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INTEGRATION OF INFRASTRUCTURE WITH THE SOCIETY IN THE OPERATION PHASE: A MULTIPLE CASE STUDY APPROACH

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ABSTRACT

The later stages of an infrastructure project occupy a significant period of its lifecycle. Even though majority of the expenses for the project are in the construction phase, the value for the society is realized only in the operation phase. Projects are often remembered for how they serve the community in the later stages more than their efficiency during the construction phase due to its long lifecycle. There is a need to understand how projects integrate with the society after its construction, especially considering the inability of the planners to create a design considering all future scenarios. In the proposed research, we employ a multiple case study research considering the Oresund bridge connecting Denmark with Sweden and the Port of Rotterdam in the Netherlands. We observe how during the operation phase the infrastructure acts as an enabler, adapt to changing needs of the society, and diversify its impacts. This study has significant implications to society as it explores how to extract value from already constructed infrastructure assets.

KEYWORDS

Integration of infrastructure, Value for society, Operation phase, Spillover effects.

1. INTRODUCTION

Infrastructure is often seen as a necessary condition for achieving sustained economic growth and for expanding markets (Démurger, 2011). Empirical studies have demonstrated a strong correlation between the availability of infrastructure and economic growth, making infrastructure essential for the progress of a region or country, as it fosters socio-economic development (Queiroz & Gautam, 1992). In addition, an improved economy invests heavily in maintaining and upgrading its infrastructure. They address essential areas that directly impact the daily lives of people and are fundamental to the functioning of modern societies (Bliemel et al., 2018). Hence, infrastructure projects, such as those focused on transportation, water, sanitation, and electricity, are critical for the well-being of communities and for generating value to society.

Even though majority of the expenses for infrastructure projects are in the construction phase, the value for the society is realized only in the operation phase or in the later stages of the project. The operation phase of an infrastructure project also occupies a significant period of its lifecycle as most infrastructure projects have a lifecycle of 60–80 years, with the initial four to five years earmarked for planning, the next four to five years for construction and the large remaining period being the operation phase (Liu et al., 2014; Ninan et al., 2022). Due to this unequal and long operation phase, infrastructure projects are remembered for how they serve the community in the later stages more than their efficiency during the construction phase. The Sydney Opera House serves as an example of a failure in project management, resulting in an actual cost 14 times higher than the planned cost, and the completion time 10 years later than the planned time, however, is now considered an iconic symbol for Sydney and even Australia.

To generate more value for the society, infrastructure projects have to integrate better with the society during its later stages. The operations of an infrastructure project need to be frequently monitored such that decision-makers can accurately evaluate the performance objectives and take corrective actions to maximize value for the society (Osei-Kyei et al., 2017). It is noteworthy that society is a dynamic entity, affected not only by external factors like climate change and technological innovations such as self-driving cars, but also by changing societal demands, including those related to sustainability issues (Hertogh et al., 2018). There is a need to understand how infrastructure projects integrate with the society after its construction, especially considering the inability of the planners to create a design considering all future scenarios. Thus, this research seeks to understand how infrastructure projects integrate with the society in the operations phase.

The following section covers the literature on the operation phase of an infrastructure project, project value creation, and spillover effects. Subsequently, the methodology to study the interventions in the operation phase of the Oresund bridge and the Port of Rotterdam are discussed. Then, the findings from these projects are discussed highlighting how infrastructure act as an enabler, how they adapt to changing needs of society and how they diversify their impact. Finally, the conclusion section provides a summary of the article's

main insights and highlights potential areas for future research while also acknowledging its limitations.

2. LITERATURE REVIEW

The following section presents a literature review on the operation phase of an infrastructure project, project value creation, and spillover effects of an infrastructure project, which helps us situate a research agenda at the intersection of these topics.

2.1 Operation phase of an infrastructure project

Infrastructure projects have a long lifecycle covering 60–80 years. The initial four to five years are earmarked for planning and is often called the front end of these projects (Liu et al., 2019). The subsequent four to five years is the construction phase and the large remaining period of more than fifty years is the operation phase or the later stages of a project (Ninan et al., 2022). Majority of the expenses for an infrastructure are incurred in the planning and construction phase, due to which their front-end draws attention from policy makers, construction companies, designers, and researchers (Osei-Kyei and Chan, 2015). However, the value to the society is realized only in the later periods of these projects, particularly the operation phase. The consistent ignoring of the operations phase by the designers, contractors, policy makers, and researchers often lead to less value for the society and an increased lifecycle cost of these projects (Karim and Magnusson, 2008).

The operations phase of an infrastructure project mainly covers the repair and maintenance of the project (Liu et al., 2014). An improper operations and maintenance of an infrastructure asset can reduce the productivity of the asset and thereby its value for the users (Ghalenoei et al., 2021). Additionally, effective safety and environmental health management systems need to be in place during the operations (Liu et al., 2014). Hence, a poorly managed operational phase undermines the project objectives and erodes an infrastructure project's value for money (Osei-Kyei et al., 2017). However, researchers need to focus not only on repair and maintenance in the operations phase, but also consider other activities for enhancing the integration of infrastructure with the society during the operation phase.

There can be other activities in the operation phase of an infrastructure asset that can affect its long-term demand and integration with society. For example, Ninan et al. (2021) notes strategic discourses in a project need to be managed over the lifecycle for adequately managing external stakeholders and generating optimum value. During the pre-construction phase, discourses focusing on the creation of an integrated infrastructure to tackle congestion can aid in the acquisition of land. During the construction phase, highlighting the construction workers' dedication and hard work, even during nighttime, can help to reduce opposition to construction activities. During the operation phase, discourses promoting the celebration of national and regional festivals through the infrastructure project can enhance its utilization. Mathur et al. (2021) records how the benefit realization of a project should be evaluated in the operations phase to check whether the project's planned objectives are

achieved. In the operations phase there can also be an opportunity to replace or upgrade existing plans to ensure that infrastructure networks can adapt promptly to changing demands (Hertogh et al., 2018). Hence, infrastructure projects require an integration of its lifecycle dynamism, stakeholder heterogeneity, and social responsibility interactivity (Lin et al., 2017), most of which are evident only during the operation phase.

An optimal value of projects for the society can only be realized if the lifecycle of the project is considered (Hertogh & Bakker, 2017). However, literature has largely focused on the project value creation in the front end of an infrastructure project (Liu et al., 2019) or its implementation phase (van den Ende and van Marrewijk, 2019). The value generated during the project operations phase has received comparatively less attention. In this research, we would like to focus on the operations phase of infrastructure projects to maximize value for the society.

2.2 Project value creation

Infrastructure projects are considered as a means to define, create and deliver value (Martinsuo et al., 2019). Infrastructure projects are primarily intended to create and distribute value to their stakeholders. (Zwikael and Smyrk, 2012; Mathur et al., 2021). Cost Benefit Analysis is the most common method for measuring an infrastructure project's value as it compares the cost invested in a project and the benefits that can be obtained from it (Mathur et al., 2021). Both financial and non-financial benefits of the project are considered in the analysis, however these are only considered in the front end of projects. These benefits set in the front end are common target benefits which are set before the start of a project, which the project funder aims to achieve through an investment in the project (Zwikael et al., 2018).

However, empirical studies show that the planned benefits of a project are rarely achieved. Flyvbjerg et al. (2003) conducted a study on 258 megaprojects in 20 countries and found that 90% of them failed to meet their intended goals in terms of time, cost, or delivering on promises to stakeholders. One school of thought in the literature for not achieving the planned benefits or demand forecasts focus on the frontend and considers optimism biases (Flyvbjerg, 2008), strategic misrepresentation (Wachs, 1989), and lack of upfront planning (Morris, 1994). In optimism bias or planning fallacy, in contrast to actual experience the planners and decision makers overestimate the positive outcomes and underestimate the negative outcomes (Kahneman & Tversky, 1979). In strategic misrepresentation, the planners and political sponsors tend to overestimate the benefits and underestimate the costs of a project in a strategic manner to enhance the likelihood of its selection over competing projects, resulting in the 'survival of un-fittest' (Flyvbjerg, 2003). Unrealistic plans can also be a consequence of inadequate upfront planning, which may occur due to time constraints and political pressures in project execution.. Another school of thought focuses on the later stages of a project and claim that demand forecasts and projects benefits are seldom realized automatically, instead they have to be managed and promoted actively (Coombs, 2015). For example, during the later stages of a project, the project sponsors may play a crucial role in promoting the realization of benefits (Breese et al., 2015). They argue that benefits and

forecast is the full potential of the infrastructure project, and it can only be achieved if interventions are in place to increase the demand.

Whether a project is successful or not is not dependent on just completing the project as per its plan. Samset (2003) argues that operational, tactical, and strategic success are the three levels of success in project evaluation. Operational success is the most commonly applied measure of project success. It evaluates whether a project is completed as per the agreed measures such as agreed time, cost, and quality. However, many projects have proven to be extremely useful to the society despite considerable cost overruns. Tactical success considers success as the usefulness of projects and evaluates whether the project has achieved its objectives or formal goals. In contrast to operational success, which measures the cost or time of construction immediately after project completion, tactical success is evaluated after the multiple effects have materialized within the estimated time frame following construction.. Strategic success takes even a wider perspective and considers the long-term effects and future needs of users. With a focus on operation phase, this research seeks to investigate how tactical and strategic success can be achieved in already constructed infrastructure projects. In addition to tapping the planned value in the operation phase of projects, there can also be spillovers from the project which have to be carefully and efficiently harnessed.

2.3 Spillover effects of an infrastructure project

Ex-ante assessment involves the cost-benefit analysis in the frontend of an infrastructure project. In contrast, ex-post evaluation involves checking whether the project really delivered the benefits planned (de Jong, 2018). Ex-post evaluation is necessary to learn which projects are doing better and which ones are doing worse than expected, and why. However, project success is a heterogeneous measure subject to different interpretations by stakeholders (Welde, 2018). Moreover, conventional infrastructure assessment methods seldom encompass the complete spectrum of strategic benefits for the transportation system (Lopez, 2009).

Along with the planned benefits of an infrastructure project, there are multiple unplanned spillover effects for an infrastructure project. Spillover effects are closely linked to network synergy and takes into consideration the impact that an infrastructure can have thereby changing network usage (van Exel et al., 2002; Peters, 2003). The spillover effects of infrastructure are widely acknowledged. For example, Chandra and Thompson (2000) note in their study that investing in motorways promoted growth in the territories they intersected. Spillovers can also exist beyond the areas where the infrastructure is located or crosses through (Cantos et al., 2005).

In this section, we highlight that research on infrastructure has largely focused on the frontend and construction phases of these projects. There is a need to find the best balance between performances, costs and risks, throughout the lifecycle of the project (Hertogh et al., 2018) and so there should be a focus on the operation phase as well. We argue that interventions in the operation phase of projects can achieve the planned benefits and

demands of the project as well as efficiently harness the spillover effects. This research seeks to understand such interventions in the operation phase of infrastructure projects in the Oresund bridge and the port of Rotterdam.

3. RESEARCH SETTING AND METHOD

For evaluating the practices of integrating an infrastructure with the society in its operation phase, this research employs qualitative research (Strauss & Corbin, 1998). A qualitative research methodology as it is preferred to gain familiarity with a problem or to generate new understandings for future research (Eisenhardt, 1989). We choose the case studies of the Oresund bridge and the port of Rotterdam and consider its different practices in the operations phase.

The Oresund bridge connects Denmark with Sweden with a 16 km long road and rail link. The construction of the bridge started in 1995 and was inaugurated in 2000. The bridge was built for its potential to contribute to the economic integration in the Oresund region. Many reports, investigations and articles on the bridge's effects in the region have been published during its operation phase such as Knowles & Matthiessen (2009), Cars et al. (2013), Helgason (2012), and Hansen & Serin (2010). The data on the practices of the bridge in the operations phase is compiled from these reports and articles.

The port of Rotterdam is located in the Netherlands and is the largest seaport in Europe. The port took various efforts to integrate with the city of Rotterdam. The data on the practices of the port of Rotterdam in the operations phase is compiled from its social media page. Tweets from the port's official page gives documented evidence of its periodic interventions. We compiled 144 tweets from 1 Jan 2021 to 31 Dec 2021. The period enables us to address the research objective, i.e., to explore the practices of how an infrastructure integrates with the society during the operation phase.

We went through the project documents and social media posts and looked for practices in the operation phase. We looked at the contextual meaning of text in each tweet or document, (McTavish and Pirro, 1990). Each of these practices were assigned a category using open codes derived from data and iterated (Flyvbjerg, 2006) to a higher level (Chun-Tie et al., 2019). The multiple case study methodology helped identify common themes across two cases thereby increasing the validity of the study. We also anchor the findings and discussion in the literature to improve construct definition, sharpen generalizability and raise theoretical level (Eisenhardt, 1989).

4. FINDINGS

4.1 Oresund bridge

The inauguration of the Oresund bridge marked a sensitive transition from the dreams and visions of the future to the harsh reality, despite the fact that it was the result of many years of planning. The journey between Denmark and Sweden became significantly quicker and

simpler for its users as they travelled for business, leisure, and tourism, in a manner previously impossible (Hansen & Serin, 2010). Still the traffic on the bridge was below forecasts in the initial years of its operation as the estimates were found to be very ambitious (Knowles & Matthiessen, 2009). However, during its operation phase the Oresund bridge was instrumental in enabling the Oresund Science Region collaboration. The collaboration was subsequent to a joint effort between the national and regional actors to kindle economic development in the area after the construction of the bridge. One of the documents (Cars et al., 2013) on the collaboration notes,

“The improved accessibility facilitated by the Oresund Bridge creates potential for increased collaboration, but this potential is not automatically unlocked”

As noted by Cars et al. (2013), it was generally perceived that a natural integration of the bridge and increased economic activity would take place on its own accord just because the bridge is constructed. However, the economic activity didn't happen automatically, and steps to increase the use of the bridge and improve the economic activity, such as the Oresund Science Collaboration, had to be carefully planned in the operations phase to achieve the demand forecasts. Along with such planned interventions, there were also spillover effects to other regions such as in the case of Helsingborg area transitioning to a housing market as noted by Olshov (2013) quoted below,

“... the greater accessibility provided by the Oresund connection has benefited Helsingborg in the sense that more and more are choosing to settle in the town simply because it is an accessible and attractive location in relation to Malmö and Copenhagen.”

There were also spillover effects on other infrastructure because of the bridge. The revenue of the port near the bridge increased as it was able to attract new customers because of the bridge, as noted by Helgason (2012) below,

“The opening of the Oresund-bridge was believed to be a death sentence for the ports and expectations were that revenues would shrink by 15-20%. The reality turned out to be quite the opposite and according to Leonard Pettersson, the deputy director of CMP, the ports saw they could share costs, work together and attract new customers.”

The establishment of new companies and the growth of previously established ones have been significant consequences of the Oresund Bridge for the area's industrial development. Thus, the bridge acted as a laboratory for institutional change facilitating various collaboration structures and institutional solutions. However, activities to improve the usage of the bridge, such as the Oresund Science Collaboration, had to be carefully planned in the operations phase to maximize the value for the society.

4.2 Port of Rotterdam

The port in its operation phase was active in creating a climate that facilitates investments and thereby improving the throughput of the port. They do so by attracting business to the

region. In one instance, a market leader in bioplastics shifted its storage facility to the port area as highlighted in the tweet below,

“@BraskemBio, the world’s largest producer of biopolymers, has moved its storage facility from Antwerp to Rotterdam.” (Tweet dated 19-01-2021)

Along with attracting investments, they also conduct events such as ‘freight forward’s cage’ to bring city together and grow. Thus, the port plays an active role in its operation phase by driving economic growth in the region. Along with the economic needs of the region, the port was also active in addressing the social needs of the city such as leasing its buildings for housing, providing covid vaccinations, or planning for flood risk management. In an instance, the port made arrangements to transfer the residue heat it generated to make 120,000 households in the region warm, as tweeted below,

“... have taken the final investment decision for the construction of a heat pipeline from the port of Rotterdam to The Hague ... 120,000 households can be heated with residual heat from the port.” (Tweet dated 22-07-2021)

The port also took steps for sustainability transitions to address climate change. They took these steps based on the changing needs of the society. The port campaigned for the container ships active in the area, to be operated on LNG fuels and partly used energy from solar panels. In another instance, a waste-to-chemicals facility within the port was repurposed to waste-to-jet fuel because of the sudden demand for sustainable aviation fuel, as noted below,

“Partners repurpose the Rotterdam waste-to-chemicals project to waste-to-jet based on demand for Sustainable Aviation Fuel.” (Tweet dated 08-06-2021)

The port also took various steps to integrate better with the Municipality of Rotterdam by conducting conferences and submits for joint problem solving. Thus, the Port of Rotterdam also took steps during the operations phase to integrate with the society and maximize its value.

5. DISCUSSION

From the case study of the Oresund bridge and the Port of Rotterdam, we were able to observe how during the operation phase the infrastructure acts as an enabler, adapt to changing needs of the society, and diversify its impacts. We discuss each of these below.

5.1 Infrastructure as an enabler

An infrastructure during its operation phase has the potential to enable planned and unplanned economic benefits. In the case of the Oresund bridge, it was seen how the infrastructure facilitated the Oresund Science Collaboration and improved the economic activity in the area. New companies also shifted to the region because of the bridge. In the case of the Port of Rotterdam, the infrastructure facilitated collaboration with the municipality of Rotterdam by conducting conferences and submits for joint problem solving. The port also played an active role in attracting new business to the region. The findings of

existing infrastructure having the potential to improve economic activity during its operation phase extends the literature which records that only new infrastructure has potential to improve economic growth (Démurger, 2011). It should also be noted that an infrastructure interacts with multiple stakeholders such as new businesses, governments, other infrastructure, etc. and a systems perspective can be considered to trace its impact on other stakeholders (Ninan et al., 2019). Infrastructure can enable a cluster that can trigger both the social and institutional innovations, conventions and learning at a regional level (Asheim and Coenen, 2005). It is important that infrastructure projects understand its current value and explore its potential to enable economic benefits. Through such sustained efforts, infrastructure projects can integrate better with the society during its operation phase.

5.2 Adapting to changing needs of society

Infrastructure projects have a long lifecycle. The planned purpose of the project may not withstand the test of time as reality is often different from expectations. This was seen in the case of the port of Rotterdam where a waste-to-chemicals project within the port was converted to a waste-to-jet because of the demand for sustainable aviation fuel. Similarly, alternative sustainable energy such as the energy from solar panels was used for its operation considering climate change. Infrastructure projects have to reinvent and upgrade itself during the operations phase to integrate with the society. Hertogh et al. (2018) notes that infrastructure projects have to be flexible and adaptive to demands of the society due to changes such as self-driving cars, heavier trucks or climate change. This adaptability can be extended to the operation phase of projects as they cope with changes and seek to integrate better with the society.

5.3 Diversifying its impacts

It is noted that because of the long lifespan of infrastructure and a focus on single purpose, many infrastructure assets have limited functionalities (Hertogh et al., 2018). From our empirical data, we observed that the Oresund bridge expanded its impacts to other areas such as the Oresund Science Collaboration. The bridge had diverse impacts such as on housing, ports, and bringing new industries to the region thereby acting as a laboratory for institutional change while facilitating various collaboration structures and institutional solutions. Similarly, the Port of Rotterdam also had impacts on heating, housing, and energy transitions. The spillover effects of infrastructure on regions beyond the areas where the infrastructure is located or crosses through is widely discussed in the literature (Cantos et al., 2005). The findings from this research extends the literature by highlighting that spillover effects can also be in other sectors. Existing infrastructure during its operation phase should seek other opportunities to expand its functions, diversify its impacts, and reach wider areas. Not just for existing infrastructure, new infrastructure should also be built with a multi-disciplinary focus considering its diverse impacts such as on housing, highways, water safety, etc. In short, existing infrastructure has to be used for a longer period of time for achieving circular construction as it saves raw materials and energy and is usually also cheaper (Hertogh et al., 2018). Designers during the planning phase and asset managers during the operations phase should the potential to increase performance of infrastructure

projects by merging multiple functions (Spiering et al., 2010). The possibility of achieving the ambitious impacts of an infrastructure project set during the planning phase should be explored throughout the operations phase. Integration of functions could also facilitate dividing expenses between multiple stakeholders in the area.

6. CONCLUSION

The current focus of value creation restricted to the frontend of infrastructure projects need to be extended to the operations phase to harness the value of projects throughout the lifecycle of the project. In this research, we explore how infrastructure projects integrate with society in the operations phase considering the case study of the Oresund bridge and the port of Rotterdam. We highlight that during the operation phase the infrastructure acts as an enabler, adapt to changing needs of the society, and diversify its impacts.

We make multiple contributions from this study. Firstly, it is empirically observed that an infrastructure in its operation is part of an environment and constantly interacts with other projects and society. Secondly, we highlight how strategic interventions in the operations phase of an infrastructure can turn it from failure to success. Thirdly, along with starting new infrastructure projects for improving economic activity, the potential of existing infrastructure in its operation phase to improve economic activity and integrate with society should be explored. Fourthly, the findings from this research highlights that spillover effects of an infrastructure can also be in other sectors extending the literature on effects in other regions. Finally, we highlight that there should be a multi-disciplinary focus considering diverse impacts such as on housing, highways, water safety, etc., for diversifying the impact of existing infrastructure as well as for constructing new integrated infrastructure.

There is a need for more research on existing infrastructure to understand how to enhance value for already constructed infrastructure assets. The research calls for future studies to systematically study how existing infrastructure can integrate with the society. We also call for qualitative ex-post evaluation of projects considering the diverse spillover effects it has in the region and other sectors.

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