

# HOW DO INFRASTRUCTURE OWNERS BUILD CAPABILITIES TO REDUCE OPERATIONAL FAILURE?

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There are limited studies that have focused on understanding the causes of operational quality failure, which is recognised to be a significant and costly problem for owners. This paper investigates why assets handed over to owners have failed during operations, and proposes new ways that capabilities can be distributed to reduce potential operational problems from arising. This study identifies and measures quality cost failure in five projects within a single client organisation. This is achieved by means of preliminary Delphi reviews on operational problems and 19 in-depth interviews with an expert sample from five specific infrastructure projects. The interviews included those involved with project delivery and operational use of the asset. Empirical data was gathered using card sorting and semi-structured interviews. The preliminary findings indicate the importance of quality cost failure and the fragmentation of capabilities in addressing operational failure. By identifying and measuring quality cost failure, owners will learn and be able to procure more integrated failure-mitigating capabilities for reducing failures.

Keywords: failure, operational capabilities, quality cost, mitigating capabilities

## INTRODUCTION

The construction industry is making clear their commitment to move away from transactional, cost driven procurement to embrace the creation of value through integrated collaborative owner, contractor and supplier alliances. However, all too frequently projects deliver failures in critical operational outcomes, put operations at risk, constrain future investments and jeopardise innovation. At every level of the construction supply chain the prices tendered by companies include allowances for the management, overhead and corrective cost of failures, all of which is avoidable. Delivery to time, cost and quality has perhaps remained the mantra of the construction industry, although failures post completion is still highly recurrent (Razak *et al.*, 2016) with little focus on the failure implications (Hall and Tomkins, 2001; Barber *et al.*, 2002). Capable owners assume that projects will integrate with operations. Some place significant weight on the capabilities of contractors and suppliers in understanding how this is done, but research perhaps shows, owner's project and operational capabilities are the key (Davies *et al.*, 2016) and understanding of the operation must be distributed across an inter-organisational network of suppliers. These capabilities need to be simultaneously managed (Davies and Brady, 2016) and

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this study will focus on those capabilities needed to reduce the cost of operational quality failure. Within the project-based organisation (PBO) literature, there is a need to understand how the distribution of capabilities create lasting performance (Brady and Davies, 2004) that collate and integrate knowledge and skills. Owners and operators must advance their capabilities (Winch and Leiringer, 2016), both strategic and operational capabilities (Helfat and Peteraf 2003 and Mora *et al.*, 2008). More specifically, owner's capabilities are needed in managing operations in responding to poor quality and performance and addressing non-conformance to owner needs and requirements.

Capabilities facilitate problem solving and can be used to structure resources (Schreyogg and Kliesch Eberl, 2007). However, projects are built on multi-organisational capabilities that dynamically embed value that is transmitted through resources and people (Davies and Brady, 2016, Flynn *et al.*, 2010). Whilst there has been much talk of the capable owner in these processes, little has been written about their capability in supporting a project that is ready for operation. Some have identified the value lost from rework (Barber *et al.*, 2002), defects or product non-conformance (Hall and Tomkins, 2001), but rarely has been explored on quantification of operational failure. This research aims to explore quality cost failure from the perspective of the capable owner. Capturing integrated capabilities across a multi-organisational network to test if this could assure operational success. This study has appraised the operational cost of quality within a single owner organisation to understand the distribution of capabilities across an owner's multi-organisation network within project-based organisations.

#### *Distribution of Capabilities within Project-Based Organisations*

There has been a move from traditional strategies to project based organisations (PBO) to address increasing complexity, uncertainty and risk (Melkonian and Picq, 2010). The complexity and uncertainty of a project can be explained as "temporary coalition", "multiple project" or "intra-organisation" environment that extended beyond the boundary of single firm (Hobday and Davies, 2005; Söderlund and Tell, 2015; Sower *et al.*, 2007; Brady and Davies, 2004). In different organisations, capabilities are developed through organisation resource allocation that is embedded in individual structures (Schreyogg and Kliesch-Eberl, 2007), thus project organisations conceive a distinct behavioural pattern that is complex in nature of building the project coalitions. Davies and Brady (2016) suggested capabilities based on multiple short term projects need to be integrated to continuously add value in competitive projects.

Capabilities require resource investment, and define how resources should be allocated, coordinated and deployed (Schreyogg and Kliesch-Eberl, 2007 and Ethraj *et al.*, 2005) also representing a repository of historical experiences and organisational learning (Winch, 2016). Capabilities distributed during the strategic stage play a significant role in delivering operational and project outcomes (Eisenhardt and Martin, 2000 and Mora *et al.*, 2008), however continuous investment is needed to build new resource configurations, and to respond and adapt capabilities to the external environment. Comparatively little attention has been devoted to how distribution of capabilities will impact project operational failure.

Research by Davies *et al.*, (2016) shows the importance of the owner requirement and capability integration role. As project participants often focused on their own interests and managing their own project risks, rather than on the operational realisation of the

owner's objectives (Hughes and Murdoch, 2003). This can lead to the misalignment of project capabilities. Capabilities are shaped and adapted by different organisational decision makers (Flynn *et al.*, 2010; Davies and Brady, 2016), although the capability role of the owner is unclear, particularly as suppliers move to operate and maintain facilities (Davies *et al.*, 2016), the balance between owner and supplier operational capabilities need further investigations.

#### *Operational Quality Failure Cost and Capabilities*

Operational capabilities may not be easily obtained as they are generally firm specific skills, processes, and routines (Flynn *et al.*, 2010) that are developed within the operations management as a continuation of project capabilities. Research shows limited understanding of capabilities in the project lifecycle that explains the fundamental source of firm heterogeneity (Helfat and Peteraf, 2003). In operation management, operations strategy places equal importance on strategic management as operational failure may be a consequence of project processes, poor management of performance or poor quality (Love *et al.*, 2018). Operational failure can occur either during the process or within the final product of the construction project. Although, much research has shown the implication of failure and its effect on quality cost (Love and Irani, 2010), few have focused on post-operations quality cost (Hall and Tomkins, 2001).

Ethiraj *et al.*, (2005) argued capabilities reflect on the evolutionary process of considering firm specific investments that results in heterogeneity of firms and its consequent is differences in their performance. However, the challenge of diversity in capability towards innovation and uncertainty (Davies and Hobday, 2005) may be apparent, but the effect on project failure may be less evident (Morris and Hough, 1987). Every failure may be quite different from one to another, and so the causes of project failure may be a contingent to the project life cycle (Pinto and Mantel, 1990). Therefore, project management literature has suggested a better understanding towards the organisational structure and project-based management in managing capabilities (Söderlund and Tell, 2015) and the quantification of quality cost (Hall and Tomkins, 2001).

Given the difficulties in addressing construction quality costs have been discussed by many (Hall and Tomkins, 2001; Jafari and Rodchua, 2014), operational quality failure costs are determined as the most significant and difficult to evaluate (Sower, 2004; Snieska *et al.*, 2013) among other cost in construction projects. Although some studies looked at owner management (Davies *et al.*, 2016; Winch and Leiringer, 2016) but none has comparatively discussed the relationship of owner and its supply chain capabilities impact on operational problem. It is therefore necessary that the evaluation of these quality costs should be initiated with the identification of potential failure and causes, in which embedded within the organisation of capabilities in the project lifecycle. By far, the quantification of failure cost frequently used to transfer the effects of poor quality into monetary terms (Hwang and Aspinwall, 1996) that can be used to visualise and assist management in preventing and improving operational failure.

## **METHOD**

A multi-project case study approach has been used within a single client organisation to understand the distribution of quality failure cost reduction capabilities. A case study protocol was used to help ensure reliability and used a mixed-method approach. The case study research method included card sorting and semi structured interviews

with a selective expert sample. An expert Delphi technique was used to identify the most suitable case study project and in selecting all experts during four stage of a preliminary study. The first stage of interviews with project managers (n=7) lead then through snow balling to a selective sample (n=12) across the five project specific case studies.

A card sorting method was used to aid the participants in selecting the cost elements incurred in each specific case, the estimated cost, the factor that influences the cost of those selected elements and those involved with the operational issues. The combination of these methods showed what is known about the causes of operational quality failure cost within the complex multi-organisation project structures and context. This method was then repeated across all interviews (n=19) with operational teams. Assessments were made in face-to-face interviews and a multi- representative workshop to further advance and generalise the findings. Note, memo, documents and voice recording were used to capture qualitative data, along with interviews which were professionally transcribed. All data was collected, displayed, reduced and verified using a thematic method that progressed through several rounds of coding transcribed interviews, case-by-case to abstract and transform data into emergent pattern codes and later categories. These categories and their respective themes are further explained, analysed and discussed in the following sections.

## **ANALYSIS AND FINDINGS**

### *Appraising the Quality Cost*

Preliminary studies within the owner organisation identified five projects with a range of operational issues that differed according to project context and environment. The studies indicated operational issues were not quantified, thus causes of failures were not understood, learned from and so improvements were frequently not made.

Table 1 demonstrates numbers of quality failure cost elements selected by the experts during the exploration of the case studies. All elements were selected more than once in almost all projects. One element ‘early obsolescence’ was only selected in two projects (C and E). Environmental cost was selected least of all the elements.

*Table 1: Cost of quality failure elements selected in project specific case study.*

Quality cost elements	Project A	Project B	Project C	Project D	Project E	Total no. selected
1. Insurance cost	6	1	1		2	10
2. Latent Defect Cost	7	1	6	2	7	23
3. Safety cost for operator	4	1	3	1		20
4. Asset availability costs	2	2	7	3	7	21
5. Energy use costs	1		2	1	2	6
6. Maintenance costs	6	4		2		31
7. Environmental costs	3	1	1		1	6
8. Lifecycle performance costs	4	2	5	2		21
9. Functionality costs	2	2	1	2	2	9
10. Unadaptable costs	1		2	1	3	7
11. Early Obsolescence costs			2		4	6
12. Reputation/ brand cost indirect consequential losses	5	1	5	2	5	18
13. Operational training/ readiness costs	6	3	6	1	4	20

A particularly important element is ‘maintenance cost’, overall this has been selected 31 times. Different projects show a different range of quality cost incurred with different awareness on quality cost selected. Project B shows the lowest selection among all quality cost elements and Project E has more range on the selected quality cost with average 2-11 times. Following on to the selection of case specific quality

cost failure elements, experts then estimated their real costs. To generalise across projects of differing scales, the failure costs were divided by the total cost of the project to show the cost of failure as a proportion of the total. The proportion of project failure was described as a percentage (%). This indicated that the cost of operational quality failure ranged from 0.1% (£40,000) to 13% (£5,000,000) of the total project cost, demonstrating the significance.

*Capability within the Supply Chain to Address Quality Failure.*

Empirical data from all project cases show the importance of strong capabilities within the supply chain during execution. Figure 1.0 mapped the cause and effect of considering the lack of value placed on technical expertise during executions that led to the operational failure such as the use of non-confirming product, poor material performance and projects overrunning the schedule.

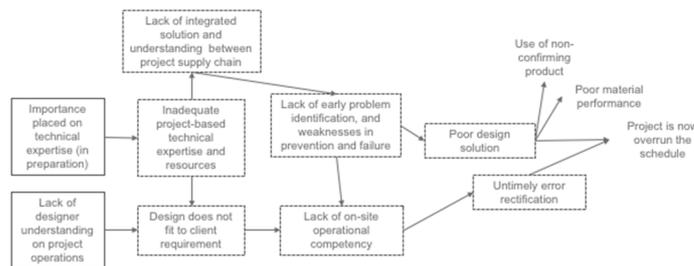


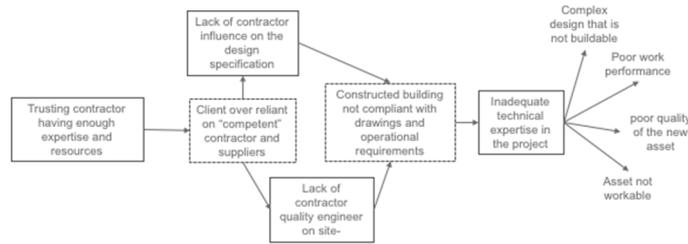
Figure 1: Cause-and-effect of technical capabilities within project supply chain

Figure 1.0 indicates there are two obvious causes from the effect of inadequate technical expertise in a project; that is lack of competency on site-operations and lack of integrated solutions and understanding between the project supply chains. In most cases, poor competency on-site operations meant that problems were not identified early. Therefore, the operational failure was not prevented and adequately appraised. In most projects, the owner assumes the contractor is more responsible, thus client technical expertise was less valued by the project team assuming the contractor has fully understood the owner operational environment. In project B, the team faced difficulties to fulfilling demanding requirements, with insufficient information and knowledge on operating of the new asset. Project C and D showed complex design and technical problems that were not understood and resolved by the contractor due to limited capabilities. The project indicated operational capabilities were not integrated during the project execution and led to the project not performing. Moreover, in some cases, less emphasises on the technical expertise role create low-motivation among the technical experts and has indirectly influenced poor capabilities of learning; because of each specialist tending to work according to individual assignments rather than integrating the systems. Some of it may be due to time constraints as projects need to be completed on time thus effecting project decisions where top management were frequently influenced by ‘getting the asset complete’.

*Capabilities within the Contractor to Address Quality Failure*

Although capabilities are usually firm specific, owners need to carefully understand contractor capability as it may affect the successful operation of project presentation aspects. Technically, the contractor is pertinent to the execution, but may not be fully involved in the operations of the asset thus not aware of the owner’s unique operation’s environment. As shown in figure 2.0, there was inadequate technical expertise in the project especially in operational capability. The owner was perhaps overly reliant on a ‘competent’ contractor and supplier thus the contractor who had

limited opportunity to influence the design, did their best to construct the complex design.



*Figure 2: Cause-and-effect of capabilities within the contractor*

Figure 2 demonstrates the contractor who has less quality involvement from engineer may have difficulties in complying with client requirement due to inadequate information from a technical expertise perspective. In project A and C, quality was given less emphasis due to limited time and non-integration of capabilities between the team. Project A was built with poor quality performance, while project C showed an unsuitable use of materials. These have led to both project non-compliance and owner dissatisfaction. What was evident, was the owner trusted the contractor could comply with the quality standard. However, the operational complexity implies continuous quality support from all parties to ensure the project will meet all parties' expectations.

*Capabilities within the Owner to Address Quality Failure*

In project A, the designer may have designed the project according to owner's needs but has limited buildability capabilities. The complex design was less integrated with contractor capability thus hindered effective quality control as the contractor was only driven by the owner's critical completion date. Frequently, design was only developed later by contractor thus poorly emphasis on the construction and functionality side of it. Mostly, projects show owner assumed contractor to have the competence capability, but supply chain shows limited influenced on design and quality executions have only led to non-compliance to design and quality for operations. Supply chain always believed that owner should provide insight when they needed, but sometimes owner focuses more on the limited time and cost, forcing contractor to work out of order thus quality was always less prioritised. Figure 3 demonstrates cause and effect mapped to show examples of how owner capability effects project performance. Commonly, projects have complex interrelated systems of systems. In some cases, data shows the owner's choice of procurement route was effected by the complexity with complex projects and are either critical to time as the project is needed to be compliant to demanding regulations, interdependence to another project or the need to avoid an operational penalty.

The owner may have selected a preferred contractor due to past experiences or long-term relationships to reduce project uncertainty. In project a, due to stronger relationship between supplier and client, the main contractor was not able to contribute to material selection. Early involvement did not occur to create integration and to align the contractor with the selection of materials' decision, thus this increased the risk of the project for the owner. Four of five projects showed that critical time significantly influence operational issues with one project abandoned. In the majority of these cases, the complexity of the project and focus on completing the project led to the quality of execution being less prioritised.

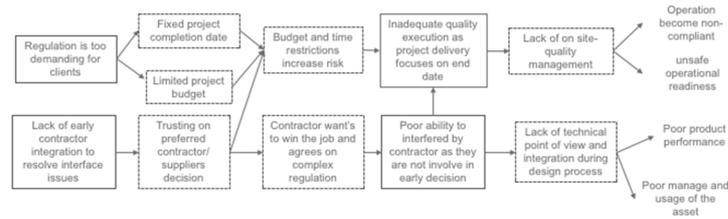


Figure 3: Cause-and-effect of capabilities within the owner

## DISCUSSIONS

A previous study (Razak *et al.*, 2016) showed low maturity in how cost of quality failure is perceived and the limitations of quality management systems during the complex and multi-organisational project process. However, the study showed high awareness of operational quality issues with owner and supply chain, but the expertise and the responsibility for resolving them to reduce failure was doubted. Owners have significant influence in dealing with operational failure, although the quality costs resulting from operational failure were intertwined within complex multi-organisational arrangements. The question is who should take a share in the risk and who pays for resulting operational failures? The finding showed quality cost failure range from 1%-13% from total cost of quality, this illustrates the range of quality cost failures that capable owners could significantly reduce. Through for example project integration, risk sharing (rather than transfer) and the distribution of capabilities across the multi-organisational owner-supplier network.

Capabilities that are embedded in different organisations (Söderlund and Tell, 2009) may influence project culture and behaviour as each unique organisation has individual expertise, but the integrated capabilities need stronger management from owner. Davies and Brady (2016) suggested, relationship between dynamic and operational capabilities need to be reciprocal, recursive and mutually reinforce. This research showed integrating project and operational capabilities will aid the project team in knowing how and when the project needs to structure their capabilities that influence the operational necessity. From the empirical case studies, integration on technicality aspects from the owner to the supply chain could better prevent the occurrences of failure. What this has shown is the need for integration capabilities between the owner and supply chain, to mutually support and share capabilities in fully understanding the project process and plan according to operational technical necessity. This shows the equal value of balancing and distributing project risk among the project stakeholders.

Empirical data demonstrated capabilities were not integrated. Resulting in project and operational quality and performance being partially not delivered. Assets as a result were not workable, design was partially unbuildable and not ready for operation. Operational integration is achievable through early and long-term contractor and supplier engagement and clear skill, training and working practices guidance from execution to handover (Ordanini and Rubera, 2008). What is evident is early engagement of the contractor helps greater understanding of project capabilities that responses to project operations thus increase the competencies among the project team to provide fair solutions and prevention of failure. Therefore, integrating capability will make the sure project is executed and operationalised. The analysis showed integrating contractor capabilities with project operations could reduce failure as they would share responsibility for project risk thus having more opportunity to provide

greater quality realisation by working together with designer and suppliers in mitigating failures.

This study has shown that it is important for a capable owner to apply system integration (Davies and Mackenzie, 2014). They must understand the full network of supplier capabilities and how these contribute to failure through design, execution and the operation of projects. Although, many teams will exhibit different behaviour when put under pressure (e.g. limits of time and budget) as demonstrated by the case studies. Quality is important during the strategic stage (Hernandez and Aspinwall, 2008), but quality at the operations stage is seldom investigated. New multi-organisational quality assurance processes must therefore withstand pressures of budget and time. By providing stronger management on integrating capabilities project risk will be shared among the owners and supply chain thus quality execution will be more assured. This instance the necessity of contractor capability to influence the design and construct project process as according to owner quality expectation.

The owner's long-term relationship with the contractor and suppliers should help the owner to better distribute the right capability, based on past-experiences and understanding of how the contractor works. The research showed that the procurement route used by the owner significantly influenced project operational quality delivery. The owner awarded contracts on a lowest project cost basis; however, all cases showed additional work during operations. The cost of quality failure was therefore not shared from the beginning, but transferred or absorbed by some parties. Additionally, poor selection of contractors who did not have adequate capabilities, increased project risk and led to project abandonment. By distributing and integrating the capabilities of various project participants, failures could be foreseen, prevented and addressed at an early stage, rather than contributing to operational failure. Love *et al.*, (2018) reports that quality failures may not only effect owners but significantly impacts the profitability of contractors. Thus, it is imperative that owners and their supply chain address quality failure so that this capability can be engendered to improve construction projects and reduce failure.

## **CONCLUSION**

This research started with the need to appraise, explore and understand the causality of post-completion quality cost failure. Literature on capabilities within owners and the supply chain in project-based organisation concepts were synthesised to describe and characterise the divergence of capabilities in a project based-organisation. This provided a useful means of understanding the multi-organisational case study environment from the perspective of a capable owner. The case studies showed the diversity of capabilities of the owner and its supply chain and the influence on the occurrences of failure. Empirical data revealed a lack of operational capabilities within the project supply chain which influenced the existence of operational failure. The long-term relationship between the owner, contractor and suppliers provided opportunity to capture and use the capabilities to address operational failures. Data also showed project procurement routes drove different behaviour and culture with significant variance in how project teams used their own capability in responding to quality issues. Capabilities were embedded and intertwined in these complex infrastructure projects. A strong capable owner requires understanding on this diversity to better distribute capabilities.

Capable owners must create collaborations and proactive approaches between the supply chains to access the capabilities of their supply chains. With greater access,

owners and suppliers can work together to balance the emergent and dynamic capabilities of the supply chain and better identify root causes and cost effective failure mitigating solutions. Therefore, by integrating capabilities between owner and its multi-organisations in projects will reduce the risk of operational quality failure. Capable owners need concerted effort in agreeing project goals between parties, thus encouraging better identification and measurement of quality issues to address failure. The findings revealed that learning capabilities were not fully attained and distributed by the project team and operational stakeholders, therefore further work is needed to clearly identify and fairly distribute failure mitigating capabilities.

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