the difficulty of the technology. Examples can be found in the decision-making process challenges, quality requirements, methods, and objectives of a project (Azim et al., 2010; Bakhshi et al., 2016; Tatikonda & Rosenthal, 2000; Xia & Chan 2012).

The greater the difficult of technology, the greater requirement of personnel to use diverse technology. Glouberman and Zimmerman (2002) identified the nature of complicated projects is related to the having the proper personnel to handle the given technology. Bakhshi et al. (2016) identified this as belonging. The authors expanded the difficulty of technology in terms of quality requirements, cost restraints, specific standards, and degree of customization. The disruption of belonging can lead to uncertainty in project success in terms of quality, scheduling and meeting cost projections.

Based on our literature review and factor grouping, we identified that the difficulty of technology is considered to be an essential project complexity factor (Bakhshi et al., 2016; Qing-hua et al., 2012; Azim et al., 2010).

2.5. Conclusion

In this chapter, the authors have answered the first research question: ‘ What factors define ICT project complexity?’

Literature identified the ICT industry as complex (Bullock & Cliff, 2004; Mckinsey & Company, 2012; NATO Science Committee, 1969) based on abstract attributes such as size and the number of interrelations. We identified a lack of project complexity factors that specifically relate to the ICT industry, with the exception of two publications (Ribbers & Schoo, 2002; Xia & Lee, 2004). To create a holistic set of project complexity factors we drew on publications from all industries. As a result of our literature review, we identified that there is not an agreed set of project complexity factors which specifically fit with our research scope inclusive of project stakeholder and project scope factors (Antoniadis et al., 2011; Kermanshachi et al., 2016; Qureshi & Kang, 2014).

Based on our literature analysis we selected 19 publications and as a result, identified in total 22 factors which contribute to project complexity. Each of the factors have been identified as relevant based on the factor being cited by a minimum of three of the 19 publications (see Table 4). Regarding these factors, eight (8) relate to project stakeholders and fourteen (14) to the project scope. With the identification of the 22 project complexity factors it allows a more objective and standardized way to understand and quantify project complexity.

3. Case Study Research

3.1. Introduction

As addressed in Section 1.7, in the second phase of the research approach, we have conducted a case study to answer the second research question (SRQ2): 'What are characteristics of an expert supplier delivering ICT projects?' The objective of the study is to further develop an enriched conceptual model with regard to identification of (1) the project outcomes of an expert ICT supplier within the ICT industry and (2) characteristics (in regard to the organizational structure and project implementation methodology) of an expert ICT supplier. First, in Section 3.2, we discuss the research methodology as applied, including case study selection, data collection and data analysis. Next, in Section 3.3 the case study findings are described including the supplier's project portfolio, two embedded cases, and the supplier's organizational structure and project implementation methodology. Section 3.4 will discuss and analyze the findings and Section 3.5 will offer a conclusion.

3.2. Case Study Research Methodology

We conducted an exploratory, case-based study to create a more in-depth understanding of the characteristics of an expert supplier delivering ICT projects (Yin, 2009). Case study research is a common research method in the field of information systems (Orlikowski & Iacono, 2001) and useful in answering 'how' and 'what' questions (Benbasat et al., 1987). A case study approach does not allow statistical generalization since the number of entities as described in case studies is too small. The main objective is to exp and theories (analytical generalization) and not to enumerate frequencies (statistical generalization) (Yin, 2009). More specifically, a case study allowed us to focus on a specific expert supplier.

The case study investigates the supplier in terms of their project portfolio, embedded cases and organizational structure and project implementation methodology. The project portfolio will be measured in terms of project outcomes as a means to validate the supplier as an expert. To strengthen the project portfolio findings, embedded cases were selected to serve as comparative instances where the supplier demonstrated results superior to the market in similar projects. Lastly, the organizational structure and project implementation methodology of the supplier was analyzed to identify characteristics which describe the expert supplier. As mentioned in our research design (Section 1.6) the supplier (inclusive of their characteristics) are separate from the project (inclusive of the project complexity factors). As the literature review (Chapter 2) identified factors to define project complexity, the case study is intended to identify characteristics of an expert supplier.

Organizational structures and employees' roles have been studied extensively (Dalton et al., 1980; Daft, 1995). Organizational structure guides employees' tasks, processes and assets and influence the firm's project outcomes. In the context of our study, this means that firms have to organize employees that conduct ICT projects effectively to achieve project success. The organizational structure then acts as the framework for the project implementation methodology. The project implementation methodology supports the execution of ICT projects by means of guiding principles, process steps, allocated resources while providing standards (Rivera, 2017). The proper organizational structure has to be appropriate and matched with the market in order to successfully deliver projects (Burns & Stalkee, 1961). Manidau et al. (2000) identified that the organizational structure affects the ability of a company to fully utilize the expertise of their employees. The organizational structure directly impacts the project implementation methodology and consequently project outcomes and the ability for the firm to handle project complexity (The House of Representatives of the Netherlands, 2014; Qing-hua et al. 2012).

3.2.1. Case Study Selection

To select a relevant case study, we used three criteria. The first criterion was to identify a supplier that demonstrated to be an expert. This would require the supplier to provide claims that their results are vastly superior to those obtained by the majority of the population (Gobet, 2015) and third-party confirmation of this claim. The second criterion is that the supplier must be recognized in the market in providing a high level of expertise for a sustainable period (minimum of two years). This criterion underpins the claim that a supplier is constant with regard to demonstrating their expertise. The third criterion is that the supplier must be willing and able to share project information. Consequently, the supplier Schuberg Philis in The Netherlands was selected as they met all three criteria. The identified expert supplier will be referred to as the 'case company'.

The case company is a privately-owned ICT company based in the Netherlands. The case company's core focus is in ICT critical application management (AM) within infrastructure management (IM) in IT outsourcing. AM relates to managing the operations of various types of often customized applications, such as application functionality, data base management, and technical application maintenance. IM, on the other hand, is the management of essential operation of information technology components, such as equipment of servers, databases, storage, and back-up solutions. The case company consistently started and grew over the last 10 years growing from 40 FTE and revenue of 6.5 million Euro to 175 FTE and revenue of 56.4 million Euro.

In looking for suppliers who were experts, there was scarce information which could be used to compare suppliers. We were unable to identify reports in the United States which could be used to perform this comparison. Hence, suppliers based in the Netherlands were targeted over the US due to the available comparable information. Giarte (2014) was the only third-party market report that contained project information obtained through the actual clients of the suppliers and compared the majority of large ICT suppliers in the Netherlands. Through Giarte (2014), the case company was the top-rated ICT supplier in terms of client satisfaction and eight other categories within the peer group of both ICT infrastructure management (IM) and End User Management (EUM) domains. The case company was not rated in the EUM domain however, in the Giarte study these two were placed in the same peer group of comparison.

Second, the case company was willing and capable to give access to their company and data. This may be primarily attributed to the size and focus of their company. Due to their specialization and age of the company they are relatively small and still fully housed in one building. With many other large organizations, the gathering of the entire company's project portfolio had proven difficult due to the level of approvals and stakeholders necessary.

3.2.2. Data Collection

The data was gathered between 2014 – 2015. Evidence was collected through three methods: desk research, interviews, and workshops. All information was gathered under the direction of two researchers, supervised by the researcher of this thesis. To ensure reliability a case study protocol was setup to guide the research and collect data.

First, information was gathered on the case company's OS and PIM through the use of desk research, which consisted of collecting available data from company documents. Desk research included the case company's annual report (100-page document), official case company published documents containing the organizational structure and project implementation methodology, past public presentations, and website. Moreover, we studied market reports provided by independent market research firms (e.g. Giarte, 2014-2015) that relate to case company's project results over time. Documents of the desk research were limited to those which would apply to the entire case company. Methods used in special cases or by individual groups were excluded. The reasoning behind limiting documentation to company wide application was to allow the information to represent the supplier's OS and PIM with respect to general case company projects and not sporadic employee application.

Second, we conducted interviews with case company's management to thoroughly explore the key characteristics of their organizational structure and project implementation methodology which could differentiate them from the market. To ensure validation of the studied documentation, we performed semi-structured interviews with six company representatives including two executive managers and four operational directors. The interview protocol had no limit in duration, each interview lasted about 1.5 hours per interviewee, during which, the researchers took notes of their observations (field notes and memos), interviews were not transcribed. Selection from the case company's top management and operational directors allowed us to validate their organizational structure and methodology both from a strategic perspective (executive management) and operational perspective (operational directors). See Appendix C for the interview template that was used. To ensure confidentiality, all names of interviewees were anonymized.

Three full-day workshops were organized with two of the operational directors of the case company. The purpose of these workshops was to gather documentation of the company's project portfolio and embedded cases. These workshops were followed by a period of six months of correspondence through email and skype calling to clarify the topics under study. This communication was an iterative method to clarify specific topics that arose regarding the project portfolio and embedded cases. The identification of collected information was conducted with the assistance of the researchers. Importantly, the collection and documentation of the case company's project portfolio and embedded cases, due to confidentiality, was the responsibility of the case company's personnel.

The collected data on project information was validated by a certified professional auditor using the audit standards as defined by Norea, the Dutch Branch organization for IT-Auditors (http://www.norea.nl/). The audit ensures that the information gathered was stored in a database with sufficient documentation and a chain of evidence.

Third, a database was created to store all project portfolio and embedded case results which were made public and are cited in this study. We put emphasis on the project outcomes of on time, on budget and client satisfaction to be consistent with comparable reports of market project outcomes.

3.2.3. Data Analysis

Related to qualitative research, coding data is an essential part of data analysis (Nueman, 2000). The research question that is studied ('What are characteristics of an expert supplier delivering ICT projects?') will guide the coding process. The first attempt at theorizing the collected data is coding the interviews by means of categories (Miles & Huberman, 1994). In particular, two constructs were carefully studied: organizational structure (OS) and project implementation methodology (PIM). This relates to Lincoln and Guba (1985) who argued that the validity of interpretive analysis defies quantification.

Based on the collected data, three researchers were involved in the coding of the data. These three researchers were the same which participated in the coding of the literature review (Chapter 2) and interviews (Chapter 5). The researchers followed four steps:

1. The first step was to read the interview and workshop notes, memos and collected documents. Next, an overview was drafted of the OS and PIM.
2. Second, we coded data into emerging characteristics of the case company. During this step we used memos and notes collected during the interviews and text paragraphs or sentences from the desk research documents to describe the OS and PIM.
3. Third, statements (i.e. codes) were grouped into two overarching categories inclusive of the organizational structure and project implementation methodology.
4. Finally, in the discussion Section (3.4.2) we analyzed the characteristics in each of the two categories to compare the impact of the OS and PIM characteristics with respect to expertise within literature. As such, statements grouped into each of the two categories were analyzed in the context of the project delivery.

To ensure a rigorous and valid interpretation of the data, we conducted several iterations when analyzing our evidence. Our intention was to 'understand the whole' by constantly revising it in 'view of the reinterpretation of the parts' (Myers, 1994). Thus, we revisited our interview notes and other documents several times and conducted follow-up questions to clarify statements in order to draw our conclusions. The final project information and conclusions were written and confirmed by participants for approval to ensure accuracy and reliability.

By consulting multiple sources of evidence, and enabling confirmation of each other via triangulation of data, we were able to achieve construct validity. By studying various documents (e.g. embedded cases, interview data) we are able to establish a chain of evidence. According to qualitative research, the issue of reliability tends to be more complex. To ensure reliability, we built a database for the case study to provide other researchers to repeat the operations of the case study (Yin, 2009). All documents were codified by the database's number.

Specific examples of the use of triangulation include the (1) identification of the organizational structure and project implementation methodology and (2) identification of case company's project portfolio.

With regard to the organizational structure (OS) and project implementation methodology (PIM), we used desk research inclusive of case company presentations and official published company regulations and procedures. As a second source of evidence we interviewed case company employees (executive and operational). By comparing the desk research with interview feedback, we were able to achieve construct validity with respect to the case company's OS and PIM. Triangulation of the case company's project portfolio data was done through the reliance of desk research inclusive of the case company's self-reported metrics, a third-party audit and interviews with case company employees.

3.3. Case Study Findings

In this section, we present the research findings inclusive of the case company's project portfolio, embedded cases, and organizational structure and project implementation methodology. The discussion and analysis of the presented findings will be described in Section 3.4.

3.3.1. Case Company Project Portfolio

The case company's project portfolio was analyzed and the results of the project outcomes in delivering ICT projects are listed in Table 5. The project portfolio included 991 projects which the case company had performed in the last ten years. To ensure project outcomes were sufficiently validated, we limited the analysis of project outcomes to large projects. The definition of large projects was based on the project awarded cost being greater than €150.000 (€ 3.3 million was the largest project). The cutoff limit for large projects was based on the workshop discussions. Small projects within the organization are lower value (cost), occurred quickly and with a limited number of people. Due to the value, speed and number of people; we found the small projects to have weak or limited documentation which could not be verified in an audit. Without documentation the project outcomes could not be validated or reliable. After our analysis of the project portfolio, we identified that projects which were greater than €150.000 would provide documentation which could be validated through an audit. In total 72 projects were identified to be categorized as 'large'. Documentation of all projects during the period (2004 - 2009) were previously discarded by the case company and not available. As a result, we identified 47 large projects that were studied (2010 – 2013). In our analysis of the case company's 47 large ICT projects, we found that the case company showed to have average project outcomes of 89.36% on time, 95.74% on budget, and 93.62% customers satisfied. In other words, of the 47 large projects five were not on time, two were not on budget, and three did not achieve a satisfied customer. The project outcomes were measured independently which excluded overlap between the respective project outcomes.

Table 5: Case Company's Project Portfolio Results

#	Project Outcomes	Metrics
1	# of large projects (€150K- €3.3 Million)	47
2	% of large projects on time	89.36%
3	% of large projects on budget	95.74%
4	% of large projects customers satisfied	93.62%

3.3.2. Case Company Embedded Cases

We collected information on embedded cases within the case company's large project portfolio. The embedded cases provide deeper insight into the project portfolio findings. The cases were selected to serve as comparative instances where the supplier demonstrated results superior to the market in similar projects. After a review of the case company's large projects we identified two embedded cases which met the criteria with the required level of documentation. The embedded cases included two categories:

1. The case company's project delivery within a specific sector (banking)
2. The case company's replacement of an incumbent (multiple industries: retail, insurance, utility, and transportation)

Category 1: The Case Company's Project Delivery within a Specific Sector.

In total, we collected information of 14 projects in the banking sector. All 14 projects of the case company were completed on time, on budget and with an average client satisfaction of 9 out of 10 (see Table 6). The duration of the banking projects ranged from 6 to 13 months. Based on the case company's feedback from their clients' experience, the delivery time of similar banking projects is over two years with a 50% rate of completion. In comparison, the Standish Group (2016) reports project outcomes for the banking sector to be at 31% (on time, on budget, and with a satisfied client). The case company's project outcomes are 69% higher than the Standish Group (2016) reported outcomes and 50% higher than client feedback.

Table 6: Case Company Banking Sector Projects

Banking Sector Project Outcomes	Metrics
Total # of bank projects	14
On time	100%
On Budget	100%
Average Customer satisfaction (1-10)	9.0

Category 2: Replacement of an Incumbent

We collected data from four projects in which the case company replaced an incumbent project team. Based on our analysis, the projects were all services which included an initial setup and continual maintenance. In all four projects the case company was able to deliver the initial setup on time, on budget, and with a satisfied client. The projects were highlighted as they were all cases where the client hired the case company due to their dissatisfaction with current project conditions with the incumbent project team. The dissatisfaction was centered on the project condition of up-time. All four projects were services which involved mission critical applications, downtime to the client's system resulted in disruption to their business operations. The case company's impact on project conditions can give context into the project portfolio results, specifically to the client satisfaction.

The first project is with an online retail company. Three key project conditions were identified to impact the client's perception of project outcomes (from dissatisfaction to satisfaction) (see Table 7). The first project condition is that the case company increased their uptime from less than 96.5% to 99.998%. The improvement in uptime was estimated to decrease downtime by 25 hours within a 30-day period. For an online retail company, having their services up and running is a key to success in their industry. All of their services are performed online, meaning each minute can be translated to dollars loss of potential customers. The second project condition was the increase in the client's number of new product groups each year from 0.5 to 3. The faster development of product groups can be translated to improving the online retail company's ability to sell their services online. The third project condition was the achievement of compliancy statements from The Payment Card Industry Data Security Standard (PCI DSS). The PCI DSS is administered and managed by the PCI SSC (www.pcisecuritystandards.org), an independent body that was created by the major payment card brands (Visa, MasterCard, American Express, Discover and JCB.). PCI is not in itself, an enforced law. The standard was created by the major card brands. Non-compliance with PCI DSS can lead to financial consequences such as fines, card replacement costs, costly forensic audits, and brand damage in the event of a breach. Becoming compliant with the PCI DSS regulations reduced the client's risk of such financial losses.

Table 7: Online Retail

Project Conditions	Before	After
Availability (uptime)	< 96.5%	99.998%
# of new product groups a year	0.5	3
Compliancy statements (PCI DSS)	NA	Yes

The second project related to an Insurance Company. Four key project conditions were identified to contribute to the client's change from dissatisfaction to satisfaction with services (see Table 8). The first project condition is that the case company increased the client's uptime from less than 98% to 99.98%. The improvement in uptime is estimated to decrease downtime by 14 hours within a 30-day period. The second, third and fourth project conditions are with respect to the organizations internal control over financial reporting and information technology. Before the case company was selected, the client did not have any compliancy statements and was not able to identify the number of compliancy issues. After the case company was selected, yearly compliancy statements under recognized standards of SAS 70 and ISAE3402 were performed with no compliancy issues found. Insurance providers deal with a substantial amount of financial activities involving claims and reimbursements. Meeting international standards of financial and information technology security, minimizes the risk in financial damages. To handle claims involving compliancy issues, the client maintained and used a contingency budget of one million euros. Due to the improved compliancy standards, the contingency budget was no longer required and was eliminated.

Table 8: Insurance Company

Project Conditions	Before	After
Availability (uptime)	< 98%	99.98%
Compliancy statements (SAS 70/ISAE3402)	N/A	Yearly
# of compliancy findings issues	Undisclosed	0
Contingency budget for claims	€1 Million	€0.00

The third project corresponded to an Energy Company. The client's dissatisfaction with the project's conditions was emphasized when the client lost a single deal due to their slow service, resulting in a loss of €1.5 million. Three key project conditions were identified to contribute to the client's change from dissatisfaction to satisfaction with services (see Table 9). The first project condition was the decreased downtime per month from 2.880 minutes to less than 1-minute. Based on the client's initial dissatisfaction, improved up time led to a faster service. The second project condition was the decrease of the total cost of ownership of the service from €480,000 (expense) in 2006 to €24,000 (profit) in 2013. For any client the cost of ownership is an important aspect to any ICT service. The case company was able to turn the service from an overhead cost to a profit producing service. The last project condition was the client's personal project completion time improving from an average of 50% on time to an average of 99.6% on time for over 450 of the client's personal projects. The ICT services provided by the case company improved the client's service which in term improved the client's personal projects which utilized their system. The three project conditions contributed to the client's satisfaction with a faster service which produced a profit for the client.

Table 9: Energy Company

Project Conditions	Before	After
Downtime per month	2.880 minutes	< 1 minute
Total Cost of Ownership	Increasing cost	- In 2006: €480,000 (cost) - In 2011: €240,000 (cost) - In 2013: €24,000 (profit)
Client's personal project results	50% not on time	450+ projects 99.6% on time

The fourth project related to a Port Authority Service. Six key project conditions were identified to contribute to the client's change from dissatisfaction to satisfaction with their ICT services (see Table 10). The first, second and third project condition relate to the ICT system downtime (hours of downtime, longest downtime, and time to mediate downtime). Due to the size of the client, each hour of downtime for the service translated into millions of euros lost. The total financial cost of downtime was worsened by consecutive hours of downtime. The case company decreased the annual downtime of the client service from more than 24 hours to less than an hour. The longest downtime before the case company was four hours, this was reduced to less than an hour. Due to the frequency of downtime, the hours dedicated to mediating the incurred incidents before the case company was equal to one full time equivalent (FTE). After the case company took over services, the downtime was decreased, and the client no longer were required to spend any time in such activities. The fifth project condition was the elimination of three years of backlogged applications related to business requirements. The backlogged applications allowed the business requirements to be more fully met. Lastly, the client no longer had any problems with legal issues, liability claims, and reputational damage caused by the project conditions before the case company.

Table 10: Port Authority Service

Project Conditions	Before	After
Downtime in a year	≥24 hours	0
Longest downtime due to IT failure	4 hours	0
Business time required related to mediate downtime and incidents	1 full FTE	0
Application deployment life cycle	26 weeks	3 weeks
Backlog of application related business requirements	3 years	0
Problems with legal issues / liability claims / reputational damage	Yes	No

3.3.3. Case Company Organizational Structure and Project Implementation Methodology

We collected information on the case company's organizational structure (OS) and project implementation methodology (PIM) to identify characteristics of an expert supplier delivering ICT projects. Through the case company's OS and PIM, we were able to observe seven characteristics (three OS and four PIM characteristics).

Organizational Structure

When studying the organizational structure of the case company we identified three important characteristics:

1. No Management

   There is no management layer in the organization as the case company is considered to be a 'flat' organization. Besides three owner-directors, all other employees are treated equally when it comes to their tasks and responsibilities. In the absence of management layers, employees within the case company's organization do not have the option to 'climb the career ladder'. Each employee is expected to remain in their operational role and to continually develop within their respective functional expertise.

2. Self-Forming Teams

   Employees have the freedom to switch roles and teams based on their own choice. As there are no management layers, the employees themselves are responsible to make the necessary arrangements for their choices. An employee's freedom is to the extent that they can also decide to leave their existing projects for a new one, however, they have the responsibility to fill their position before leaving.

All ICT project teams are staffed by employees who volunteer for their positions. There are no managers who will force an employee to be a part of the team and similarly there are no managers who will force a project team to accept a new team member. Each employee is personally responsible to find a place for themselves within the organization and to be competitive and desirable to be accepted by their peers within that place.

3. Peer Review Compensation

All personal compensation is based on peer reviews of individual employees. Each employee's pay is based on their personal achievements and contribution to the organization. The accuracy of such achievements and contributions is verified through the input of peer evaluation. Each employee has a responsibility to provide and justify their contribution to the organization through dominant, objective metrics. Based on the peer evaluations and the personal justification of contributions to each employee, the final decision is made by the case company's directors or a delegated committee.

Project Implementation Methodology

4. Internal Project Justification

As there are no management layers, the identification of which projects the case company pursues is fully controlled by the employees. When an employee identifies a project which they wish to pursue, lead project managers form teams with employees volunteering as team members for the potential project. In order to pursue the prospective client, the project team must provide a business case to the director(s) and selected peers. The business case includes the project team which will be performing the project. Examples of methods of justification include (1) previous projects that team members have completed which are similar to the potential project and (2) team members have necessary qualifications and knowledge base. The project team will then present a project plan which includes a schedule, price breakout (including profit), risk mitigation plan, and future performance metrics. Lastly, the project team will show that the organization itself has the necessary technology (hardware and software) to support the project. The committee composed of the director(s) and selected peers, based on the project team's proposed business case will reject, accept or accept with modifications to the business case.

5. Expert Front Line

With regard to ICT services, the case company perceived the industry to be divided into generic applications and mission critical applications. The generic applications were standard, required a low level of integration with business processes, and were not essential but convenient. The generic applications in the case company's view did not require a great deal of expertise and were functions which were often automated due to their predictability. Mission critical applications are applications which are essential for the survival of a client's business. Failure in mission critical applications significantly affects the operations of a client's business. These functions require a great deal of expertise as they are generally unique, highly integrated throughout the client's organizations, and financially damaging in cases of failure.

The case company defined two models in handling ICT services. Model A attempts to package a wide range of services to sell to clients (see Figure 3). This package includes both generic and mission critical applications. In Model A, support is offered through an escalation which requires a client to go through multiple lines of support until their specific need is matched with the correct level of expertise. An example of this could be a call center which the first support line is very generic. If the first support line cannot meet your service needs, you are then passed to the second line which is slightly more specific. The case company identified Model A works well with generic applications for example, if your desktop does not work. Model A is not applicable to mission critical applications which require immediate response with the correct level of expertise. An example could be if an online retail company's entire on-line portal fails to support all sales online, this would disrupt their business operations.

The case company decided to use a different approach, Model B, which focuses only on mission critical applications. In Model B, the case company creates project teams with all the required expertise to meet the client's requirement. There is no escalation flow because the project team deals directly with the client and will always have the expertise needed to respond appropriately. In other words, the front line of support is staffed by the case company's experts needed to deliver the client's specific requirement.

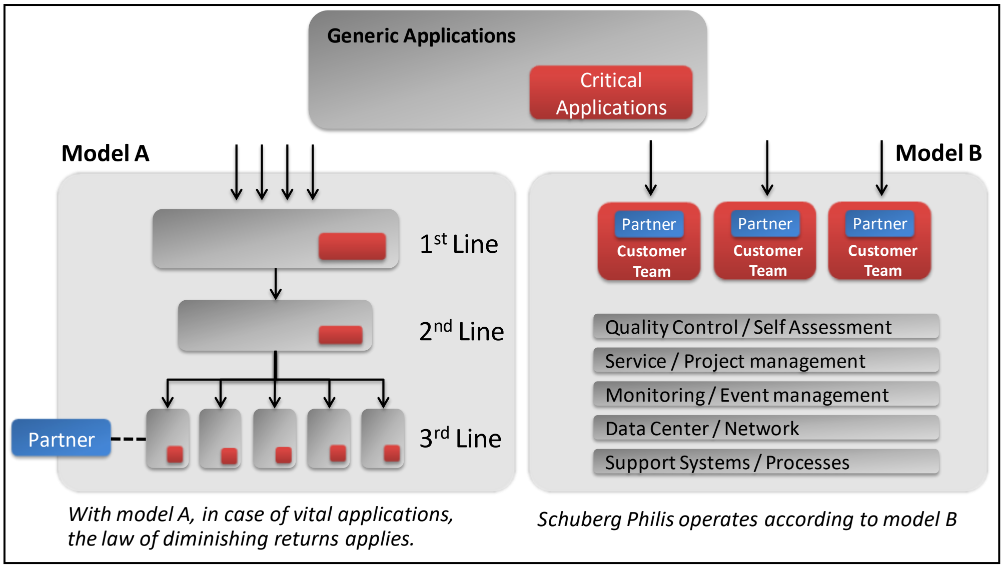

Figure 3: Expert Front-Line Client Interface

6. No Functional Silos

Taking a classic approach to project implementation into account (see Figure 4), suppliers use functional organizational silos to support their project related tasks. These approaches can be applied in different forms such as Prince2, PMI/PMBOK and stage gate process (Rivera, 2017). In practice this means that project tasks are handed over between teams through stages which could include marketing, design, operations, and support. This can be seen by the supplier using different teams to bid, design, execute and maintain project related tasks. For instance, a supplier may use a marketing team to create a proposal to win the client's project. Once the project is awarded, the marketing team will then pass the project to the design team. The design team will then plan the client's requirements based on what marketing proposed. Once finished the design team would then pass the project to the operations team who will then build the project. After the project is built the operations team will then pass the project to be run and supported by different teams.

Importantly, this approach will increase transaction and coordination costs and may cause hand-over issues between teams as the steps to fulfill a project are sequential (Mandiau et al., 2000). For instance, the marketing team may create a proposal which is not feasible to design. The design team may design a system which is not buildable, or the operations team may build a system which reoccurring breaks down during the support period. The accountability of each functional team can be perceived to be decreased as there are multiple entities which now share responsibility.

The case company applied an alternative approach, which does not have functional silos. From a practical perspective, the case company has one project team which is responsible for all the project functions. The project team will take the project from the marketing to the support of a project (See Figure 4). The new, more integrated, approach allows the client to have one team to be accountable and gives the case company's project team full control of the entire project. For instance, the project team that creates the initial proposal to win the client's project, is the same team that will design, build and support the project.

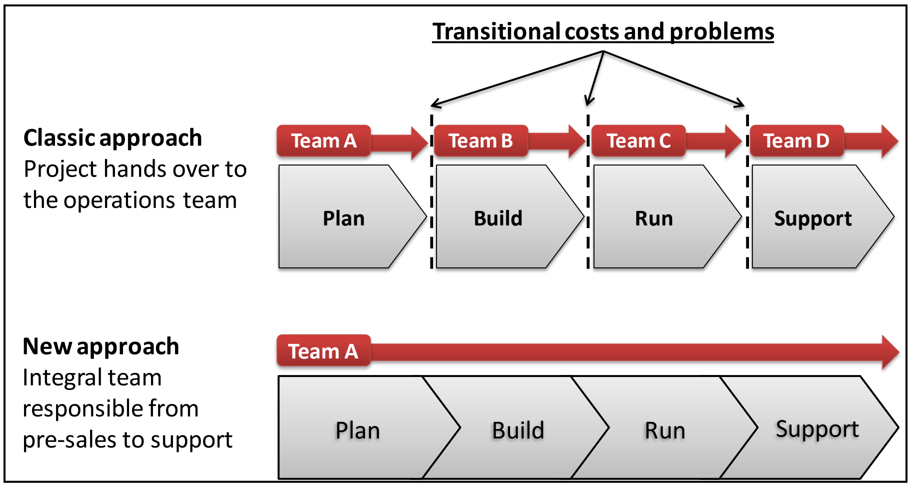

Figure 4: Integrated Project Teams

7. Upfront Cost Transparency

The case company's objective is to provide full transparency of their costs to their clients before a project will start. The pricing principle is to provide a fixed price model. Once the case company receives the service requirements, they will estimate their work force, determine a profit percentage and then provide a fixed service price. Before starting a project, the case company will provide a service list pricing and identify the financial impact in changing any of the listed services. The upfront transparency is to ensure that the client understands what is being provided and the impact of changes to the initial requirement.

3.4. Discussion and Analysis of Case Study Findings

The case study findings are intended to answer the second research question (SRQ2): What are characteristics of an expert supplier delivering ICT projects? In this section we will address and analyze the case study findings in comparison to existing literature, to gain further insights and discussion.

3.4.1. Validation as an Expert Supplier

We validated the case company as an expert through their project portfolio and embedded cases.

The case company's project portfolio of 47 large projects were identified to have an average project outcome of 89.36% on time, 95.74% on budget and 93.62% client satisfied. In context of the literature regarding ICT project outcomes; the case company's project outcomes are higher than the ICT market project outcomes (see Table 11). The case company's project portfolio gives an accurate measurement of their project outcomes, as no large projects were excluded within the last six years.

The case company achieved relatively high project outcomes in an industry identified to be complex (Bullock & Cliff, 2004; Adami, 2002; Tarride, 2013; Horgan, 1995). Based on the results. the case company's project outcomes do not seem to be affected by project complexity as reported in the literature (Al-ahmad et al., 2009; Legislative Assembly of the Northern Territory, 2014; Public Administration Committee, 2011; Sauer & Cuthbertson, 2003; The House of Representatives of the Netherlands, 2014; The Standish Group, 2016).

Table 11: Market Reported Project Outcomes

Comparison of Project Outcomes	On time	On Budget	Client satisfied
The European Services Strategy Unit (2007)	67%	43%	N/A
McKinsey and Company (2012)	50%	50%	44%
The Standish Group (2016)	40%	43%	38%
Schmidt et al. (2001)	N/A	20%	N/A
Fenech & De Raffaele (2013)	68%	66%	58%
Whittaker (1999)	13%	44%	45%

The embedded cases provide specific instances where the case company achieved higher project outcomes than the market in comparable projects. The first embedded case was with 14 projects in the banking sector, which were all completed on time, on budget, and with a satisfied client (average satisfaction of 9 out of 10). In comparison, the Standish Group (2016) reported project outcomes for the banking sector to be at 31% (on time, on budget, and with a satisfied client). The case company's project outcomes are 69% higher than the Standish Group (2016) reported market average. The project outcomes (100% on time, on budget and with a satisfied client) and the size of the gap (69%) provide evidence that the case company's project outcomes are more than mere luck of the draw. The second embedded case identified projects where the case company replaced an incumbent project team. As these were existing services, the project scope and stakeholders remained relatively the same. The case company in each of the four cases demonstrated the ability to improve the project outcome of client satisfaction by improving key project conditions.

Based on the case company's project portfolio and embedded cases, we conclude that the identification of the case company as an expert supplier to be validated and accurate, as defined by Gobet (2015).

3.4.2. Characteristics of an Expert Supplier Delivering ICT Projects

The findings of the case company's organizational structure and project implementation methodology identified seven characteristics of an expert supplier delivering ICT projects. This section compares the seven characteristics with existing literature to gain further insight into the characteristic's relation to expertise. The analysis of this section identified all seven characteristics to emphasize the expertise of the case company and identified the case company to:

1. Foster and values expertise within their organization.
2. Place sufficient expertise necessary to deliver projects.

Francis and Gunn (2015) identified that expertise is not needed in industries which are not complex. In contrast, in industries which are considered to be complex, expertise can improve project outcomes. Arisholm et al. (2007) studied 295 ICT consultants and identified that project outcomes were dependent on the consultant's expertise. Qureshi and Kang (2014) suggested that reducing the degree of project complexity mainly depends on the expertise of the project manager and entire project team. Based on the case company's project outcomes within a complex industry, it can be argued that expertise is the differentiating factor (Arisholm et al., 2007; Francis & Gunn, 2015; Qureshi & Kang, 2014). With regard to project outcomes, these findings correspond to research in the field of new product development in which the study of Hultink and Atuahene-Gima (2003) demonstrated that new product adoption by a firm's sales force, which is strengthened by internal marketing and expertise, positively support selling performance. In other words, expertise does matter.

Organizational Structure Fosters and Values Expertise

The organizational structure of the case company identified three characteristics which demonstrated how the case company fostered and valued expertise within their organization, including: (1) no management, (2) self-forming teams, and (3) peer review compensation.

Wu and Fang (2007) identified that how firms are structured can affect the organizational development of expertise. Through the proper organizational structure, firms can leverage existing knowledge and build stronger expertise within their organization. The case company's organizational structure minimizes layers of management and increases freedom through self-forming teams and peer compensation reviews. Through the case company's organizational structure employees are encouraged to build and strengthen their expertise based on a technical skillset.

Rishipal (2014) identified flat organizations have minimal management and put an emphasis on the individual before the organization through a horizontal career path and function. Rishipal (2014) identified flat organizations to affect employees' motivation and accountability to personally develop their expertise within the organization. In vertical organizations, the pay scale is dependent on moving into positions of management. Within a flat organization, technically skilled employees are no longer required to leave their technical role in order to increase their compensation. When technically skilled workers are moved into management, it often requires a different set of skills. For instance, engineers may not be suitable for higher level management positions, as they may be too involved in detailed work due to the nature of their expertise. Placement of technically skilled workers into management can potentially discard their technical skill and force the development of skills which may not be as natural or refined to the employee. Wulf (2012) identified flat organizations limit "vertical" promotion to allow employees to personally develop. Instead of increasing vertically through management positions, employees expand horizontally to improve their expertise and increase their scope of control. The no management structure of the case company would allow employees to stay and develop within their field of expertise their entire career. This structure allows the case company to maintain and continually develop a larger base of expert employees.

Steiger et al. (2014) identified functional structures which emphasize professional skills of the employees are key in fully utilizing the expertise within an organization. In a functional structure expert power is placed over legitimate power. The freedom given to expertise within a functional structure allows experts to govern their respective areas without interference. The organizational structure of the case company aligns with a functional structure as it provides freedom for employees to correctly align and select projects based on their expertise. Moravec (1999) identified that it is difficult for organizations to switch from a hierarchical structure to an environment where each individual is responsible for their own decisions. Based on the case company's self-forming teams, employees can no longer depend on the decision making of management to be assigned on a project and must proactively select their projects. Parker et al. (2015) identified that with self-forming teams' jobs are loosely defined which places a high priority on multi-skilling and training. This environment gives each individual an intrinsic motivation to obtain a greater degree of expertise. Moreover, it is by their expertise that they are accepted by team members of the potential project they wish to join.

The peer reviews coupled with the voluntary team compositions naturally promotes developing, finding and utilizing expertise within the supplier organization. If an employee does not have sufficient expertise to be acceptable by his/her peers, they will not be able to participate in projects. Consequently, without being accepted on a project team, they will not be able to justify their salary during peer reviews. This form of policing will filter out employees with insufficient expertise. Mohapatra (2015) identified that peer reviews can be used for more than a natural filter of expertise but can also be a developmental process for an employee's expertise. The researcher described how feedback from peer reviews is a structure which assists the employee in their career growth and development of expertise. As the case company's employees are regularly being given feedback due to their peer review compensation process this allows the further development of expertise within the case company's organization.

Project Methodology Places Sufficient Expertise Necessary to Deliver Projects

Buckland and Florian (1991) identified that the expertise of the individual must match the project complexity. The project implementation methodology (PIM) of the case company identified four characteristics which demonstrated how the case company ensures that the employees being placed on projects have sufficient expertise and that their expertise is being utilized throughout the entire project. The four characteristics of the PIM include internal project justification, expert front line, no functional silos, and upfront transparency.

Identifying the level of expertise of an individual to match the project complexity is key to achieving high project outcomes (Buckland & Florian, 1991). Du et al. (2007) analyzed 118 ICT project experts and 140 novices in determining the differences between the two groups. Experts were identified to be more capable to address risks and know *how* to deliver the project. Experts also perceived to have greater control over the project. Anwar et al. (2013) identified the importance of other expert indicators such as experience, success of previous projects and their technical skillset to achievement of project outcomes.

The case company's project implementation methodology (including internal project justification and upfront transparency) naturally checks the level of expertise of their project team (Riaz et al., 2017). Before the case company approaches a client, the internal project justification ensures that there was sufficient expertise on the project. This process acts as an internal filter to ensure the case company is an expert in all projects they choose to accept. The same justification and transparency is then put through a third-party filter, as the case company provides upfront transparency to all their clients. By providing a complete plan (risk mitigation, planning, budget, and team skillset composition) to the internal case company committee and then the client, it allows a twostep confirmation that the case company has sufficient expertise to deliver the project.

Riaz et al. (2017) identified that there are multiple roles within a project team and each team member requires different knowledge and skills. Project leads may require less technical skills such as budgeting and scheduling, while software developers require more technical skills of coding and analysis. Project teams who are not fully rounded or are separated by functional silos of an organization reduce their ability to leverage the expertise of their team members. Mandiau et al. (2000) identified that by grouping by specialty and workflow, a project team can contribute to the development of expertise through collaboration and synergy. The grouping of specialty is related to the field of abilities and the grouping of workflow is related to the personnel needed to carry out a given project. The case company's structure of an expert front line and no functional silos facilitates the grouping by both specialty and workflow throughout the entirety of the project.

The case company's expert front line ensures that each project team is comprised of all the expertise required to deliver a project, without having to rely on members outside of the project team. The absence of functional silos within the company ensures that the same expert project team is used throughout the duration of the project.

The findings from the analysis of the organizational structure and project implementation methodology identified the case company:

1. Fosters and values expertise within their organization (Characteristic 1, 2 and 3).
2. Places sufficient expertise necessary to deliver projects (Characteristic 4, 5, 6 and 7).

The identified seven characteristics of the case company were all found to emphasize the case company's expertise. Based on these findings, we identify expertise as a key differentiator between the case company's project outcomes and market project outcomes.

3.4.3. Implication of Case Study Findings

Based on the discussion of the findings of the case study, we present two propositions that relate to the definition of project complexity and an expert supplier's impact on the effect of ICT project complexity on project outcomes.

Project complexity is currently defined to be the difficulty in delivering a project (Vidal et al., 2011; Tie & Booluijt, 2014; Xia & Chan, 2012). Based on the findings it is arguable that the case company does not have difficulty delivering ICT projects. Additionally, the case company was identified to be an expert which corresponds to Gobet's (2015, p.12) definition, 'somebody who obtains results that are vastly superior to those obtained by the majority of the population'. Gobet's (2015) emphasizes perception to be at the center of expertise. Experts have been identified to perceive things differently than novices (Schoenfeld, 1982). Based on this chain of reasoning, we argue that expert's do not perceive projects difficult to deliver, and therefore do not perceive projects as complex.

Secondly, taking the definition of expert into account (Gobet, 2015) we assume that the expert supplier would have a greater amount of expertise within their area than the majority of the suppliers within their respective sector of the ICT industry. Being an expert according to this definition does not necessarily mean that the expert is perfect (100% expertise, knowledge and skills in all tasks). The case company did not have a perfect project portfolio (100% on time, on budget, and with a satisfied client) but results were above the reported market project outcomes. Based on these findings we do not know if expertise can fully eliminate the effects of project complexity but propose that expertise reduces the effect of project complexity on project outcomes.

As a result of the case study findings, we present two propositions that can be tested in the next step of our research:

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.
- Proposition 2: An expert does not perceive projects as complex.

3.5. Conclusion

The case study research analyzed the organizational structure and project implementation methodology of a single case company validated to be an expert, and identified seven characteristics:

1. No management.
2. Self-forming teams.
3. Peer review compensation.
4. Internal project justification.
5. Expert front line.
6. No functional silos.
7. Upfront cost transparency.

The identified seven characteristics answers the second research question: 'What are characteristics of an expert supplier delivering ICT projects?' The seven characteristics represent a single expert ICT supplier. The characteristics are not representative of the only characteristics of an expert ICT supplier. The characteristics are limited to the areas of a supplier's organizational structure and project implementation methodology and do not include the characteristics of the employee's expertise. Future research is needed to establish definitive characteristics which can be generalized to the entire industry (see Section 7.5: Future Research).

The findings resulted in the creation of two propositions that relate to an expert's impact on the effect of ICT project complexity on project outcomes and the expert's perception of ICT projects.

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.
- Proposition 2: An expert does not perceive projects as complex.

4. Survey Research

4.1. Introduction

This chapter describes the quantitative research that is conducted to answer the third research question ‘How does supplier expertise influence the effect of project complexity factors on project outcomes?’ The objective of the study is to further develop an enriched conceptual model with regard to the impact of expertise on the effect of project complexity (measured through project factors) on project outcomes. Section 4.2 describes the methodology after which the pretest survey is described in Section 4.3 and the main study findings are described and analyzed in Section 4.4. Consequently, the conclusions are described in Section 4.5.

The methodology described in Section 4.2 is the same methodology used in both the preliminary and main study survey. There are a few adjustments made to the methodology of the main study survey based on lessons learned from the pretest survey. The adjustments made to the methodology are noted in Section 4.2 but are described in detail in the respective pretest survey lessons learned (Section 4.3.2).

4.2. Methodology

4.2.1. Project Complexity Factors

As described in Chapter 2, we identified 22 project complexity factors relating to the project stakeholder (8) and the project scope (14) (see Table 12). Adjustments to the factors were made based on the lessons learned of the pretest survey. The adjustments were to clarify the context of the supplier and client entities. These adjustments were not considered changing the factor itself from previous literature as it was merely clarifying the context of the factor. An example of such adjustment is changing the factor, lack of senior management support, to specify the client, lack of client senior management support (see section 4.3.2 for lessons learned during pretest survey).

This chapter focuses on the influence that the supplier’s expertise has on the effect project complexity factors have on project outcomes. The project outcomes are defined by the criteria of on time, on budget and client satisfaction. Expertise is defined as ‘knowledge and skill, with an expert being defined as somebody who obtains results that are vastly superior to those obtained by the majority of the population (Gobet, 2015).

Table 12: Survey Project Complexity Factors

#	Project Complexity Factors
1	Lack of the client's senior management support
2	Appropriate authority and accountability between stakeholders
3	The interaction and interdependence between stakeholders
4	Multiple stakeholders
5	Availability of the client's people, material and of any resources due to sharing
6	Conflict between stakeholders
7	The client stakeholder's technical knowledge and/or experience
8	Geographical location of stakeholders
9	Largeness of scope (man hours, components, deliverables, etc.)
10	The client's project requirement is poorly defined
11	The project comprises a diversity of tasks
12	The size of the project budget
13	The length of the project's duration
14	The client's information uncertainty in the project
15	A client with unrealistic goals
16	The project's alignment with the client's business goals and interests
17	The number of decisions to be made on the project
18	The integration between technology (hardware, software, processes or methods)
19	The newness/novelty of the technology (hardware, software, processes or methods)
20	The technology is continuously changing (hardware, software, processes or methods)
21	The diversity of technology in the project (hardware, software, processes or methods)
22	Highly difficult technology (hardware, software, processes or methods)

4.2.2. Sample and Data Collection

The survey used consists of three parts and was accompanied by means of a cover letter that explained the goal of the survey (see Appendix D and E). The first section collected background information of the respondents. The second section provided definitions and addressed the instructions to fill out the survey. The third section addressed the survey questions.

With regard to the survey questions, the respondents were asked to rate each of the 22 project complexity factors' (identified in Chapter 2) likelihood to be a cause of low project outcomes. Specifically, two situations are sketched out: (situation 1) when the supplier performing the project is an expert and in contrast (situation 2) when the supplier is a nonexpert. We used a 5-point Likert scale to rate each factor. The scale ranged from 1 = Extremely Unlikely, 2 = Unlikely, 3 = Neutral, 4 = Likely, and 5 = Extremely Likely (See Figure 5). The basic statistics (i.e. mean, standard deviations, etc.) were performed using excel. The statistical tests of Kruskal Wallis, Dunn Post Hoc, and Wilcoxon Signed Rank tests were performed using excel programs MegaStat and RealStatistics. Both MegaStat and RealStatistics programs were sufficiently able to perform the needed statistical analysis. For further analysis inclusive of factor analysis more advanced software such as SPSS was used. See Appendix D and E for the full survey and structure for the pretest and main study.

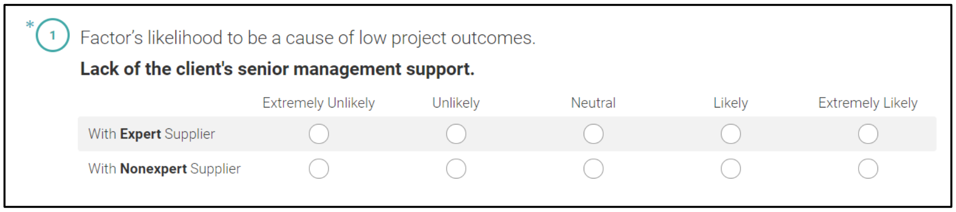

Figure 5: Survey Format

A sample frame of respondents was gathered through contacting major ICT suppliers, clients and organizations to establish a point of contact within each firm. The respondents were not told the exact survey they would be given but were asked to assist as a practitioner involved in ICT projects with respect to the field of complexity. After the survey was initially distributed, three follow-up reminders throughout the course of a month were sent to respondents. In the cases which the respondent did not feel fully qualified to take the survey, the respondent would pass the survey to the colleague within the respondent's group who felt qualified to complete the survey. To minimize issues caused by framing, we created a sample frame with a diverse range with respect to the background information (country, role, function and experience). The survey was closed after all follow-up reminders were sent and no response was received within a week. Late responders were not accepted within the qualified survey respondents.

The prequalification to select the respondents for the main study included: (1) the respondents' participation in ICT project implementation and (2) minimum of two years' experience within ICT project implementations. To meet the objective of the pretest survey, the prequalification was opened to the project implementation in any industry with no requirement of years' experience. The background information responses were mandatory for each participant, as through our statistical analysis, it could then be examined the possible bias and impact that background information of country, role, function and years of experience could have to the respondents' scores. The identified background information was selected to gain a holistic view of the ICT industry's perception of complexity including: (1) country was measured as cultures and markets may create bias or differences in results, (2) roles of the client and supplier were measured as they are two of the primary entities identified in the research model, (3) functions (Ex. procurement, project management, etc.) within a project were measured as they may have different insights as generally no single function covers the entire project and (4) years of experience was measured as familiarity within the ICT industry may change perspectives. The background information of industry was gathered in the pretest survey as it was not limited to the ICT industry.

The survey data was collected and stored in an Excel sheet. The data was then reviewed to identify the validity of each survey. There was no time limit placed on the survey, which would allow respondents to potentially start and finish the survey over an extended period of time. Respondents' data was disqualified (not used in the research) if two situations appeared:

1. The respondent identified that they were not involved in (ICT) projects.
2. The respondent did not complete all questions in the survey.

4.2.3. Analyzing the Impact of Background Information to Results.

In order to analyze the quality of the data in terms of bias, we analyzed the impact of differing background information. An analysis of the variance was performed using the Kruskal Wallis test to analyze the participants responses according to their background information. The background information considered include:

1. Country of practitioner
2. Role of the practitioner
3. Function of practitioner
4. Years of experience of practitioner

Initially the paired one-way ANOVA test was considered to analyze the results, however, the ANOVA test had four general assumptions:

1. The dependent variable must be continuous (interval/ratio).
2. Independent variable should consist of at least two categorical levels.
3. The dependent variable should be approximately normally distributed.
4. The dependent variable should not contain any outliers.

The data satisfied rules one and three, but the responses were not normally distributed, and the conservative approach would be to treat the Likert scale as an ordinal (discrete) scale. Research reveal that Likert scales can be treated like interval (continuous) (Glass et al., 1972; Lubke & Muthen 2004). This method of measurement is not accepted consistently (see

Jamieson, 2004; Likert, 1932; Sullivan & Artino, 2013). With these conditions, the data has potentially violated two (2) of these assumptions. The Kruskal Wallis Test was considered to be a nonparametric alternative to the one-way ANOVA test. This test does not require the dependent variable to be normally distributed and is acceptable to be used with ordinal data. The Kruskal Wallis test is considered an omnibus test statistic, meaning it tests for a significant difference between the categorical levels. Importantly, it does not tell in which of those categorical levels the difference exists. To create clarity, categorical groups with a significant difference were further tested using the Dunn post-hoc test to identify which specific levels the difference exists.

The hypothesis can be observed as:

H_0: Background information based on population (Ex. Country) medians are equal.
H_A: Background information based on population (Ex. Country) medians are not equal.

After testing each of the 22 factors in both situations, which include the expert and nonexpert, we analyzed the survey data. The results were separated into factors which assumes that the groups (background information) are based on identical populations (fail to reject H_0) and those which showed statistical significance that at least one of the groups (background information) comes from a different population than the others (Accept H_A). The factors that showed a significant difference were further analyzed using post hoc tests to determine which categorical level, within that background information, showed a significant impact to the respondents' score for that factor. The post-hoc was based on the Dunn's test (used with Kruskal Wallis test). The analysis process is summarized in Figure 6.

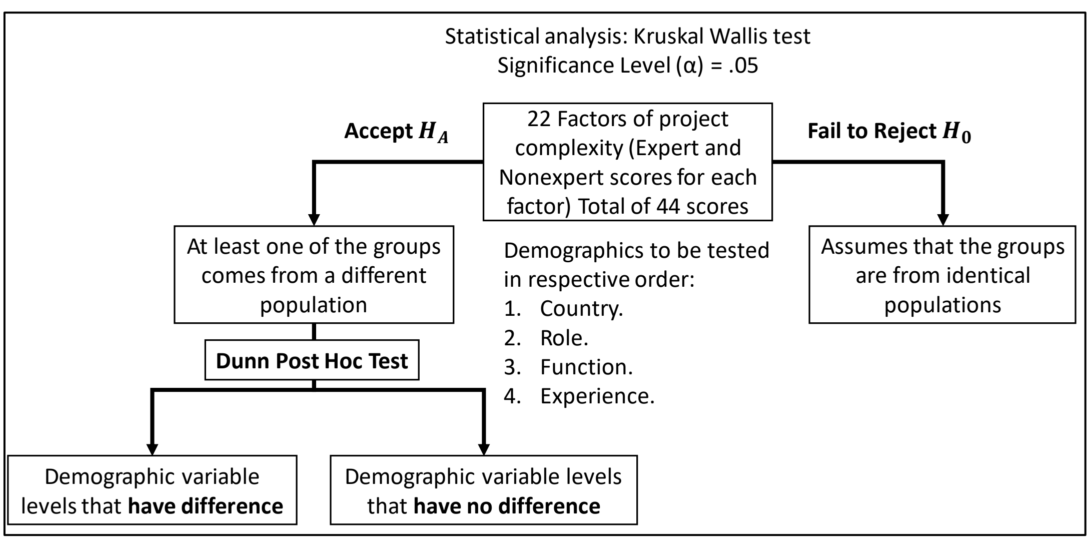

Figure 6: Statistical Test of Background Information

4.2.4. Analyzing the Impact of Expertise

The Wilcoxon Signed Rank Test was performed to identify if there was a statistically significant difference in the likelihood that the indicated factor would be a cause of low project outcomes between a project with an expert supplier and with a nonexpert supplier.

Initially the paired sample T-test was considered for this analysis however, the paired T-test has four general assumptions:

1. The dependent variable must be continuous (interval/ratio).
2. The observations are independent of one another.
3. The dependent variable should be approximately normally distributed.
4. The dependent variable should not contain any outliers.

The data tested was independent and a matched pair, as the same subjects were present in both groups. However, similar to the ANOVA testing, the responses were not normally distributed, and the Likert scale is generally treated as an ordinal (discrete) scale. The Wilcoxon Signed Ranks Test is a nonparametric test equivalent to the paired t-test. The Wilcoxon test does not assume normality of the data, is much more robust in terms of outliers and works with ordinal and continuous measurements.

The hypothesis test can be observed as:

H_0: The median difference between expert and nonexpert scores is zero.
H_A: The median difference between expert and nonexpert scores is not equal to zero.

After each of the 22 factors were analyzed, they were separated into factors which showed the median difference is zero, no statistically significant difference (failed to reject H_0) and those which showed the median difference is not zero, a statistically significant difference (H_A). To gain further insight the 22 factors were then analyzed in two stages.

Stage 1: We analyzed the frequency of the differential of scores between the expert and nonexpert and frequency of scores in an expert situation and the nonexpert situation. The differential between the expert and nonexpert score was to gain further insight into the Wilcoxon Signed Rank test. The differential is calculated by subtracting the nonexpert situation score from the expert situation score (expert situation score – nonexpert situation score). Negative differential signified the respondent scored the expert less likely to be a cause of low project outcomes than the nonexpert. Positive differential will signify the opposite and no differential will signify the respondent scored both situations the same and did not perceive expertise to have a dominant impact on the factor's effect on the project outcomes.

Stage 2: We analyzed the scores of the expert situation and nonexpert situation for the median, mode and mean through prioritization and comparison. Jamieson (2004) has noted that treating ordinal scales as interval scales has long been controversial. Methodological and statistical texts are clear that for ordinal data should employ the median or mode as the measure of central tendency (Clegg, 1982; Kuzon, 1996). However, the mean has been used in published studies with ordinal data as a practical measurement (Hren et al., 2004; Santina & Perez, 2003). Blaikie (2003) identified this form of analysis has become common practice, with some merit to it (Knapp, 1990). To gain a holistic understanding the analysis of all three statistics (median, mode and mean) was considered.

4.2.5. Identification of Project Factors that Affect Project Outcomes

In addition to the Wilcoxon Signed Rank test, an exploratory factor analysis was considered to identify underlying factors, within the 22 identified factors, which affect project outcomes. The analysis would consider both situations of an expert and a nonexpert. The identification of underlying complexity factors which affect project outcomes would contribute to answering SRQ1, "what factors define ICT project complexity?" The 22 project complexity factors identified in Chapter 2 would be a holistic measurement of project complexity. The factors identified through the exploratory factor analysis are factors grouped by their effect on the project outcome. New insights in regard to the impact of expertise can be formed with a list of factors grouped by their effect on the project outcome.

Supporting tests to be performed to measure the sampling adequacy with EFA are the Bartlett's test for sphericity and Kaiser–Meyer–Olkin (KMO) (Janssen et al., 2008). The KMO identifies the variance of variables that may be due to underlying factors, this number should generally be above 0.5 to indicate the appropriateness to use EFA (Field, 2005). The Bartlett's Test is used to indicate correlation of variables, the significance level less than 0.05 would support the use of EFA.

4.3. Pretest Survey

The main purpose of the pretest survey was to error proof the survey content and practicality in terms of duration to complete the survey and to test the understandability of the 22 project complexity factors. To minimize the risk of respondents not understanding the survey's terminology, it would be beneficial to have the pretest survey's target group to include multiple industries and participants with little familiarity with the ICT industry. By including respondents outside the ICT industry, the listed factors terminology could be sufficiently tested for understandability as common language which does not require technical knowledge of the ICT industry.

4.3.1. Sample and Data Collection of Pretest Survey

To meet the pretest survey's objective, the survey was distributed at the 2018 Annual Best Value Conference held in Tempe, Arizona. This conference was selected due to its alignment with the background information criteria and purpose of the pretest survey including:

1. The annual conference draws from both the United States and the Netherlands which are the two countries of focus for this study's scope of research (see Section 1.6).
2. The attendees are involved in all or part of project implementations from procurement to project execution from a wide range of industries, roles and functions.

The survey was presented in hardcopy format (see Attachment D) and was distributed to all attendees of the conference. The survey was optional to attendees and there was no time limit. Thus, the practitioners could spend as much time thinking about each question as they thought necessary. The respondents were instructed to ask questions if any part of the survey was unclear or which they did not understand. A researcher was available throughout the duration of the survey to explain any questions and take notes on the comments of participants. In total 60 invitations were distributed with 46 responses, a response rate of 76% (see Table 13 and 14). Six of the surveys were disqualified due to partial completion, leaving 40 qualified responses used in the analysis. The respondents of the survey gave a spread of background information to test the survey including:

1. An almost even split between US and Netherlands respondents, 21 respondents to 19 respondents respectively.
2. Fewer suppliers than clients (13 respondents to 21 respondents respectively) with six respondents which identified as both client and supplier.
3. Eight different industries with the construction, services and ICT industries predominating with 14 respondents, nine respondents, and eight respondents respectively.
4. Five different functions, predominantly consultants with 19 respondents, project management with seven respondents, procurement with seven respondents, management with six respondents and sales and marketing with one respondent.
5. An average experience of 16 years with respondents from all defined age groupings including: 0 to 5 years with eight respondents, 6 to 10 years with seven respondents, 11 to 20 years with respondents 14 and 21+ years with 11 respondents.

Based on the background information of respondents there was a sufficient spread amongst varying countries, roles, industries, functions and years of experience to meet the aim of the pretest survey.

Table 13: Summary of Respondents

Factors	Final
Total Number of Invitations	60
Total Number of Responses Received	46
Response Rate	76%
Number Disqualified	6
Number of Qualified Responses	40
Average Years of Experience	16

Table 14: Background Information of Survey

Country	Total	Function	Total
United States	21	Consultant	19
Netherlands	19	Project management	7
Role		Procurement	7
Client	21	Management	6
Supplier	13	Sales and Marketing	1
Client and Supplier	6	Years of Experience	
Industry		0 - 5 years	8
Construction	14	6 - 10 years	7
Services	9	11 - 20 years	14
ICT	8	21+ years	11
Government	4		
Education	2		
Public Admin/ Procurement	1		
Consulting & Engineering	1		
Healthcare	1		

4.3.2. Lessons Learned

After the pretest survey was distributed and analyzed, we found no severe issues with the survey content or process. Each respondent completed the survey and had no questions regarding the instructions, definitions or factors. There were two lessons learned by the observations of the researchers, which helped to refine the survey in preparation for the final larger distribution.

The first lesson learned was the description of the factors. There were three factors identified that potentially caused confusion due to ambiguity as to the entity (client or supplier) that these factors refer to including:

1. Lack of senior management support
2. The project's alignment with business goals and interests
3. Availability of people, material and of any resources due to sharing

In previous literature, these factors were described to be related to the client of the project but when cited as a factor it may require additional context to make that assumption. The factors were therefore clarified to be connected with the client of the project. This was not considered changing the factor itself from previous literature as it was merely clarifying the factor.
The original described factors were adjusted to:

1. Lack of the client's senior management support
2. The project's alignment with the client's business goals and interests
3. Availability of the client's people, material and of any resources due to sharing

The second lesson learned was the wording in terms of the focus of the survey and need for more explanatory introduction to the respondents. The main study's focus is the ICT industry. Due to the change in focus of the main study's survey from all industries to be limited to the ICT industry, a few sentences and explanations required adjustments. For example, the phrase "a key issue to project outcomes" was changed to "a key issue to ICT project outcomes". Another change was the elimination of the background information of industry, as all respondents are intended to be from the ICT industry. Additionally, the option to select "client and supplier" was eliminated and adjusted to only offer the options to select client or supplier. This was done to improve the statistical analyst of the two entities individually. The final change was the addition of an introductory invitation to respondents to explain the purpose and overview of the survey. Based on the results of the pretest survey, the main study survey was slightly adjusted and prepared to be distributed to a larger audience.

4.4. Main Study Survey

The main study survey was created after refinement from the pretest survey. In Section 4.4.1 the sample and data collection is described including the background information of the respondents. In Section 4.4.2 the survey findings were given in terms of the statistical results.

Lastly, in Section 4.4.3 the analysis of the meaning of the results and discussion of the survey findings are given.

4.4.1. Sample and Data Collection

The main study survey was conducted in 2018 via online distribution using the platform Survey Monkey. The survey details used can be found in Appendix E, with the adjustments made from lessons learned in the pretest survey. In total 140 invitations were distributed via email to representatives of organizations who met the criteria:

1. Geographically located in the United states or the Netherlands
2. Involvement in ICT projects either from the client or supplier perspective with a minimum experience of 2 years to ensure a basic understanding of the ICT industry and practices to fit the purpose of the main study survey

The sample size contained 140 invitations with 112 respondents, and a response rate of 80% (see Table 15). Of the responses, 15 were disqualified due to partial completion, leaving 97 surveys which met the validation requirements and were used for the statistical analysis. The detailed background information is represented in Table 16.

Table 15: Summary of Respondents

Survey Respondent Results	Final
Total # of Invitations	140
Total # of Responses Received	112
Response Rate	80%
# Disqualified	15
# of Qualified Responses	97
Weighted Average Years of Experience	16

The respondents of the survey gave a spread from multiple backgrounds including:

1. A greater number of responses from the Netherlands than the United States (32 respondents to 65 respondents respectively).
2. An even split between clients and suppliers (49 respondents to 48 respondents respectively).
3. Seven different functions, with varying responses: consultants with 28 respondents, project management with 18 respondents, procurement with 22 respondents, management with

11 respondents and sales and marketing with 16 respondents. The functions of academic and delivery only received one response each.

4. An average experience of 16 years with respondents from all defined age groupings including: 0 to 5 years with 15 respondents, 6 to 10 years with 21 respondents, 11 to 20 years with respondents 33 and 21+ years with 28 respondents.

Table 16: Background Information of Survey

Main Study Survey	Total
Respondents	97
Country	
Netherlands	65
United States	32
Role	
Client	49
Supplier	48
Function	
Consultant	28
Project Management	18
Procurement	22
Management	11
Sales and Marketing	16
Academic	1
Delivery (Development / Technical)	1
Years of Experience	
0 - 5 years	15
6 - 10 years	21
11 - 20 years	33
21+ years	28

The Kruskal Wallis test was used to determine if there were any statistically significant differences between two or more groups. The results of the Kruskal Wallis test are summarized in Table 17. All 22 factors were independently analyzed according to the country, role, function, and years' experience respectively, using the Kruskal Wallis (KW) test. The country was analyzed between the United States (US) and the Netherlands (NL). The role was analyzed between the client (CL) and supplier (SP). The function was analyzed between the consultant (CO), procurement (PR), management (MN), procurement (PO), project manager (PM), and sales and marketing (SM). The years' experience was analyzed between 0-5 years, 6-10 years, 11 -20 years and 21+ years. In Table 17 a summary of the statistically significant differences in populations was found in the identified Background Information with "/" representing a statistically significant difference was identified by the test between the two areas of background information, with blank cells representing no statistically significant difference was identified.

The background information of country, role and function were identified to have statistically significant differences in the respondents with respect to some of the project complexity factors. Due to the low frequency of identified biases in role and function, the results were considered acceptable to use the data. With respect to the background information of country there was a high frequency of factors detected with bias, 19 factors in the case of an expert and seven factors in the case of a nonexpert. The results indicate a general difference in opinion with respect to an expert and nonexpert's impact on the effect of project complexity factors on the project outcome. The difference in results could be attributed to the difference in the number of respondents, as the United States had half of the respondents than the Netherlands (32 to 65 respectively).

Based on the bias detected, the background information of country (Netherlands and United States) was tested individually using the Wilcoxon signed rank and stage 1 testing (explained in section 4.2.4). The results identified that the statistical differences did not change the results of the Wilcoxon signed rank test or the general conclusions drawn from the stage 1 testing. Based on these results, we found it acceptable to use the data for an overall analysis. Due to the aim of this research, it is not within this research scope to determine why each of the background information have a statistical difference, but it is sufficient for our needs to ensure the demographics do not significantly affect the survey conclusions. Further research is suggested to refine and understand the factors of complexity based on the specific background information.

Table 17: Kruskal Wallis Test Summary Results

	Country		Role		Function		Years of Experience	
Factor	Expert	Nonexpert	Expert	Nonexpert	Expert	Nonexpert	Expert	Nonexpert
1					CO / PR			
2	US/NL		CL/SP		SM / PR			
3	US/NL	US/NL						
4	US/NL	US/NL						
5	US/NL							
6	US/NL	US/NL						
7	US/NL							
8	US/NL							
9	US/NL							
10		US/NL						
11	US/NL							
12	US/NL	US/NL						
13	US/NL				MN / CO MN/ PM MN /SM			
14	US/NL					MN/ PR		
15		US/NL		CL/SP		PR/SM		
16	US/NL				CO / PR	SM/CO SM/PR		
17	US/NL			CL/SP		PR/PM		
18	US/NL							
19	US/NL							
20	US/NL							
21	US/NL	US/NL				PR/SM		
22	US/NL							

4.4.2. Survey Findings

A Wilcoxon signed-rank test showed that the expertise of the supplier elicits a statistically significant change in the likelihood to be a cause of low project outcomes in the case of all 22 project complexity factors (α of .05, p = 0.000), see Table 18, 19 and 20.

Table 18: Wilcoxon Signed Rank Test Results for Factors 1 – 8

Wilcoxon Signed Rank Test	1	2	3	4	5	6	7	8
Sum of positive ranks	29	254	71.5	12.5	10	11.5	64.5	8.5
Sum of negative ranks	3292	3401	3249.5	2913.5	2405	2334.5	3505.5	1476.5
N (excludes tie rankings)	81	85	81	76	69	68	84	54
Expected value	1661	1828	1661	1463	1208	1173	1785	743
Standard deviation	129	168	157	146	99	120	175	77
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 19: Wilcoxon Signed Rank Test Results for Factors 9 - 16

Wilcoxon Signed Rank Test	9	10	11	12	13	14	15	16
Sum of positive ranks	12	51.5	51.5	10.5	14.5	12	12	105.5
Sum of negative ranks	4083	3434.5	3188.5	2690.5	3225.5	3474	2616	2309.5
N (excludes tie rankings)	90	83	80	73	80	83	72	69
Expected value	2048	1743	1620	1351	1620	1743	1314	1208
Standard deviation	196	170	154	141	148	160	135	90
p-value (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 20: Wilcoxon Signed Rank Test Results for Factors 17-22

Wilcoxon Signed Rank Test	17	18	19	20	21	22
Sum of positive ranks	49.5	14	9	11.5	13	9
Sum of negative ranks	3691.5	3641	3231	3391.5	3390	3561
N (excludes tie rankings)	86	85	80	82	82	84
Expected value	1871	1828	1620	1702	1702	1785
Standard deviation	178	173	163	171	168	176
p-value (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000

To provide further understanding of the results of the Wilcoxon signed rank test, an analysis was done on the differential of the expert and nonexpert scores for each factor. The differential is calculated by subtracting the nonexpert situation score from the expert situation score (expert situation score – nonexpert situation score). Negative differential signifies the respondent scored the expert less likely to be a cause of low project outcomes than the nonexpert. Positive differential will signify the opposite and no differential will signify the respondent scored both situations the same and perceived there to be no significant impact due to expertise. The analysis gave the following results summarized in Table 21.

The frequency of negative differential amongst the 22 factors was a minimum of 55% (Factor 8) with a maximum of 92% (factor 9) and an average per factor of 79%. This would indicate that the majority of respondents per factor (55% to 92%) scored the likelihood of the project complexity factor to be a cause of low project outcomes higher in the case of a nonexpert than an expert. The frequency of no differential, per factor, was a minimum of 7% (Factor 9) with a maximum of 44% (Factor 8) and an average per factor of 19%. This would indicate that per factor, 7% to 44% of respondents perceived no significant difference between an expert and nonexpert situation. The frequency of positive differential amongst the 22 factors was a minimum of 1% with a maximum of 7% and an average per factor of 2%.

Table 21: Overview of Respondent Frequency of Score Differential

Difference (Expert - Nonexpert)	Min	Max	Avg	1	2	3	4	5	6	7	8	9	10	11
Negative Differential	55%	92%	79%	81%	80%	81%	77%	70%	69%	85%	55%	92%	84%	80%
No Differential	7%	44%	19%	16%	12%	16%	22%	29%	30%	13%	44%	7%	14%	18%
Positive Differential	1%	7%	2%	2%	7%	2%	1%	1%	1%	2%	1%	1%	2%	2%
Difference (Expert - Nonexpert)				12	13	14	15	16	17	18	19	20	21	22
Negative Differential				74%	81%	85%	73%	67%	87%	87%	81%	84%	84%	86%
No Differential				25%	18%	14%	26%	29%	11%	12%	18%	15%	15%	13%
Positive Differential				1%	1%	1%	1%	4%	2%	1%	1%	1%	1%	1%

The magnitude of the negative differential scores varied from a negative differential of one to four (see Table 22). The frequency of a negative differential of four, per factor, had a minimum of 11% and a maximum of 25% and an average of 17%. The frequency of a negative differential of three, per factor, had a minimum of 5% and a maximum of 25% and an average of 15%. The frequency of a negative differential of two, per factor, had a minimum of 16% and a maximum of 33% and an average of 24%. The frequency of a negative differential of one, per factor, had a minimum of 15% and a maximum of 28% and an average of 22%. In general, amongst the negative differential scores, the magnitude of one and two were greater than three and four, with the average amongst factors of 22%, 24%, 15%, and 17% respectively.

The magnitude of the positive differential scores varied from a positive differential of one to three, there were no factors which respondents scored a positive differential of four. The frequency of a positive differential of three, per factor, had a minimum of 0% and a maximum of 1% and an average of 0%. The frequency of a positive differential of two, per factor, had a minimum of 0% and a maximum of 4% and an average of 0%. The frequency of a positive differential of one, per factor, had a minimum of 1% and a maximum of 2% and an average of 1%. In general, amongst the negative differential scores, the magnitude of one and two were greater than three and four, with the average amongst factors of 22%, 24%, 15%, and 17% respectively.

Table 22: Detailed Respondent Frequency of Score Differential

Differential (Expert - Nonexpert)	Min	Max	Avg	1	2	3	4	5	6	7	8	9	10	11
-4	11%	25%	17%	12%	11%	14%	16%	13%	12%	25%	12%	20%	18%	18%
-3	5%	25%	15%	9%	21%	15%	13%	7%	12%	16%	5%	25%	20%	12%
-2	16%	33%	24%	33%	23%	29%	24%	31%	23%	20%	22%	25%	20%	26%
-1	15%	28%	22%	27%	26%	23%	24%	19%	22%	24%	15%	23%	27%	25%
0	7%	44%	19%	16%	12%	16%	22%	29%	30%	13%	44%	7%	14%	18%
1	1%	2%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%
2	0%	4%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	1%	1%
3	0%	1%	0%	0%	1%	1%	0%	0%	0%	1%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Differential (Expert - Nonexpert)				12	13	14	15	16	17	18	19	20	21	22
-4				19%	16%	15%	11%	11%	24%	24%	23%	20%	22%	24%
-3				13%	11%	15%	19%	8%	14%	13%	24%	19%	21%	21%
-2				23%	26%	31%	21%	32%	25%	23%	19%	24%	16%	25%
-1				20%	28%	23%	23%	15%	24%	27%	16%	22%	25%	16%
0				25%	18%	14%	26%	29%	11%	12%	18%	15%	15%	13%
1				1%	1%	1%	1%	2%	1%	1%	1%	1%	1%	1%
2				0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%
3				0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
4				0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Next, an analysis was done on the distribution of scores for each factor in the situation of an expert and nonexpert.

In the case of an expert, the frequency per factor to score likely or extremely likely range from 6% to 43% with an average of 20%. The frequency per factor to score unlikely or extremely unlikely range from 39% to 71% with an average of 58%. The frequency per factor to score neutral range from 7% to 39% with an average of 22%. In the case of an expert the range for unlikely or extremely unlikely are greater than the ranges for likely or extremely likely. The distribution of the magnitude of scores was examined to find that in a situation with an expert (see Table 23):

1. The frequency per factor to give an extremely unlikely score was a minimum of 13% (factor 15) with a maximum of 37% (factor 18) and an average per factor of 25%.
2. The frequency per factor to give an unlikely score was a minimum of 26% (factor 6 and 8) with a maximum of 40% (factor 3, 9 and 11) and an average per factor of 33%.
3. The frequency per factor to give a likely score was a minimum of 6% (factors 12) with a maximum of 29% (factor 15) and an average of 16%.
4. The frequency per factor to give an extremely likely score was a minimum of 0% (factor 8, 9, 11, 12, 13, and 18) with a maximum of 14% (factor 15) and an average per factor of 3%.

Table 23: Frequency of Scoring in Expert Situation

Expert Situation	Avg	1	2	3	4	5	6	7	8	9	10	11
Extremely Unlikely	25%	15%	34%	23%	23%	18%	13%	34%	27%	26%	20%	30%
Unlikely	33%	32%	37%	40%	30%	31%	26%	33%	26%	40%	30%	40%
Neutral	22%	20%	7%	26%	31%	19%	28%	19%	39%	16%	18%	23%
Likely	16%	28%	20%	10%	15%	27%	26%	13%	8%	18%	26%	7%
Extremely Likely	3%	5%	2%	1%	1%	6%	7%	1%	0%	0%	7%	0%
Expert Situation		12	13	14	15	16	17	18	19	20	21	22
Extremely Unlikely		32%	26%	16%	13%	25%	30%	37%	32%	24%	30%	29%
Unlikely		32%	37%	35%	31%	29%	33%	32%	32%	34%	33%	38%
Neutral		30%	22%	25%	12%	22%	23%	19%	24%	24%	26%	14%
Likely		6%	15%	22%	29%	18%	11%	12%	8%	16%	10%	16%
Extremely Likely		0%	0%	2%	14%	7%	3%	0%	4%	2%	1%	2%

In the case of a nonexpert, the frequency per factor to score likely or extremely likely range from 45% to 97% with an average of 81%. The frequency per factor to score unlikely or extremely unlikely range from 0% to 19% with an average of 3%. The frequency per factor to score neutral range from 3% to 44% with an average of 16%. In the case of a nonexpert the range for likely or extremely likely are greater than the ranges for unlikely or extremely unlikely. The distribution of the magnitude of scores was examined to find that in a situation with a nonexpert (see Table 24):

1. The frequency per factor to give an extremely unlikely score was a minimum of 0% (factor 3 to 6, 9, 11, 13 to 15, 17, and 19 to 22) with a maximum of 4% (factor 2) and an average per factor of 1%.

2. The frequency per factor to give an unlikely score was a minimum of 0% (factor 4 to 6, 10, 14, 15, 17 and 22) with a maximum of 14% (factor 2) and an average per factor of 3%.
3. The frequency per factor to give a likely score was a minimum of 23% (factors 10) with a maximum of 47% (factor 5 and 11) and an average of 35%.
4. The frequency per factor to give an extremely likely score was a minimum of 19% (factor 8) with a maximum of 71% (factor 10) and an average per factor of 45%.

Table 24: Frequency of Scoring in Nonexpert Situation

Nonexpert Situation	Avg	1	2	3	4	5	6	7	8	9	10	11
Extremely Unlikely	1%	1%	4%	0%	0%	0%	0%	1%	2%	0%	1%	0%
Unlikely	3%	1%	14%	2%	0%	0%	0%	4%	8%	2%	0%	5%
Neutral	16%	5%	11%	27%	18%	12%	11%	15%	44%	4%	5%	25%
Likely	35%	39%	34%	33%	46%	47%	37%	31%	27%	36%	23%	47%
Extremely Likely	45%	54%	36%	38%	36%	40%	52%	48%	19%	58%	71%	23%
Nonexpert Situation		12	13	14	15	16	17	18	19	20	21	22
Extremely Unlikely		1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%
Unlikely		4%	2%	0%	0%	5%	0%	3%	3%	1%	1%	0%
Neutral		31%	27%	6%	3%	26%	15%	22%	12%	14%	15%	8%
Likely		33%	35%	38%	30%	33%	36%	31%	31%	27%	41%	37%
Extremely Likely		31%	36%	56%	67%	35%	48%	43%	54%	58%	42%	55%

The factors were then analyzed by the experts and nonexpert's median, mode, and mean scores. The following findings are summarized in Table 25.

The scores for the median, mode and mean of an expert in the case of all 22 factors, with an N of 97, range from 2 to 3, 1 to 3, and 2.06 to 3.00 respectively. The scores for the median, mode and mean of a nonexpert in the case of all 22 factors, with an N of 97, range from 4 to 5, 4 to 5, and 3.84 to 4.64 respectively.

We examined scores for the median, mode and mean of an expert and identified that the majority were scores below three. It was beneficial to focus on the top scores rather than the lower scores to understand the reasoning for the deviation from the majority. The expert's top scores for the median, mode and mean were more frequently associated with factors which related to the project stakeholders. In the case of the median and mode, the highest score is a three (neutral), five factors have a median score of three and three factors have a mode score of three. Three of the five top scores for the median are stakeholder factors and all three top scores for the mode are stakeholder factors. With respect to the mean scores for an expert, three of the top five scores were stakeholder factors. This would indicate that five out of the 8 stakeholder related factors are within the top scores of the median, mode and/or mean and two of the 14 scope related factors are within the top scores for the mode and mean.

We examined scores for the median, mode and mean of a nonexpert and identified that the majority were higher scores, above four. It was beneficial to focus on the lower scores rather than the higher scores to understand the reasoning for the deviation from the majority. The nonexpert's lowest scores for the median, mode and mean were identified in the majority of factors which related to the project stakeholders. The frequency of the lowest scores were relatively split evenly amongst project stakeholder and scope related factors.

In the case of the factors related to the project stakeholders, six out of eight of the factors were within the lowest scores for the median, mode and/or mean. With respect to the lowest scores of the median, there was one factor to score three and 12 factors to score a four. Six of the eight stakeholder related factors had the lowest scores of the median, one of which had the median score of three. With respect to the lowest scores of the mode, there was one factor to score three and four factors to score four. Three of the five lowest mode scores were factors which related to the project stakeholder, one of which had a mode score of three. With respect to the mean scores, two of the top five lowest mean scores were stakeholder related.

Table 25: Analysis of Scores Prioritized by Median, Mode and Mean

		Expert Scores			Nonexpert Scores		
Factor #		Median	Mode	Mean	Median	Mode	Mean
1	Project Stakeholder	3*	2	2.75*	5	5	4.43
2		2	2	2.19	4**	5	3.84**
3		2	2	2.27	4**	5	4.07
4		2	3*	2.42	4**	4**	4.19
5		3*	2	2.73*	4**	4**	4.28
6		3*	3*	2.88*	5	5	4.40
7		2	1	2.14	4**	5	4.22
8		2	3*	2.29	3**	3**	3.52**
9	Project Scope	2	2	2.26	5	5	4.50*
10		3*	2	2.71*	5	5	4.63*
11		2	2	2.07	4**	4**	3.88**
12		2	1	2.10	4**	4**	3.89**
13		2	2	2.27	4**	5	4.05
14		2	2	2.58	5	5	4.50*
15		3*	2	3.00*	5	5	4.64*
16		2	2	2.54	4**	5	3.96**
17		2	2	2.25	4**	5	4.33
18		2	1	2.06	4**	5	4.12
19		2	1	2.21	5	5	4.35
20		2	2	2.39	5	5	4.41
21		2	2	2.20	4**	5	4.25
22		2	2	2.25	5	5	4.46*

*Factor that scored among the top scores (top five for the mean scores).

** Factor that scored among the lowest scores (bottom five lowest scores for mean scores).

Lastly, the 22 factors were then analyzed using an exploratory factor analysis (EFA). The KMO and Bartlett's Test used as supportive statistical tests to identify sampling adequacy. The KMO value was 0.823 and the Bartlett's Test was significant with a $\chi2=3125.036$ (p-value < .000). The communalities scores for the initial all scored 1.000 and the extraction all scored high (≥ 0.5). These tests provided suitable justification to use an EFA.

Among the 22 factors, a total of 9 components were identified from a principal component analysis with varimax rotation. The eigen values of the 9 factors were all greater than one and accounted for 70.095% of the total variance. The first principal component reported the largest part of the total variance with an eigen value of 14.982 totaling to 34.051% of the total variance. The second principal component reported the second largest part of the total variance with an eigen value of 4.867 accounting for 11.061% of the total variance. Subsequent components three to nine had relatively low eigen values of 2.438, 1.989, 1.540, 1.494, 1.246, 1.163, and 1.124 respectively accounting for 5.540, 4.520, 3.500, 3.396, 2.831, 2.643, and 2.554.

Table 26 shows the nine project complexity components which affect project outcomes with factor loadings ranging from 0.535 and 0.870. There were 18 factors measuring component 1 with factor loadings ranging from 0.535 to 0.816. Component 2 was measured with six factors with factor loadings ranging from 0.583 to 0.693. Component 3 was measured with 5 factors with factor loadings ranging from 0.549 to 0.870. Component 4 was measured with 2 factors with factor loadings of 0.618 and 0.677. Component 5 was measured with 4 factors with factor loadings ranging from 0.555 to 0.684. Component 6 was measured with 1 factor with a factor loading of 0.796. Component 7 was measured with 2 factors with factor loadings of 0.762 and 0.583. Component 8 was measured with 2 factors with factor loadings of 0.761 and 0.641. Component 9 was measured with one factor with a factor loading of 0.734. Three factors were not found to have factor loadings sufficient to be included within a component.

Table 26: Project Complexity Factors Effecting Project Outcomes (Factor Loadings)

	Components								
	1	2	3	4	5	6	7	8	9
E-18	0.816								
E-9	0.810								
E-17	0.809								
E-4	0.794								
E-22	0.780								
E-13	0.769								
E-19	0.764								
E-7	0.740								
E-21	0.725								
E-11	0.713								
E-20	0.705								
E-12	0.672								
E-5	0.666								
E-3	0.645								
E-8	0.629								
E-14	0.618								
E-6	0.586								
E-16	0.535								
NE-13		0.693							
NE-5		0.664							
NE-12		0.660							
NE-8		0.638							
NE-4		0.606							
NE-11		0.583							
NE-20			0.870						
NE-19			0.829						
NE-22			0.735						
NE-21			0.711						
NE-18			0.549						
E-15				0.677					
E-10				0.618					
NE-7					0.684				
NE-17					0.624				
NE-15					0.56				
NE-6					0.555				
E-2						0.796			
NE-1							0.762		
NE-14							0.583		
NE-2								0.761	
NE-10								0.641	
NE-16									0.734

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 11 iterations. (Excludes Expert factor 1 and Nonexpert factor 3 and 9 due to no significant loadings

4.4.3. Analysis and Discussion

The survey research findings are intended to answer the third research question (SRQ3): 'How does supplier expertise influence the effect of project complexity factors on project outcomes?' This section will address the survey findings, which answers SRQ3, and other implications of the findings.

The Influence of Expertise on the Effect of Project Complexity Factors on Project Outcomes

The respondents were asked to answer the survey questions and rate each of the 22 project complexity factors' likelihood to be a cause of low project outcomes. Specifically, two situations are sketched out: situation 1 when the supplier performing the project is an expert and in contrast situation, 2 when the supplier is a nonexpert. We used a 5-point Likert scale to rate each factor. The scale ranged from 1 = Extremely Unlikely, 2 = Unlikely, 3 = Neutral, 4 = Likely, and 5 = Extremely Likely.

Wilcoxon signed rank test and analysis of the frequency of the differential of scores

The Wilcoxon signed rank test results indicated a statistically significant difference between the respondents' scoring of the two situations. Based on these findings there is statistical support that respondents perceive that an expert or nonexpert supplier will influence the effect that each of the 22 project complexity factors have on project outcomes. The results of the Wilcoxon signed rank test did not show the direction of the difference (positive or negative) or the magnitude of the difference.

To provide further understanding of the results of the Wilcoxon signed rank test, we conducted an analysis on the differential of the expert and nonexpert scores for each factor. The differential is calculated by subtracting the nonexpert situation score from the expert situation score (expert situation score – nonexpert situation score). The frequency of zero differential (no differential) ranged from 7% to 44%. There were six factors with a frequency of zero differential above 20%, the remaining 16 factors had a frequency of zero differential equal to or below 18% (see Table 27). The minority of respondents perceived project complexity factors to be equally likely to be a cause of low project outcomes with a nonexpert or expert. The resulting frequencies of zero differential is consistent with the Wilcoxon signed rank test results, supporting the claim that expertise has an influence on the effect of the 22 project complexity factors on the project outcome.

Table 27: Range of Frequency of Zero Differential

Range of Frequency of Zero Differential	# of Factors
Between 20% and 44%	6
Less than 18%	16

The frequency of positive differential scores and negative differential scores assisted in determining if the influence of expertise would increase or decrease the effect that project complexity factors have on project outcomes. It is reasonable to assume that by definition, the expert has a greater amount of expertise than a nonexpert. Therefore, negative differential would indicate that expertise decreases the effect and positive differential would indicate that expertise increases the effect.

The frequency of positive differential ranged from 1% to 7%. There were two factors which had frequency of positive differential greater than 2%, the remaining 20 factors had a frequency of less than 2% (see Table 28). Based on these results the minority of respondents perceived a project complexity factor to be more likely to be a cause of low project outcomes with an expert, than with a nonexpert. Due to the low frequency of positive differential, the magnitudes of the positive differential are inconsequential. The resulting frequencies of positive differential would reject the claim that expertise increases the effect of that the 22 project complexity factors have on project outcomes.

Table 28: Range of Frequency of Positive Differential

Range of Frequency of Positive Differential	# of Factors
Between 2% and 7%	2
Less than 2%	20

The frequency of negative differential ranged from 55% to 81%. There were three factors with a negative differential below 70%, the remaining 19 factors had a negative frequency equal to or above 70% (see Table 29). Based on these results the majority of respondents (in the case of most factors above 70%) perceived a project complexity factor to be more likely to be a cause of low project outcomes with a nonexpert than with an expert. The resulting frequencies of negative differential would support the claim that expertise decreases the effect that the 22 project complexity factors have on project outcomes.

Table 29: Range of Frequency of Negative Differential

Range of Frequency of Negative Differential	# of Factors
Between 70% and 81%	19
Between 55% and 70%	3

The strength of this claim can be analyzed through the magnitude of the negative differential. The magnitude of the negative differentials ranged from one to four, four signifying the greatest difference between the expert and nonexpert. Based on the results of the analysis of the magnitude of negative differentials, the magnitude of one and two were greater than three and four for most cases, with the average amongst factors of 22%, 24%, 15%, and 17% respectively.

To give context, the ratings are based on an ordinal scale, the differences between the ordinal ratings are not necessarily equal. The difference between extremely likely (5) and likely (4), is not necessary the same as neutral (3) and likely (4), even though they both have a numeric difference of one. Similarly, the difference between neutral (3) and extremely likely (5), is not necessary the same as likely (4) and unlikely (2), even though they both have a numeric difference of two. The magnitude of the differential represents, to some degree, the respondents felt the expert or nonexpert (depending on the factor) was more likely to have low project outcomes due to that factor. The differential if extreme can add significant insight, for instance the differential in negative four would require complete opposite scores, extremely likely (5) and extremely unlikely (1). The differential if less than negative four is difficult to interpret due to the ordinal scale. We argue that based on the ordinal scale, the difference in magnitudes are not extreme enough to strengthen or weaken the initial claim that expertise reduces the effect that the 22 project complexity factors have on project outcomes.

Analysis of the frequency of scoring for the expert and nonexpert

The nonexpert maximum factor's frequency score of extremely unlikely and unlikely are respectively 1% above and 22% below the minimum factor's frequency score for an expert. In an expert situation the maximum factor's frequency score of extremely likely and likely are respectively 5% below and 2% above the minimum factor's frequency score for a nonexpert (see Table 30). Based on these results the majority of respondents perceived a project complexity factor to be more likely to be a cause of low project outcomes with a nonexpert than with an expert.

Table 30: Ranges of Frequency Scores of Nonexpert and Expert

Range of the Frequency of Scores	Nonexpert	Expert
Extremely Unlikely	0% to 14%	13% to 34%
Unlikely	0% to 4%	26% to 40%
Likely	27% to 47%	6% to 29%
Extremely Likely	19% to 71%	0% to 14%

<u>Analysis of the median, mode and mean scores of the expert and nonexpert</u>

The expert's median, mode and mean scores fall within the ranges of 1 to 3 which is extremely unlikely (1), unlikely (2) and neutral (3). The nonexperts median and mode scores fall within the ranges of 4 to 5 which is likely (4) and extremely likely (5) and the mean falls within 3.52 to 4.64 which is above neutral (3) (see Table 31). Based on these results the majority of respondents perceived a project complexity factor to be more likely to be a cause of low project outcomes with a nonexpert than with an expert. In other words, it supports the claim that expertise reduces the effect that project complexity factors have on project outcomes.

Table 31: Ranges of the Median, Mode and Mean Scores for the Nonexpert and Expert

Ranges	Nonexpert	Expert
Median	4 to 5	2 to 3
Mode	4 to 5	1 to 3
Mean	3.52 to 4.64	2.06 to 3.00

Based on the findings of the main study survey, we conclude that expertise reduces the effect that project complexity factors have on project outcomes.

Identification of Underlying Project Complexity Factors Effecting Project Outcomes.

The Exploratory Factor Analysis (EFA) factor loadings identified nine components within the 22 project complexity factors. The EFA results did not provide sufficient evidence to draw contributing insight into the research. Future research can be done (see section 7.4) to improve the analysis inclusive of a greater sample size and specific literature analysis to identify the initial list of factors which have been determined to effect project outcomes.

The expert factors were grouped into three components with factor 1: Lack of senior management support, not included within a component. Component 1 was measured by 18 of the factors. Component 4 was measured by two factors, factor 10: the client's requirement is poorly defined and factor 15 a client with unrealistic goals. Lastly Component 6 was measured by factor 2: Appropriate authority and accountability. It could be argued that factor 10 and 15 are measuring the client's scope description in terms of the goals and requirements. As the majority of factors show no differentiation amongst components there is insufficient evidence to identify implications of results. The lack of differentiation could suggest that for an expert there is little difference in the factors as they are all equally affecting or not affecting the project outcomes.

The nonexpert factors were grouped into six components. Component 9 was measured through one factor, factor 16: the project's alignment with the business goals and interests. As there was only one factor component 9 did not add new insight into the factors. Component 3 was not surprising as all technology related factors were grouped together inclusive of factors 18 to 22. Technology factors related to the difficulty, integration, newness/novelty, diversity, and continuous change. Component 7 and 8 were each measured through two factors. In both cases the two factors do not seem to have a relation, additional factors may allow for a greater grouping of factors by which a pattern can be established. For instance, component 8 included the factors: "Appropriate authority and accountability" and "the client's project requirement is poorly defined". Component 2 and component 5 had a loading of six and four factors respectively. Due to the diversity of factors there was insufficient evidence to draw any conclusions which would add to the existing research.

The EFA was able to distinguish component 3 as technology, component 9 as factor 16: the project's alignment with the business goals and interests and component 4 as a realistic and defined client requirement/goal. The remaining six components did not provide sufficient evidence to establish clear constructs. Further research is required to identify clear constructs of project complexity factors which affect project outcomes.

Implications of Survey Findings

The findings of the survey strengthen Proposition 1 and adjusts Proposition 2 identified from the case study findings (Chapter 3) and leads to two new propositions that relate to expertise and ICT project complexity factors.

<u>Proposition 1: Expertise reduces the effect of project complexity on the project outcome.</u>

The survey findings identified that expertise reduces the effect that project complexity factors have on project outcomes. Project complexity for our research is explained to be the "difficulty in delivering a project" (Vidal et al., 2011; Tie & Booluijt, 2014; Xia & Chan, 2012). In order to measure project complexity, it is common practice in project complexity research to identify project factors (Azim et al., 2010; Qing-hua et al., 2012; Qureshi & Kang, 2014; Vidal et al., 2011; Xia & Chan, 2012). Based on the common practice of measuring project complexity through defined factors, we argue that it is reasonable to assume if expertise reduces "the effect" of project complexity factors it may consequentially reduce the effect of project complexity. The survey findings strengthen Proposition 1 in which we argue that expertise reduces the effect of ICT project complexity on project outcomes (Section 3.4.3).

<u>Proposition 2: Experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex.</u>

Based on the expert's frequency of scores, the minority of respondents (less than 50%) perceive the 22 factors to be a cause of low project outcomes with an expert (likely and extremely likely). In contrast, the majority of respondents (more than 50%) perceive 17 of the 22 factors to not be a cause of low project outcomes with an expert (unlikely and extremely unlikely). In the case of the remaining five of 22 factors, the scores of unlikely and extremely unlikely are similar or greater than their counterpart scores of likely and extremely likely. For instance, factor one, lack of senior management support, has an unlikely frequency score of 32% and likely frequency score of 28%. Similarly, factor one (Lack of senior management support) has an extremely unlikely frequency score of 15% and an extremely likely frequency score of 5%.

Based on the nonexpert's frequency scores, the majority of respondents (more than 50% per factor) perceive the 22 factors to be a cause of low project outcomes with an expert (likely and extremely likely). These results are supported by the ranges of the median, mode and mean being greater than 3 (neutral). It is reasonable to assume that the majority of respondents perceive that nonexperts will experience poor project outcomes due to these factors. We argue that if a supplier is unable to deliver a project on time, on budget and with a satisfied client that it recursively proves the project delivery was difficult for the supplier. Based on the findings we adjust Proposition 2 and argue that experts do not perceive projects as complex while nonexperts perceive projects as complex.

<u>Proposition 3: Expert's challenges that relate to project complexity factors, correspond to project stakeholder factors.</u>

The analysis of the top factor scores based on the median, mode and mean of an expert, were identified to be associated with stakeholder related factors. The top factor scores for median and mode were factors with a score of 3 and the top factors for the mean were the top five highest prioritized scores. This would indicate that five out of the eight stakeholder related factors are within the top scores of the median, mode and/or mean. There were two out of the

14 scope related factors which ranked among the top scores for the median and mean. Based on the findings, we provide the proposition that an expert's challenges that relate to project complexity factors correspond to project stakeholder factors. Literature has identified priority of importance to project complexity factors (Kermanshachi et al., 2016; Xia & Chan 2012). In previous prioritizations, a distinction or relation to the expertise of the individual was not established. Kermanshachi et al. (2016) prioritized nine project complexity factors with no distinction between situations with an expert and nonexpert. For instance, the top two prioritized factors were scope related including the number of participants on the project and scope definition, and the third was related to the stakeholders, availability of resources. In cases of an expert or nonexpert the prioritization of factors may change which may cause stakeholder related factors to be prioritized over scope related factors. Xia and Chan (2012) identified 18 project complexity factors of which the top four factors were scope related including the building structure, construction method, the project schedule, project size, and geological conditions. Tatikonda and Rosenthal (2000) modeled project complexity with 16 factors which were all scope related factors. Based on the new insights from the proposition, we argue that adjustments are required for previous prioritizations (Kermanshachi et al., 2016; Tatikonda & Rosenthal, 2000; Xia & Chan 2012).

Proposition 4: Nonexpert's challenges that relate to project complexity factors correspond to project scope factors.

In contrast to Proposition 3, the analysis of the lowest factor scores for the median, mode and mean of a nonexpert were identified to be associated with the stakeholder related factors. Of the factors relating to the project stakeholders, six out of eight were within the lowest scores for the median, mode and/or mean. In context, the range of median, mode and mean scores of a nonexpert are almost all above 3 (neutral), so the nonexpert is perceived to have a challenge with all 22 factors. The concentration of lowest scores indicates that the scope related factors may be more of a challenge than the stakeholder factors. Based on the lowest scores, we provide the Proposition 4 that nonexpert's challenges that relate to project complexity factors correspond to the project scope factors. Similar to the findings of Proposition 3, we argue that adjustments are required to previous prioritizations which differentiates between expert and nonexpert situations (Kermanshachi et al., 2016; Tatikonda & Rosenthal, 2000).

4.5. Conclusion

This Chapter reviewed the results of the main study conducted in 2018 through the platform Survey Monkey. The main study was completed by 97 ICT practitioners. The survey responses were analyzed by the Wilcoxon signed rank test, the frequency of scores, frequency of the differential of scores and the ranges of the median, mode, and mean. Lastly, the survey responses were analyzed through an exploratory factor analysis.

First, the findings identified that the effect on the project outcomes of all 22 project complexity factors are impacted by having an expert or nonexpert supplier. Secondly, the findings identified that the factors are more likely to be a cause of low project outcomes in a situation with a nonexpert than with an expert. Third, the findings revealed that the respondents perceived the project complexity factors to be a cause of low project outcomes with a nonexpert. In contrast they identified the project complexity factors to not be a cause of low project outcomes with an expert. Fourth, the findings showed that in the situation with an expert, the project appears to have a greater difficulty with stakeholder related factors than scope related factors. In contrast the findings showed that in the situation with nonexpert, the project appears to experience low project outcomes with all factors. The findings reveal nonexperts may experience poor project outcomes due to project complexity factors relating to project stakeholders less frequently than with scope related factors. Lastly, the exploratory factor analysis results were inconclusive based on the initial results.

This chapter has answered the third research question: ‘How does supplier expertise influence the effect of project complexity factors on project outcomes?’

5. Interview Research

5.1. Introduction

This chapter elaborates on the research findings as identified in Chapter 3 and 4 to gain context and insights into each finding through interview research. As such, we contribute to the main research question: 'Can supplier expertise impact the effect of ICT project complexity on project outcomes?' First, Section 5.2 will discuss the methodology as applied including interviewee selection, data collection and data analysis. Next, in Section 5.3 the interview findings are discussed. Lastly, Section 5.4 provides the conclusion.

5.2. Interview Methodology

5.2.1. Interviewee Selection

We conducted interviews with 15 practitioners of ICT projects to elaborate on research findings. Three criteria were used to determine eligibility. The first criterion is background information. To avoid bias caused by background information, a wide range of practitioners was included using similar background information as used in our survey including country (US and NL), position or role (client or supplier) and function (procurement, sales, management, consultant, and project management), see Section 4.2.2. The selected background information is aligned with our goal to elaborate the findings obtained through the case study and survey research. The ICT participants and their respective background is listed in Appendix F. The second criterion to select participants was a minimum of five years of experience. The interviews are qualitative in nature which required a certain depth from the participant. The interviewees would need to provide context to our findings through examples they have either seen or experienced themselves. Five years was determined as sufficient time to accumulate a foundation of experiences to support the interviewees responses. The third criterion is that the interview candidates drew from the non-responders of the survey sample frame to ensure independent, unbiased results.

5.2.2. Interview Data Collection and Analysis

All interviews were conducted via video conferencing due to the geographical location of the participants in the period of October and November of 2018. Interviews varied from 25 to 50 minutes in length and we used a semi structured design. Applying a semi-structed interview method as a research instrument allowed us to elaborate on the findings through probing and discussion. The primary objective of the interviews was to elaborate on the research findings. We conducted a semi-structured interview with open ended topics to explore different views and opinions as they arose. The research propositions one to four were selected as the discussion topics as we identified them to summarize the key findings of the case study and survey research.

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.
- Proposition 2: Experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex.
- Proposition 3: Expert's challenges that relate to project complexity factors correspond to project stakeholder factors.
- Proposition 4: Non-Expert's challenges that relate to project complexity factors correspond to project scope factors.

All interviews were recorded for reference purposes to ensure accuracy and reliability. Any discrepancies from field notes or memory are verified through this recorded direct dialogue from the interviewees. All interview notes and recordings were included in an interview database which consists of interviewee information, interview protocol, and analysis. The survey protocol was sent to all interviewees prior to being interviewed. The protocol contains background and purpose of the research, instructions to the interviewee and the four research findings to be discussed (see Appendix G).

After the completion of all interviews, the recordings were then analyzed based on the interviewees' responses. When conducting qualitative research coding data is a crucial part of analysis (Nueman, 2000). In analyzing the recordings, we used the method of categorized subjects (Miles & Huberman, 1994). Based on the interviews, we categorized the data by reoccurring patterns or themes. Due to the limited number, depth and the qualitative nature of interviews, the responses were not intended to conclude the exact level of agreement with each finding. Instead, through three researchers, the responses of each interviewee were categorized to provide greater context to the research and to help understand the case study and survey research findings.

Three researchers coded and categorized the interviewee data independently in two rounds: (1) categorized transcripts into major themes (2) categorized transcripts into specific areas which supported the major themes. Next, the researchers compared and integrated their results into one comprehensive set of three major themes including:

1. Experts understand the project (5.3.1)
2. Limitation of an expert's influence (5.3.2)
3. Nonexperts have a challenge with scope and stakeholder factors (5.3.3)

Although the validity of the interpretative research is difficult to quantify, extracts were used to allow the reader to determine the validity of the specific areas within those themes identified in our research. The specific areas within each theme are supported by the quotations taken from the transcripts.

5.3. Interview Findings

After the interviews were conducted the discussions were analyzed and categorized based on the key elaborations to the research findings. There were three key elaborations to the propositions identified through this process. The first key finding, 'experts understand the project' elaborates on proposition one and two. The second key finding, 'limitations of an expert's influence' elaborates on Proposition 3. Lastly, the third key finding, 'nonexpert's have a challenge with scope and stakeholder related factors' elaborates on Proposition 4. Each key elaboration is described in Section 5.3.1 to 5.3.3 and supported by examples and excerpts taken from the interviews.

5.3.1. Experts Understand the Project

The interviews identified that a key characteristic to an expert is that they understand the project. The understanding allows the expert to know how to manage and execute the project and have sufficient capability to properly do it. Participants found it difficult to provide reasoning beyond this concept.

'Because they know what to do. Yes, it is hard to explain because if you have the expertise you know what to do… you just know that this is the way to go and you know that something isn't complex.' (Interviewee R13).

Interviewees identify a connection between the individual's understanding of the project and the project's perceived complexity. Experts who understand the project, do not see it as complex, in contrast they perceived nonexperts who do not understand the project to see it as complex.

'If you're an expert, then things are not complex at all. That's because you have an overview of the total situation. If that's one of the findings, I'm not surprised.' (Interviewee R12). 'I can definitely see where an expert is going to look at that ICT project and see it as noncomplex because that is what they do, they know how to do it, they can look at it and understand it.' (Interviewee R3).

Experts were identified to understand the project based on past experience. The experience is gained due to performing similar projects, lessons learned and repeated actions. The past experience of an expert allows them to reduce the amount of times they are ever surprised.

'I would say an expert would always see the project as simple because they have done it, they know what it takes to do it, and they know where the pitfalls are, so they have already avoided it a bunch of times and it's so easy to avoid it again' (Interviewee R1). 'I think the things they view as complex are things, they have less experience... If they did have more similar situations that weren't new, by in large it would not be complex.' (Interviewee R4).

One interviewee gave an example of cycling in the city of Amsterdam to explain his logic. If you cycled every day you find it normal and noncomplex. In contrast if you are visitor and rent a bicycle for the first time and ride around Amsterdam, the ride would be quite complex. Similarly, the interviewee referred his example to his job description.

'I don't think I do a difficult job. But our clients still hire our company to help them with these projects because they say, we need help because it is very complex. And we say it's everyday work, this is what we are good at and this is why we come in and help' (Interviewee R10).

There was disagreement by two of the interviewees with Proposition 2, regarding the complexity of a project being related to the expertise of the supplier. The interviewees separated the complexity of a project from the individual. Regardless of the understanding of a supplier, the project's defining nature of complexity would be in the project not the individual. Schlindwein and Ison (2004), described these two views as descriptive and perceived complexity. Although the interviewees differed in the defining nature of the complexity of a project, they agreed with the other interviewees, that expertise reduces the effect of project complexity on the project outcomes.

'I don't know if it reduces the complexity, but it certainly makes it less of a factor.' (Interviewee R6). I wouldn't say expertise necessarily reduces that complexity, but it makes it easier to function (Interviewee R5).

The reasoning given as to what allows an expert to reduce the effect of project complexity on project outcomes was their expertise. Experts are able to look into the future and see what it is going to look like before it happens, they can actually plan the project from end to end and explain it in understandable terms to someone without their level of expertise. They are able to anticipate what is going to happen, which allows them to manage and mitigate risk more successfully.

'…if you haven't done it before there are going to be surprises and the more projects you have done, it is easier to anticipate those surprises. Even if it is something completely new…' (Interviewee R7)

These motivations correspond to project team factors as identified in the literature including the factors: Planning and scheduling (Azim et al, 2010), risk management, (Geraldi et al, 2011), and team cooperation and communication (Qureshi & Kang, 2015; Vidal et al., 2008; Vidal et al., 2011).

One interviewee described this in terms of his organization becoming an expert supplier. An organization's employees are trained by experience to avoid specific problems. If these specific problems recurrently happen, management becomes aware of the problems. When necessary, management can then train all employees how to avoid the problem without the employees having to experience it firsthand. Organizations with this approach can leverage the experience of experienced employees to allow all projects to work like "clockwork".

Interviewees compared the contrast between experts and nonexperts within the same field or project to emphasize the difference between an expert and nonexpert. The nonexpert was identified to have the opposite effect of an expert. Nonexperts who don't understand how to manage and execute a project increase the effect of complexity because they add to the degree and possibly cause the complexity.

'If I were to go in and say this is what you are going to do, and this is how you are going to do it, I don't actually understand all the backend relational complexities that could be there, so then I'm making it inherently more complicated… I'm adding the complexity because I don't know what I'm talking about.' (Interviewee R3).

One interviewee gave an example of an ICT project which required the creation of a website. The project initially failed, costing the client over two million Euros. A second supplier was hired shortly after, who successfully built the project in three months for 200,000 Euros. The interviewee identified the difference between the two situations. In the first situation the client, was telling a nonexpert how to build the website. The second situation involved hiring an expert and letting the expert tell the client how to build the website.

'This is a good example of first spending years and millions of EUROs with a nonexpert on a project and making it very seemingly complex. Then moving it around, leaving the experts telling us how to build it.' (Interviewee R15).

The interviewees' identified that experts understand how to execute and manage the project. The findings gave context as to why experts perceive projects as noncomplex, and nonexperts perceive them as complex. The findings also gave context as to how experts reduce the effect of project complexity on project outcomes.

5.3.2. Limitation of an Expert's Influence

Experts were seen to perceive projects as noncomplex and be able to reduce the effect of project complexity on project outcomes. The interviews identified that there was a limitation to the expert's influence. The stakeholder aspects were identified as a challenge for an expert because to an extent they are outside of an expert's control.

'That's the thing when a project becomes bigger, the number of stakeholders and the number of people involved becomes bigger. So, on the project content part, size doesn't really matter… what becomes complex is more people trying to influence or become involved.' (Interviewee R13). 'The larger the scale, the larger the number stakeholders there will be, which are things outside the control of even the expert. However, depending on the maturity of the expertise of the expert there is a scale by which this will start.' (Interviewee R14)

This is not to say that an expert has absolutely no control, but the amount is limited. Expert's due to their expertise, are able to reduce the effect of project complexity on project outcomes. Their minimizing effect is attributed to their ability to justify and explain their actions in laymen's terms. Interviewees suggest that the greater the expertise, the greater capacity to handle client stakeholder issues. The ability for an expert to deal with stakeholder conflict and resistance is related to the project complexity team factor cited in the literature review, 'stakeholder management' (Azim et al, 2010).

'Now that's a mark of a software expert. They should be able to overcome even the limitations of the client. If I have a really bad subject matter expert in one of my groups, the expert should still be able to overcome that.' (Interviewee R2). 'Well I consider expertise also good at helping clients to come along and to see. Unfortunately, they don't have complete control no matter how good you are... I do think true experts have a way of helping the competent feeling comfortable with the decisions they are making and the impact of decisions they are making. Part of being an expert is helping them realize this. I think you can mitigate a lot of it but not all of it.' (Interviewee R6).

Some stakeholder related factors, even when anticipated by an expert cannot be controlled. An interviewee explained how experts can see and are aware when there are going to be stakeholder issues. The problem is that many of these issues are out of the expert's reach and hide behind other aspects of the business. For example, it may be a stakeholder in top management or an indirect stakeholder which the supplier never is able to personally confront.

'You can see it, but you have no control over it. It's like you can see a bird flying over your head but you can't stop the bird from flying over. You can stop it nesting on top of you, but you can't stop it from flying over.' (Interviewee R2)

The stakeholder related factors that are within an expert's reach can be directly communicated to the respective stakeholder. The stakeholder factor may still be an issue if the stakeholders are unwilling to listen or unwilling to change their direction. Regardless of how well it is explained or presented, since the stakeholder is outside of the supplier's control, the end decision is out of the supplier hands. An interviewee explained a major reason of resistance is that the client often feels attacked and does not want to admit to their internal organization that they have made a mistake. Another interviewee described it can be more than just shame but active resistance due to a power struggle.

'…we have the experts from the client side (the IT staff) and the experts from the IT provider. I have seen challenges for the provider because the IT staff think they know it better than the IT provider... t*hat's a struggle for the expert.' (Respondent R9)*

In analyzing the survey findings, the project scope factors of the client's project requirement are poorly defined and a client with unrealistic goals were among the challenges for the expert. Based on the interview responses, these may be stakeholder related as they involve not just the project scope of the requirement and goal but the client's willingness to accept the expert's defined requirement and realistic goals.

Different goals and interests described as 'hidden agendas' or 'politics' were frequently cited as a stakeholder related factor which are outside of the expert's control. An example given by an interviewee explained a project they performed, as the expert, which involved many other third parties. They as the expert were motivated to successfully deliver the project quickly and efficiently, however, the majority of stakeholders were only interested in making as many hours as possible. This phenomenon is defined by the project stakeholder factor 6 'conflict between stakeholders. Another interviewee described a project he performed as the supplier with similar issues due to different goals and interests. The project involved three different client organizations trying to work together.

'*They all wanted to do different things that had to work together. This was the first project they did together. That made it complex. It made it a project which lasted far too long and costed* *way too much. But it wasn't due to the complexity of the project, it was due to the complexity of the clients.' (Interviewee R13).*

In analyzing the responses, two of the project's scope factors (factor 10: the client's project requirement is poorly defined and factor 15: a client with unrealistic goals) were identified to be related to the project stakeholders. The stakeholder factors, such as the client's technical knowledge and/or experience, were found to be overcome by the supplier's expertise. Ultimately, interviewees identified that there is a limitation to the expert's influence. Project stakeholder factors to a degree are outside the control of the expert and dependent on the client stakeholders. In contrast scope related factors are within the expert's control, which explains why they are not a challenge for an expert. Based on these findings proposition 3 is supported by the interview findings.

5.3.3. Nonexperts have a Challenge with Scope and Stakeholder Factors

The interviews identified that the nonexpert has a challenge with scope related factors. Since nonexperts do not understand a project, they perceive it as complex and do not have clear vision of what to do. Nonexperts will encounter issues, many of which are self-inflicted mistakes, that an expert would never have to deal with.

'The challenges of a nonexpert is not being able to oversee the different processes of the project right. If you don't oversee the priorities, risk and time then each one of those would lead to inefficiency. (Interviewee 14). 'If you're a nonexpert you are bound to be making mistakes along the way. It is going to exacerbate; it's going to create bad feeling with the client. They are going to feel like they are paying you for expertise and they are not getting it and you are going to run into a lot of issues that an expert would not have to make' (Interviewee R6).

The challenge with scope related factors does not mean the stakeholder factors are not a challenge for the nonexpert. The interviewees indicated that the question is a matter of priority of challenges. The nonexperts will first focus on delivering the project scope. One interviewee explained the scope related factors are prioritized higher because it is more acceptable to have a poor or broken product or service than to not have a product at all.

'The thing is when you are a nonexpert you are trying to struggle so much with the technology that you are totally forgetting the client aspects…' (Interviewee R11). That is true because they don't get to the stage of the client. The client challenges are always there. It's just that for a nonexpert the project scope complexity dwarfs the client aspects. And so, it seems like an immaterial thing because that's a problem but it's not as a problem as the scope content factors' (Interviewee R5).

Interviewees identified nonexpert supplier's priority with the project scope may be related to the chronologically of an expert's activities. A nonexpert is prone to jump right into working on the scope of the project. They are unable to see potential risks or mistakes which they will encounter nor the stakeholder issues that may arise. An interviewee gave an example of a client with too small of a budget or an unrealistic goal. An expert would be able to identify this problem early on and encounter stakeholder issues. In contrast the nonexpert would only focus on working on the project scope and may never get to the stakeholder issues due to their inability to finish the project scope.

'If a client defines a certain scope, an expert supplier will understand if that the scope is too big, cannot be handled or cannot be done within the given timeframe. An expert would see this and warn the client, the nonexpert doesn't even know it.' (Interviewee R15)

The nonexpert may eventually have to deal with the stakeholder factors. If this occurs, the nonexpert will have a more difficult time with stakeholder factors than an expert. Interviewees explain that experts have their expertise to mitigate stakeholder factors. Since experts understand the project they can justify and reason with the stakeholder. Nonexperts on the other hand have no method to mitigate stakeholder factors. This will result in the nonexpert being outranked by a stakeholder due to their inability to explain their recommendations and then be forced to perform whatever actions the stakeholder dictates.

'*Nonexpert will have an even harder time I think with client aspects. They will be blown right away by the IT staff of the buyer. He has from the beginning a difficult time. I certainly think a nonexpert is not successful in this business.' (Interviewee R9)*

The interviewees further identify that nonexpert suppliers eventually place the requirement of expertise on the stakeholders. In cases with a nonexpert, someone has to manage the tasks and actions to complete the project. If the supplier is a nonexpert, they will require the stakeholders to direct them on what to do. One interviewee explains the danger of this, as the accountability would then lie with the stakeholder. In cases of project failure, the supplier would be able to blame the stakeholders, as they were the entity responsible for every decision.

'And at the end of it if there is an issue or failure, at that point they say well, we tried to go down this root and you wouldn't let us, so we just did exactly what you told us to do and it didn't work but we did exactly what you told us to do.' (Interviewee R3).

The interviewee's identified nonexperts to have challenges with both scope and stakeholder related factors. It is difficult to determine which one is of higher priority in terms of the effect it has on the project outcome. It was identified that nonexperts place more importance on project scope factors due to the requirement and chronology of a project. Lastly, nonexperts, due to their lack of knowledge, may increase the need for the client to have personnel with the technical knowledge and/or experience. Based on these findings proposition 4 is supported.

5.4. Conclusion

In this Chapter we elaborated on the case study and survey findings through interviews. The interviews were conducted with 15 ICT project practitioners.

The findings strengthened propositions one to four, by giving additional context to each proposition. First, the findings identified that experts understand how to manage and execute a project and have sufficient capability to properly do it. The findings described the context as to why experts may perceive projects as noncomplex and what may allow an expert to reduce the effect of project complexity on project outcomes. These findings provide a motivation to further explore the project complexity factors of the project team in defining and measuring the expertise of the individual.

Second, the findings identified that there is a limitation to an expert's influence. Experts can mitigate and handle the project complexity factors which are within their control. Stakeholder related factors were identified to be outside of the expert's control and unless the stakeholders utilize the expert's expertise, the expert is unable to influence the effect of those factors on project outcomes. The last finding identified that nonexperts have a challenge with both stakeholder and scope related factors of project complexity. The priority or focus of the nonexpert tends to first lie in the project scope related factors.

Based on the elaboration of the research findings we have come to an answer to the main research question 'Can supplier expertise impact the effect of ICT project complexity on project outcomes?' with the conclusion that:

- The expertise of the supplier can impact the effect of ICT project complexity on project outcomes. Additionally, we found the supplier's expertise to reduce the effect of ICT project complexity on project outcomes, up to the limit that client stakeholders are willing to release control and utilize the expertise of the supplier.

6. Conclusion

6.1. Introduction

Based on our research, we argue that expertise is considered to be an essential factor in dealing with the effect of ICT project complexity on project outcomes. By means of utilizing and applying expertise, clients and suppliers are better able to manage complex ICT projects. In Section 6.2 we address the research objective and then in Section 6.3 and 6.4 we address the findings of the research.

6.2. Research Objective

Over time, the ICT industry has been perceived to have poor project outcomes. For instance, the Standish Group (2016), report project outcomes of 43% completed on time, 40% on budget and 38% with a satisfactory result globally. Although there are many possible factors to explain these poor project outcomes, project complexity has been recurrently identified over the years as a major source of poor project outcomes (NATO Science Committee, 1969; Sauer & Cuthbertson, 2003; Whittaker, 1999).

Literature in project complexity revealed that there is no generally accepted definition (Vidal & Marle, 2008). Project complexity was initially defined to be centered around the project itself by factor's involving its size, variety, uncertainty, dynamics and socio-political complexity (Baccarini, 1996; Maylor et al., 2008; Shenhar & Dvir, 1995). Recent literature has provided definitions which have centered more around the individual or team performing the project, by the difficulty to deliver the project (Tie & Booluijt, 2014; Vidal et al., 2011; Xia & Chan, 2012).

Literature has identified various project complexity factors, of which each factor has a different weighting (Dao et al., 2016), prioritization (Xia & Chan, 2012), and correlation amongst other factors (Qureshi & Kang, 2015). Literature has not provided an all-inclusive framework to measure project complexity or reduce the effect of project complexity on project outcomes. Research in project complexity appears to still be at a theoretical and conceptual state and has not yet reached a sustained and lasting practical level to the industry.

The supplier's expertise has been suggested as a key factor in handling the effect of project complexity on project outcomes (Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014). Yet, little is known about the extent of impact. Hence, our research aim was to create a better understanding of the impact that the supplier's expertise may have on the effect of ICT project complexity on project outcomes.

6.3. Answers to the Sub Research Questions

In this section we discuss the answers to the sub research questions mentioned in Section 1.5.

6.3.1. SRQ1: What Factors Define Project Complexity?

The detailed research findings to answer SRQ 1 can be found in Chapter 2. Through an extensive literature review, 19 publications were found that correspond to project complexity. Based on our analysis, we derived a useable list of 22 factor groupings that influence project complexity (see Table 32). These factor groupings can be divided into two main components of the project, namely factors that relate to project stakeholders (8) and project scope (14).

Table 32: Project Complexity Factors

#	Project Complexity Factor		Publications [out of 19]	
			#	% Frequency
1	Stakeholder	Lack of senior management support	11	57.9%
2		Appropriate authority and accountability	7	36.8%
3		The interaction and interdependence between stakeholders	13	68.4%
4		Multiple stakeholders	7	36.8%
5		Availability of the people and material due to sharing	12	63.2%
6		Conflict between stakeholders	8	42.1%
7		The stakeholder’s technical knowledge and/or experience	6	31.6%
8		Geographical location of stakeholders	6	31.6%
9	Scope	Largeness of scope	12	63.2%
10		The client’s project requirement is poorly defined	10	52.6%
11		The project comprises a diversity of tasks	7	36.8%
12		The size of the project budget	13	68.4%
13		The length of the project’s duration	8	42.1%
14		The information uncertainty in the project	8	42.1%
15		A client with unrealistic goals	3	15.8%
16		The project’s alignment with the business goals and interests	4	21.1%
17		The number of decisions to be made on the project	10	52.6%
18		The integration between technology	8	42.1%
19		The newness/novelty of the technology	5	26.3%
20		The technology is continuously changing	8	42.1%
21		The diversity of technology in the project	10	52.6%
22		Highly difficult technology	4	21.1%

6.3.2. SRQ2: What are Characteristics of an Expert Supplier Delivering ICT Projects?

The research findings to answer SRQ 2 are based on case study research which can be found in Chapter 3.

We selected a supplier (case company) identified to be an expert in the ICT industry. We first analyzed the case company's project portfolio consisting of 47 large projects that had an average project outcome of 89.36% on time, 95.74% on budget and 93.62% client satisfaction. The project outcomes of the case company were identified to be higher than the market project outcomes. Within the project portfolio we investigated two embedded cases. The first embedded case included 14 projects in the banking sector. The results revealed that their project outcomes were 69% higher than the market sector's project outcomes (Standish Group, 2016). The second embedded case studied four projects in which the case company replaced an incumbent project team. The case company was able to improve the project outcome (client satisfaction) by improving project conditions. Project conditions improved include availability (downtime), compliancy, cost of ownership, application deployment time, backlog, contingency budget, and the client's personal project results. The case company's project outcomes identified the company to achieve high project outcomes in an industry identified to be complex (Bullock & Cliff, 2004; Adami, 2002; Tarride, 2013; Horgan, 1995; Giarte, 2014) and affected by project complexity (Al-ahmad et al., 2009; Legislative Assembly of the Northern Territory, 2014; Public Administration Committee, 2011; Sauer & Cuthbertson, 2003; The House of Representatives of the Netherlands, 2014; The Standish Group, 2016). Based on the findings, the case company, was validated to be an expert based on Gobet's (2015) definition.

After validation of the case company as an expert, we analyzed the organizational structure and project implementation methodology to identify characteristics of an expert supplier delivering ICT projects. Within the areas of the case company's organizational structure (OS) and project implementation methodology (PIM), we identified seven characteristics of an expert supplier delivering ICT projects.

1. No management
2. Self-forming teams
3. Peer review compensation
4. Internal project justification
5. Expert front line
6. No functional silos
7. Upfront cost transparency.

The seven characteristics were identified to emphasize the expertise of the case company through (1) fostering and valuing expertise within the organization and (2) placing sufficient expertise necessary to delivery projects.

As a result of the case study findings, we presented two propositions that can be tested in future research:

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.
- Proposition 2: An expert does not perceive projects as complex.

6.3.3. SRQ3: How Does Supplier Expertise Influence the Effect of Project Complexity Factors on Project Outcomes?

The research findings to answer SRQ 3 are based on survey research which can be found in Chapter 4.

To answer our research question, we conducted a survey and asked respondents to rate 22 project complexity factors' likelihood to be a cause of low project outcomes in two situations: (1) with an expert supplier and (2) with a nonexpert supplier. The survey included the responses of 97 practitioners involved in ICT projects.

The Wilcoxon signed rank test identified a statistically significant difference for all 22 factors between the two situations (α of .05, $p = 0.000$). An analysis of the differential of scores (of each situation per factor) strengthened the Wilcoxon signed rank test. The analysis identified a minority of respondents scored the 22-project complexity factors the same in both situations (no differential). A majority of respondents per factor scored the expert less likely to experience low project outcomes compared to the nonexpert. In an individual analysis of the frequency, median, mode and mean scores for an expert and nonexpert, it corroborated that the expert is less likely to experience low project outcomes due to the project complexity factors than a nonexpert. Based on the findings of our survey, we concluded that expertise reduces the effect that project complexity factors have on project outcomes. The exploratory factor analysis showed a clear distinction between expert and nonexpert scores but was not able to give further insights into the underlying complexity factors which affect project outcomes.

Based on the survey findings, we strengthened Proposition 1 while adjusting Proposition 2 and we presented two new propositions (3 and 4).

- Proposition 1: Expertise reduces the effect of project complexity on the project outcome.

- Proposition 2: Experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex.
- Proposition 3: Expert's challenges that relate to project complexity factors correspond to project stakeholder factors.
- Proposition 4: Nonexpert's challenges that relate to project complexity factors correspond to project scope factors.

6.4. Answer to Main Research Question

To answer to the main research question, we found evidence that the supplier's expertise can impact the effect of ICT project complexity on project outcomes.

The literature review identified 22 project complexity factors which define ICT project complexity. The Case study identified seven characteristics of an expert supplier, of which all seven emphasize the importance of expertise. The survey identified that in the case of all 22 project complexity factors, expertise was shown to reduce the effect of project complexity on project outcomes. The interviews identified that stakeholder related complexity factors were outside of the expert's control and unless the stakeholders are willing, the expert is unable to influence the effect of those factors on project outcomes. Based on our findings, although an ICT project might be complex by nature, when applying the lens of expertise, an expert supplier is capable to reduce the effects of project complexity on project outcomes.

7. Reflection

7.1. Introduction

By means of multi methods research (e.g. including literature, case study, survey and interviews), we have identified unique findings applied within the field of ICT project complexity. Section 7.2 and 7.3 address the scientific and practitioner contributions of our research and in Section 7.4 the limitations of our research are discussed. All future research which can be performed based on our contributions and limitations are addressed in Section 7.5. In Section 7.5 we address our proposal for further research which can be performed to progress the field of ICT project complexity.

7.2. Scientific contribution

For decades, project complexity has been identified as a cause of poor project outcomes (Al-ahmad et al., 2009; Sauer & Cuthbertson, 2003; Standish Group, 2016). Importantly, research into project complexity appears to be at a theoretical and conceptual state and has not reached a sustained and lasting practical level to the industry. Literature within project complexity reveal that multiple factors influence the degree of project complexity and consequently project outcomes (Geraldi & Adlbrecht, 2007; Vidal et al., 2011; Ribbers & Schoo, 2002; Geraldi et al., 2011; Vidal & Marle, 2008; Bakhshi et al., 2016). It has been suggested that the supplier's expertise is perceived to be a potential solution to handle the effect of project complexity on project outcomes (Arisholm et al., 2007; Bakhshi et al., 2016; Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014). Since the extent of impact which the supplier's expertise has on the effect of project complexity on project outcomes is under-researched, our research contributes by partially filling this gap.

7.2.1. Providing a Unique Compilation of Complexity Factors

Our literature review on project complexity revealed a broad set of factors that represents various industries, such as construction, information systems, product development, research and development (Geraldi et al., 2011), biopharmaceutical, information and communication systems, energy and transportation infrastructure (Floricel et al., 2016). Based on our literature review, which is comprised of 19 project complexity publications, we identified 379 individual factors within our research scope. Through a two-stage coding process the 379 factors were grouped into 22 factors. These 22 factors are a unique compilation of project factors that influence ICT project complexity (Geraldi et al., 2011; Bakhshi et al., 1999; Qing-hua at al., 2012; Bosch-Rekveldta, 2010; Qureshi & Kang, 2015; Abdou et al., 2016).

Our study shows a distinction between project complexity factors that relate to project stakeholders (8 factors) and project scope (14 factors). Next, we applied this set of unique factors to the field of ICT project complexity.

The results of our research reveals that all 22 factor groupings are applicable in the field of ICT project complexity. As our literature review identified two publications specific to the field of ICT (Ribbers & Schoo, 2002) and six which were inclusive of ICT (Bakhshi et al., 2016; Floricel et al., 2016; Geraldi et al., 2011; Maylor et al., 2008; Qureshi & Kang, 2014; Vidal & Marle, 2008), our study contributes to the field of ICT literature by extending the insights of project complexity factors. Importantly, all factor groupings as used in our study are applicable to the field of ICT and consequently contribute to ICT project management literature. Moreover, our empirical research helps to understand the dependencies between project complexity factor groupings (e.g. stakeholders, project scope) and the individual factors which can be used to model project complexity factors more effectively.

7.2.2. Providing Characteristics of an Expert Supplier Delivering ICT Projects

The case study shown herein identified and validated the case company's claim as an expert through an analysis of their project outcomes. Through a four-step approach the data was coded and we identified seven characteristics of the expert supplier (case company). Literature has focused on identifying characteristics of an expert based on an individual's level, such as diplomas, years' experience, and amount of time (Campitelli & Gobet, 2004; Meehl, 1954; Richman et al., 1996). Our study extends the identification of an expert ICT suppliers' characteristics from an individual level to a firm level. We identified a distinction between supplier characteristics based on their organizational structure (3 characteristics) and project implementation methodology (4 characteristics). Furthermore, our research helps to better understand the relationship between an expert supplier and expert characteristics from a firm's level. This relationship can understood in terms of the hierarchical management (Rishipal, 2014; Wulf, 2012), team composition (Mohapatra, 2015; Steiger et al., 2014) and project execution (Buckland & Florian, 1991; Mandiau et al., 2000), which can be used to better identify expert suppliers and improve expertise within the firm.

7.2.3. Modelling Project Complexity and the Impact of Expertise

Based on our survey research we were able to measure the effect of project complexity factors on project outcomes. By building an enriched conceptual project complexity model (22 factors), we tested the effect of project complexity factors on a supplier's project outcomes (e.g. on time, on budget and with a satisfied client). We argue that project complexity can be measured by the effect that project complexity factors have on project outcomes.

Our research identified that the role of an expert has the potential to reduce the effect of project complexity factors on project outcomes. In contrast, based on our results, the nonexpert is unable to reduce that effect. As such, our findings contribute to project complexity theory as we found that expertise is considered to have a moderating effect between project complexity factors and project outcomes. Existing models such as Azim et al. (2010), Tatikonda and Rosenthal (2000) and Florciel et al. (2015) measure project complexity factors which describe the project inclusive of the technology, size, stakeholders and interrelations/interdependence. The models are currently isolated and limited to the projects (factors) themselves, excluding the effect of project complexity on project outcomes. Our findings suggest the need to expand the modelling of complexity to include project outcomes. The expansion of the model would incorporate project management and project delivery research to improve modelling complexity. The inclusion of project outcomes within project complexity emphasizes the perceived complexity component while incorporating the descriptive (objective) method of measurement of "difficulty" through project outcomes.

Our study sheds light on the value of expertise in reducing the effect of project complexity on project outcomes. Literature shows various studies that relate to expertise and project management. These studies focused on specific concepts such as project team performance (Ong et al., 2005), expertise coordination (Maruping et al., 2009), project risks (Wallace, et al., 2004), and project portfolio management (De Reijck et al., 2005). It is important to note that existing research does not have defined factors which identify expertise or impede expertise. Our results contribute to research of expertise within the context of project complexity. Project complexity has an inherent perceived component to it. The identified value of the expertise of an individual to complexity would suggest an emphasis on perceived complexity over the descriptive complexity as defined by Schlindwein and Ison (2004).

Literature suggests that expertise is a key component to handling project complexity. However, to the best of our knowledge, ICT project complexity models have not been studied by using the lens of expertise. Literature, such as Bakhshi et al. (2016), has addressed project team factors which may pertain to expertise, including competencies, knowledge, experience, education, and training; however, these models do not focus on expertise or place a priority on factors which may pertain to expertise (Abdou et al., 2016; Bakhshi et al., 2016; Qing-hua et al., 2012; Xia & Chan 2012). Based on our findings we claim that existing project complexity models should be adjusted to include the perceived component (e.g. expertise) when studying project complexity and corresponding factors. Moreover, the importance of expertise contributes to research of Busi and Bititci (2006) who argue that there is a need to design a dynamic process for managing strategy and performance to create a collaborative enterprise. Through incorporating expertise into the modelling of project complexity, the perception of the individual can be further incorporated into project complexity.

The theoretical modelling of existing project complexity models can be enhanced by incorporating (1) the effect that project complexity factors have on project outcomes and (2) the supplier's expertise. Xia and Lee (2004) introduce a model to measure the complexity within Information System Development Projects (ISDP) through 20 factors. The factors were divided into four components, (1) Structural organizational, (2) Structural IT, (3) Dynamic organizational, and (4) Dynamic IT. All four components were shown to have a negative impact on project performance (delivery time, cost, functionality, and user satisfaction). In analyzing the 20 factors, we identified 11 (55%) to be related to the project scope, six (30%) to be related to the project stakeholders, and two (10%) to be related to the personnel executing the project. Based on our research findings, the 11 factors related to the project scope may measure complexity however, the factors (which comprise 55% of the cited factors) may be minimal effect to the project outcome when an expert supplier is present. Based on our findings, the model could be adjusted by emphasizing factors which measure the supplier executing the project and the stakeholder factors which impede the supplier from executing the project. Similar changes could be made with other ICT project complexity models. For example, Ribbers and Schoo's (2002) model based on ICT ERP projects used 11 factors to measure complexity. Among the factors 1 (9%) measured the project team while 5 (45%) measured the scope content which could potentially be eliminated and 2 (18%) measured the stakeholder factors.

The research findings could potentially be applied to project complexity models of other industries. Vidal and Marle (2008) created a model within the field of project management inclusive of 68 factors. The scope of research included any project, as they sought to create a universal project management focused complexity model. Among the factors, 9 measured the project team while 30 measured the project scope and 11 the stakeholders. We propose their model could be refined by incorporating an emphasis of expertise and the impact of such on the project outcomes.

We argue that future models need to have a primary focus on the expertise of the supplier and incorporate measuring project complexity in terms of the effect that they have on project outcomes. The refocusing of project complexity models has the potential to improve their accuracy and effectiveness.

7.3. Practitioner Contribution

As research into project complexity is a long-standing issue, it is observed that the industry is having difficulties shifting from the theoretical to the practical state. In general, this study contributes directly to the field of ICT practitioners in that it increases their understanding of the importance of expertise in dealing with ICT project complexity. The understanding of the importance of expertise may emphasize the need to change business practices of both the client and supplier to be rooted in expertise. More specifically, our study aims to contribute to ICT practitioners in three ways: (1) the organizational structure of suppliers and (2) their project methodology, and (3) clients' process to select suppliers.

7.3.1. Organizational Structure of Suppliers

Based on our findings, we suggest that suppliers adjust their organizational structure and determine what areas of expertise are needed to meet their target pool of client requirements. After identifying the areas of expertise, suppliers may determine which combination of roles within their organization are needed to comprise a team that meet's the level of expertise required. This corresponds with research of Saynisch (2010) who argued that the principle of self-organizational structures supports a firm's degree of adaptability within the context of project management. The organization and team composition (e.g. self-organization, no management) could be optimized to free up resources for other functions. An example of this was found in our case study describing two general silos of marketing and the execution of projects. On an organizational level these two silos should be merged to allow the collaboration of both marketing and project management. This example is consistent with research of Baccarini (1996) who found that project complexity can be defined in terms of differentiation and interdependency and that it is managed by integration. In any ICT project there will be a gradient of degrees of the level of expertise within an organization. Those with the highest level of expertise will be in high demand. We argue that organizations have to restructure their project teams to optimize the role of experts. In other words, expertise first. This relates to research of Chou and He (2011) who found that firms that address the importance of expertise encourage reciprocity between team members while centrality of expertise affect expertise integration positively.

7.3.2. Supplier ICT Project Implementation Methodology

In addressing the supplier ICT project implementation methodology, we suggest that supplier's management may reduce the effect of ICT project complexity from the very beginning of a project. For instance, changes include structuring their project implementation methodology to include a filter to ensure there is sufficient expertise amongst the team. Through this structure a filter is created by which projects, which are not staffed with sufficient expertise, will be identified and dealt with early on. In contrast to the organizational structure, which is a general filter of expertise, this approach ensures a project specific (case by case) filter of expertise. Besides the reduction of the effect of ICT project complexity, the supplier's business model may also change as projects are centered around expertise. As such, this may support a supplier's value proposition to the market (De Reuver et al., 2013). Other checklists can be developed as measurement tools throughout the execution of a project that gauge the level of expertise throughout the entire project.

Education to supplier management to implement these changes in the structuring and alignment of expertise would be critical. However, the education needed to increase the level of expertise is undetermined based on this research. There is insufficient information to know if the education of experts is adequate or if there is a lack of experts within an organization to meet this demand. The research would highlight these areas to be critical to an organization.

7.3.3. Client Selection Process of Suppliers

From the perspective of a client, we suggest adapting the supplier selection process and focus on the supplier's expertise, utilizing criteria which align with the client's specific project rather than a low price, general past performance or certificates and awards. Criteria which does not align with the definition of an expert can be removed. For example, potential criteria of expertise may include the requirement for suppliers to create a plan including applicable risks and risk mitigation actions. Further research will be required which develops criteria which can accurately identify such expertise (see section 7.4).

After the selection of an expert supplier, client's management would have to adopt the practice of releasing control of ICT projects to the expert while utilizing their expertise. This may require education to assist clients in making such a paradigm shift as it will be different then their current business practices. In cases where education may not close the gap, clients may develop a structure to enforce such a paradigm. This structure could include a reporting structure by which experts are required to clearly report the status of the ICT project to assure that the expert is meeting their expectations. The key to the tracking tool, would be in its non-technical nature. As the expert is intended to have the highest amount of understanding of the project, the reporting tool would have to be understandable to those which do not have this same level of understanding.

Through the implementation of these changes within client and supplier organizations the expected contribution would be to reduce the effect of ICT project complexity. Consequently, as project complexity is identified as a factor of poor project outcomes (Whittaker, 1999), the resolution of this factor should increase project outcomes including time, budget, and satisfaction (Al-ahmad et al., 2009; Emam & Koru, 2008; KPMG, 2005).

7.4. Limitations

Although our study provides important insights for the ICT Industry and the field of project complexity in relation to project outcomes, there are also several limitations associated with this study.

First, there is a limitation concerning the constructs of ICT project complexity, experts, stakeholders and the project outcome. As stated in Chapter 1 (Section 1.2) there are various ways in which literature has defined each of these constructs. Literature was used to create proxies to measure and reduce this constraint however, different descriptions or wording of the same definition may lead to differing results. Expertise, in particular, was represented throughout the research at extreme spectrums on the scale of expertise, i.e. expert and a nonexpert. Based on the extremes of the spectrum of expertise, propositions were formed in regard to an expert and a nonexpert. It is understood by the researchers' that expertise is on a gradient scale and not binary (expert and nonexpert). The research results may differ when applied to a gradient scale of expertise.

Second, our research is within the context of an ICT project which the supplier is considered to be fully responsible for executing the project (product or service), which is defined by the client (McCarthy & Anagnostou, 2004; Tayauova, 2012). Based on the context of project execution, the results may not be generalizable to projects which are jointly implemented by client and supplier. Additionally, the client's expertise was considered within the project context and was included as a factor of project complexity (factor 7). The client's expertise when in the implementation role may have differing results than when the supplier is fully responsible for the implementation. For instance, Plugge (2011) identifies that the fit between client and supplier has an impact on outsourcing project outcomes. Similarly, the differing levels of expertise in terms of compatibility requires further research in terms of its generalizability amongst ICT projects.

Third, when analyzing project complexity literature, we identified 19 publications. Although the literature review was quite extensive, this is not an all-inclusive list. Other models, such as in the private industry, may exist which are not accessible, available or documented due to reasons of proprietary information. These models may provide instances of success and insights that are not included in this research. Additionally, we filtered publications based on the contribution of a unique list of project complexity factors. This process of filtering may exclude relevant factors which have not been recognized in previous publications' lists. The absence of additional information may cause a limitation to the research results. Future research should extend to other databases and be inclusive of additional key words and fields of research. With respect to coding data within the research, other methods of coding and use of professional software can give greater insight or results.

Fourth, the factors selected to measure project complexity are not an all-inclusive list by which it can be measured. There were 623 factors of project complexity that were identified by studying the literature. We focused on using a grouping technique to select a broad range of factors to serve as a proxy for ICT project complexity in order to identify the impact of expertise on the effect of project complexity on project outcomes. Our results may not extend to all types of project factors beyond the 22 factors tested. Each of the 22 factors tested in the survey represent a factor grouping of multiple factors. In focusing an investigation on specific factors, exceptions and factor differentiation can be better defined. For instance, software projects may be different than infrastructure projects, or ICT healthcare projects may be different than ICT financial projects. By selecting a more specific sector or type of project within the ICT industry there may be project factors which better represent the project. Additional testing would be required within the desired sector of applicability.

Fifth, since our qualitative case study research was based on data derived from only one supplier, the generalizability of the results forms a limitation. A survey and interviews were used to minimize this limitation; however, they do not eliminate it. Moreover, replicated cases focusing on common characteristics of expert suppliers and the results of expert suppliers through a longitudinal research design of case studies may provide more evidence to recognize and understand complexity patterns. Extending the cases to nonexpert suppliers may also benefit research by means of a contrasting view. Additionally, with respect to the two embedded cases, these cases were limited based upon availability of information, before and after project execution, and the propriety of the case company. For these reasons, only positive cases were searched and identified. A holistic analysis of both positive and negative ICT projects would provide more complete insights. Additionally, the casual mechanisms to link the characteristics of a supplier and their expertise were identified only through literature and not the case company themselves. Literature allows for general trends which may not be specific to the single case company selected. To improve the reliability of the link between characteristics and expertise, case company’s evidence would be required. Lastly, the seven characteristics identified from the expert case company were limited to the areas of the supplier’s organizational structure and project implementation methodology. The characteristics do not include the characteristics of the supplier’s employee expertise.

Finally, when related to the quantitative research results there were limitations based on respondent background information, survey structure, survey single item measures, and response rate.

We focused on a broad range of practitioners in the United States and the Netherlands with no set exclusionary background conditions including roles, functions, and years of experience. Due to the broad range of participants, the generalizability of the results forms a limitation. For instance, the Netherlands and United States are different with respect to their size, population, cultures, technology focus and ICT governance.

The survey structure of questions required a scoring of project complexity factors for two situations per factor, with an expert and with a nonexpert. Since the respondents were able to see both their scores, there is a risk that instead of rating the factors on an independent scale, the scores were based on their overall belief that the expert (or nonexpert) should be higher or lower than the nonexpert (or expert). This potential bias could have affected the end statistical results. In analyzing the results, the respondents paired scores suggest the bias to be minimal as the difference in scores were generally evenly distributed between the differential scores of 1 to 4. Separating the scoring of expert and nonexpert on two separate surveys (for an expert and nonexpert) might mitigate the risk caused by this bias.

The survey used single-item scales to represent each project complexity factor which introduces issues with reliability. The research results may be unreliable in understanding individual factors and more suited to understanding project complexity as a whole and the components of the stakeholders and scope as they can be described by multiple factors.

A more extensive exploratory factor analysis could provide insight into the measurement model by the identification of project complexity factors affecting project outcomes. An exploratory factor analysis was conducted in our research however, the differentiation of factor loadings was not sufficient to add relevant insight into the research findings. Further analysis is needed which may lead to new insights including: (1) the increase in the number of respondents and (2) the identification of complexity factors through a literature analysis with the objective to identify project complexity factors substantiated to affect project outcomes. With a refined list of project complexity factors a different perspective of insights into the impact of expertise on the effects of project complexity can be uncovered.

The survey sample pool consisted of 140 committed participants of which 112 responded and 97 which were valid respondents (completed the full survey). The response rate resulted in a total response rate of 80% and 69% excluding invalid respondents. We perceived the response rate of 80% to be high for an online survey (based on previous first-hand experience). Possible reasons for the response rate include: (1) A sample frame was used which may have introduced bias when the respondents were pre-committed to participate in the survey. The interaction was done between people (one researcher and the respondent), as such the respondent could have been more or less likely to participate based on the individual asking them to participate.

(2) the survey was well prepared which made it more likely for respondents to participate. (3) the research covered an area which interested the majority of respondents which motivated them to participate. Without further research and analysis, the reasoning behind the response rate is unknown, which may pose a problem if the reason is related to bias in the survey responses.

Lastly, the interviews conducted were limited in terms of sample size and potential social desirability bias. The sample size of the interviews were based on 15 ICT project practitioners. As this was primarily an elaborating step this was considered sufficient however more insight may be gained through the expansion of participants. Secondly, the interviewees were taken from the same sample population as the survey respondents. The interviewees were non-responders to the survey which introduced selection bias as the interviewees have already been filtered by the lack of interest in the topic, active schedule, and/or possible exposure to the survey without submitting a response. We do not see any obvious indicators of bias but independent sample populations for surveying and interviewing would ensure this bias is avoided.

The preparation of participants may also be considered as the level of understanding of the topic of complexity and knowledge varied. An interview preparation document was given to the participants beforehand, however other methods may be used to prepare participants more extensively such as workshops, webinars, and informational videos.

Due to social desirability bias, interview participants may have been less likely to disagree with the findings presented as they were based on our research findings. We attempted to reduce the bias by the explanation and purpose of the interviews. It was explained that the findings were based on a single survey and the interviews were needed to elaborate on the findings. Furthermore, the survey is not a confirmation step but an elaboration step. It was important that the interviewees knew the purpose was not to necessarily agree or disagree but to elaborate and give context that would help better understand complexity. The agreement or disagreement was a necessary discussion points as mentioned in the instructions however, it was not the primary purpose of the interviews. In the future to further minimize this bias, the interviewees would not be aware that the discussion topics were based on any previous research and contrasting propositions would be presented in the discussion.

7.5. Further Research

Studying the impact of expertise on the effect of project complexity on project outcomes is a relatively new line of research, and clearly, there is a need for further research. This research is intended to help develop the foundation theory and concepts which incorporate expertise into project complexity. More specifically, the repeated testing of our research findings would ideally take the lessons learned from the limitations and expand upon the limitations to ensure reliability of the results. This could potentially include:

1. Conducting a more extensive literature study expanding specifically into the private sector to ensure that the 19 complexity publications as identified are truly a microcosm of the both the public and private fields of research into project complexity.
2. Refining and if necessary, redefining the constructs of project complexity factors and expertise. These constructs were developed through literature research. Developing a more extensive research model which includes multiple factors would be required. As a first step, additional qualitative research may create new insights to develop a more robust research model including relationships between constructs. Additionally, the investigation into the construct of client expertise and its implications may lead to more generalizable results as to expertise and project complexity.
3. Conduct more extensive qualitative research by means of case studies including multiple suppliers or more embedded cases by which positive and negative complex projects and suppliers can be analyzed. A focus of future case studies would be to expand the areas of measured characteristics beyond the organizational structure and project implementation methodology. Additionally, the identification of the casual mechanisms which link the characteristics of a supplier and their expertise. The case study evidence of the casual mechanisms would strengthen the link between characteristics and expertise.
4. Conduct a more extensive survey among clients and suppliers with multiple statements to define each individual project complexity factor. These changes will help the generalizability and validation of the findings. By applying quantitative research other researchers may test the relationships between the research model's constructs. This approach may provide additional insights and statistically generalize the findings. Expanding the research by involving a substantial number of practitioners (both clients and suppliers) will provide more rigorous measurement that can be used to enhance and strengthen our results. A quantitative study may include multiple backgrounds and testing a wider range of complexity factors. In addition to this, by increasing the amount of project complexity factors tested, a more in-depth analysis and grouping of these factors can be done to reveal common patterns and trends. Future research should differentiate categories of project complexity factors based on their effect on project outcomes through an exploratory factor analysis.

The research findings suggest that expertise reduces the effect of ICT project complexity on project outcomes. However, literature suggests there is a perception in the industry that project outcomes are being affected by complexity. For this reason, we recommend exploring the area of expertise within the ICT industry. This research is proposed to be conducted through multi method research including both surveys and interviews. The results of this research may provide insights into the source of the project complexity in the ICT industry. We propose areas to be explored include: (1) identification if there is sufficient expertise within the ICT industry, (2) obstacles to utilizing the existing expertise within the industry and (3) amount/balance of expertise required between the client and supplier.

Literature identified expertise to be a major role in handling and reducing project complexity (Qureshi & Kang, 2014). Our research into expertise and complexity identified a gap in literature in terms of the effect of expertise on project complexity. Further exploration into the effect of expertise on project complexity (perceived and descriptive) may provide additional insights into the casual mechanisms between project complexity and project outcomes. Additionally, the differentiation between perceived and descriptive complexity may lead to new insights and emphasis in terms of the importance and priority of the two. The lessons learned from the effect of expertise on perceived and descriptive complexity could be incorporated into project models to refine the factors used to define and measure complexity. Our research findings suggest that expertise may be a useful lens by which perceived complexity can be studied.

Finally, our findings with regard to the impact of expertise on the effect of project complexity on project outcomes suggest a potential new approach to modelling complexity. This new model may include: (1) the measurement of factors contributing to the level of expertise of the supplier executing the project, (2) the measurement of the stakeholder factors which prevent the utilization of the supplier's expertise and (3) the elimination of factors which do not pertain to the supplier's expertise or limit the supplier's expertise. The adjustments would potentially reduce the number of factors to be measured, improve the accuracy of modelling project complexity and assist the theoretical modeling of project complexity move towards a more practical state. This new approach to modelling would require further research into the identification of factors which best indicate project specific expertise.

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9. Appendices

The following Appendices can be accessed online at:

https://www.dropbox.com/sh/6enk8kzp0czyv2x/AADCpQinDl9wuu7hcxLcJ5Mva?dl=0

Appendix A: Literature Database Design
Appendix B: Project Complexity Publications
Appendix C: Case Company Interviews
Appendix D: Pretest Survey
Appendix E: Main Study Survey
Appendix F: Overview of interviewees
Appendix G: Interviewee Instructions and Questions

10. Curriculum Vitae and Publications

Curriculum Vitae

Isaac Kashiwagi was born in Riyadh, Saudi Arabia, on November 17th, 1988. He studied at Arizona State University (ASU), where he obtained his master's degree in 2014. After and during his education at ASU he volunteered as a researcher at the Performance Based Studies Research Group (PBSRG) at ASU from 2011 – 2016 while working as a private consultant from 2011 – present for KSM-Inc. Through his experience at PBSRG and KSM-Inc he began to experience the consequences of project complexity through the participation in multiple outsourcing arrangements. Isaac has project experience within the construction, services, healthcare and ICT industries both national and international. From 2010 – 2011 he managed the performance tracking and measurement of execution of 400+ projects within the US Army Medical command. From 2014 – 2015 he managed the performance tracking of the State of Oklahoma's procurement of services ranging from ICT systems to foster care services. From 2015 – 2017 he managed the performance tracking and measurement of multiple government agency's construction projects from procurement to execution. Additionally, in this time period he managed the performance tracking and measurement of Arizona Department of Environment Quality's engineering services projects. From 2015 – present, Isaac has acted as a leading educator in the Best Value Approach which specializes in the utilization of expertise to improve performance. He has certified and trained 400+ individuals and been a prime contributor to the development of training curriculum. He is currently assisting the Saudi Arabia Ministry of Municipal and Rural Affairs with the design and implementation of a national classification system for construction and services projects. These projects became the basis for his interest in the field of complexity. During his PhD period he mentored four PhD dissertations and acted as a teaching assistant to six ASU courses funded through the GIAN program at the Sri Jayachamarajendra College of Engineering located in India. Additionally, he has acted as a journal reviewer for the CIB W117 Journal of Construction Performance (2015–Present).

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