

DELIVERY OF COMPLEX CONSTRUCTION MULTI-PROJECTS IN CONTRACTOR-LED PROCUREMENT

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As the demand for Contractor-led procurement routes for large and complex projects increases, the pressure for improved delivery also increases, putting the construction contractor at the fore-front of creating value through innovation, collaboration and integrated working. Companies have to adopt approaches that not only successfully deliver a single project at a time but which recognise the multi-project environment of the construction contractor. This research builds upon a theoretical socio-technical systems framework for understanding and managing complex construction projects. The paper outlines the evaluation and revision of the framework through a series of expert interviews and pilot case study. Empirical feedback is used to provide a better understanding of the nature of complex construction projects and an insight into how they can be managed accordingly.

Keywords: socio-technical systems, contractor, framework, collaboration

INTRODUCTION

Within the construction industry, the increasing demand for contractors to play an integrated role especially in contractor-led procurement systems (such as design and build, Private Finance Initiative (PFI's), etc) has increased the pressure to improve performance. According to *Constructing Excellence in the Built Environment (2009)*, the “era of client-led change is over, at least for the moment, and that it is time for the supply side to demonstrate it can create additional economic, social and environmental value through innovation, collaboration and integrated working”. For project-based firms, such demonstrations mean improved performance when managing complex projects in their multi-project environment. This view had been previously articulated by Winter *et al.* (2006) who stressed that the performance of the industry could be improved if the current conceptual base of project management were made relevant to practice. Winter *et al.* further argued that there was the need to develop new models and theories which recognise and illuminate the complexity of projects in order to enrich the industry's understanding of the actuality of projects and project management practice.

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Construction contractors are moving towards multidisciplinary teams offering diverse services ranging from design to management services. Most projects take place in a multi-project environment. However, project management literature and research have predominantly been carried out as if projects take place without the impact of the environment in which they are executed. Project-based organizations tend to run more than one project at any time, which may be interdependent at least on resources. These projects are undertaken simultaneously and managing them not only to cost or budget and timely completion but also to create value for a business is a challenge. The consequences faced by a construction contractor, who plays a leading role in the procurement process are significant, especially in terms of integrating and co-ordinating the entire supply chain to achieve client satisfaction and also anticipated repeat business. For such companies, the focus of management goes beyond achievement of individual project objectives to pursuing approaches that deliver value for the organization and its stakeholders.

In this paper, the authors present the final stage of a research project, the aim of which was to develop a suitable approach for managing complex construction projects in a multi-project environment by the contractor. The paper builds on a theoretical socio-technical systems framework for understanding and managing complex construction projects which can be found in Hagan, *et al.* (2011). The outcome of an empirical evaluation of 21 expert interviews and a pilot case study is described to revise/confirm the framework and evaluate its use in delivering complex multi-projects. In addition, the framework and its underlying relations are discussed along with how it delivers complex construction projects.

COMPLEX CONSTRUCTION MULTI-PROJECTS

The bundling of construction work into fewer, but larger contracts means that more responsibility is transferred from major clients of the construction industry to contractors. The construction contractor in such leading role is faced with the challenge of managing the interrelationships of the whole supply chain which makes the projects complex. According to Ruuska *et al.* (2011), such large complex projects present unique challenges due to the: 1) the dynamic network of organizations that combine resources, capabilities and knowledge of participating actors to achieve clients needs and 2) differing and often conflicting objectives and expectations not evident if the projects were carried out by individual firms. However such challenges are not easily dealt with, resulting in lack of performance and in some situations project failure.

Several reasons have been attributed to this lack of performance, some of which are: reluctance to accept and adapt to change (Constructing Excellence, 2009); project complexity (Remington and Pollack, 2007); lack of committed leadership, focus on customer and commitment to people (Egan, 1998); and procurement issues (Bower, 2003); among others. Another important reason given is the lack of understanding of the effect of running projects in a multi-project environment (Artto and Dietrich, 2007, Payne, 1995).

The players in the construction industry therefore are under immense pressure to perform, and especially more now, in the current economic downturn. All parties involved in the construction process will be expected to make changes in order to improve performance and remain competitive. Thus there is the urgent need for clients, contractors, subcontractors, suppliers, or consultant organisations of the industry to reshape and align their strategies and structures to meet the challenges of

their environment and the complexity of projects. According to Winch (1987: p.970), “construction projects are amongst the most complex of all undertakings”. Baccarini (1996: p.201) also emphasises this view by stating that “the construction process may be considered the most complex undertaking in any industry”. However, there are no well-defined frameworks for describing the key dimensions and characteristics of project complexity according to Xia and Lee (2004). It is therefore vital that the dimensions of complexity are understood and appropriate approaches developed for the delivery of such projects.

Construction contractors like any project-based organization, with the responsibilities of integrating the entire supply chain, run more than one project at any time or several projects that may be interdependent on each other. Thus they operate in a multi-project environment which is dynamic and unstable. In any typical construction organization (i.e. project-based firm), there would be one or more projects being executed at anytime with limited resources and information. These projects may be executed at different sites or locations and may also have different start times or be at the same stage of construction. The dependencies connecting the different projects may be organizational, technological, knowledge-oriented, systems or inter-linked by the deliveries made to the client (Baccarini, 1996, Danilovic and Borjesson, 2001). Additionally they may share important resources with other independent projects such as people. Irrespective of this practical situation, mainstream literature in the field of project management has been dominated by single project environment as if companies execute one or more projects independently or as loosely interdependent projects (Hossain and Ruwanpura, 2008, Pellegrinelli, 2011). According to Payne (1995), managing complex projects in a multi-project environment is concerned with dealing with issues wider than in the single project environment. For example, in a single project environment, scheduling are performed independently for each project, while productivity methods focus narrowly on individual activities (Sacks, 2004). Also the multiple interfaces between projects and resources utilization are not harmonized (Eskerod, 1996).

Antoniadis *et al.* (2011) argued that understanding the characteristic of interconnections in a construction environment and how they affect project performance will contribute to a more efficient project delivery system. Typically this environment is a challenge to the construction contractor who has to undertake several projects of different sizes and types at different sites with limited resources (Danilovic and Borjesson, 2001). Hossain and Ruwanpura (2008) also argue that the ability of the construction contractor to optimise schedules and resource utilization while competing with other projects executed by other contractors is critical.

To better understand and conceptualise the real world context within which organizations manage projects, there is the need not only to:

- Conceive the organization as a structured, bounded phenomenon, existing in an ordered and given social context; capable of skilfully organizing flows of action and information in an unstructured, fluid, dynamic interrelationships (Chia and King, 1998, Tsoukas and Chia, 2002), but also more importantly,
- Encapsulate the relationships between projects and the intricate network of intra and inter organizational relations which define the way many project-based activities and operations are nested and embedded (Engwall and Jerbrant, 2003, Sydow *et al.* 2004).

The systems concepts provide the basis for thinking about organizations and the environments in a holistic manner. In the context of the systems approach in relation to the construction process, Walker (2007) argues that “the attraction of systems theory as a medium for identifying a conceptual framework for the management of the construction process lies in the basic premise that a system is an organized or complex whole: an assemblage or combination of things or parts forming a complex or unitary whole, which is greater than the simple sum of its parts”.

EARLIER WORK - THEORETICAL FRAMEWORK

In the early stages of the research, an extensive literature review was conducted in order to identify a gap and establish the opportunity for the research. The review also led to the development of a theoretical framework which identified the main themes and factors that influence the management of complex projects in the multi-project environment of the construction contractor. The set of factors and themes identified were used in a causal relationship to develop the framework which was based on the underlying logic of socio-technical systems approach. With the help of the relevant literature, the framework was adapted to suit contractor organisations in construction. Figure 1 illustrates the resulting framework, more details of which can be found in Hagan, *et al.* (2011).

The underlying logic of the framework is based on the philosophy that the effectiveness of an organisation is related to the joint maximization of its social and technical factors (Cherns, 1987, Clegg, 2000, Katz and Khan, 1978). On this basis, an organisation is viewed as a system comprising various interrelated, co-dependent sub-systems in a state of dynamic interplay (Clegg and Shepherd, 2007). It becomes necessary therefore, to view the organisation as a single, interrelated system whose sub-systems must be considered jointly for maximum performance. Thus to the extent that organisations are effective and efficient in delivering complex projects, there is the justification for viewing all that is involved in the organisation as interdependent and given joint consideration. Therefore for effective and efficient delivery, the whole system including its people, processes, product, goals, decision-making and resources should be viewed as interdependent and given joint consideration.

In this way, the different factors that have impact and causal changes to the system can be observed, investigated and managed. It can also increase understanding on how other factors that emerge may affect the system. This understanding should provide a basis for manipulating the system to maximise its performance or delivery.

The framework uses the socio-technical systems approach to draw out links that exist between identified themes or factors. The logic of the framework is that a whole variety of relationships exist within executing organisations, the nature of which may determine the impact such interactions have on the delivery of projects.

The framework also reflects the importance of integration as a key business function for bringing together the product, goals, people, process, and resource. These factors, along with its inherent uncertainties, aid good decision making that enable better field performance. The framework focuses attention upon the need to bind together the differentiated yet interdependent contributors to project delivery in a multi-project environment.

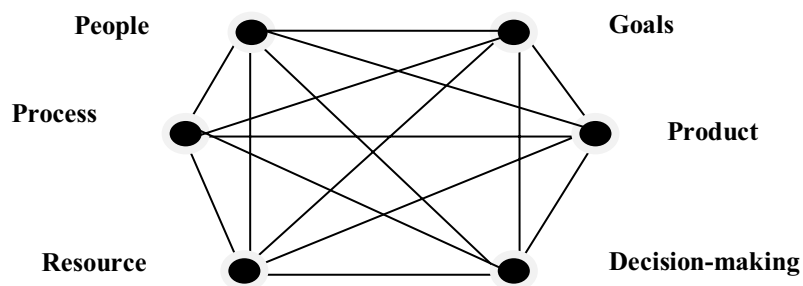


Figure 1 – Theoretical framework - interrelated factors involved in delivering complex projects in multi-project environment (Adapted from (Challenger et al. 2009))

EXPERT INTERVIEWS

Twenty-one construction project management practitioners with long and varied experience of managing complex projects were interviewed. The practitioners included chief executives, managing directors, project directors, project managers, planners, design director, commercial director and human resource manager. To provide form to the interviews and also allow probing, semi-structured interviews were used to collect data (Fellows and Liu, 2008). The objectives of the interviews were to seek both qualitative feedback of the framework and also detailed description of the interrelationships involved in managing complex projects.

Feedback

Missing themes/factors and any underlying logic among the factors were identified using the semi-structured interviews. The interview sessions were recorded with the permission of the interviewees, transcribed and coded. Interviews were usually between an hour and two. The coding was formed into clusters of contextual areas so that relationships that otherwise would not have been clear was brought out. Patterns and revisions resulted from the analysis which was worth considering in revision or confirmation of the framework. The main feedback resulting from the interviews can be summarized as follows:

- Risk was identified a common factor inherent in all the other factors already identified. The impact of risk not only in the individual factors but also in combination with other interrelated factors were considered crucial to effective delivery of complex projects
- Organizational culture in terms of understanding and how the organisation do things was considered as very important when dealing with other organisations or stakeholders in the delivery of complex projects. This was however considered to be embedded in the people and processes of the organisation.
- The qualitative feedback on the framework's usefulness, practicability and applicability was very positive. The framework was mostly seen as easy to use and understandable in capturing factors which could affect the delivery of projects. Factors that feature predominantly can easily be identified, monitored and addressed.

CASE STUDIES

The research included a pilot case study at the exploratory phase to test the theoretical framework developed, gain feedback and test the methodology / data analysis method adopted. Four further case studies were conducted at the investigative phase to gain understanding of how construction contractors manage complex projects in their multi-project environment. The case studies complemented the semi-structured interviews by providing deeper insights (Rowley, 2003). Using a triangulated approach for the data collection encompassing evidence from interviews, documentation and archival records, the cases were formulated. The analysis of the case study was based on the theoretical framework acting as a prior proposition and evidence gathered used to either confirm or revise the framework (Yin, 2003). The case studies involved construction contractor companies within the construction industry delivering integrated contracts like design and build and PFI, which have high levels of interdependencies and uncertainties. All the five cases were major UK based construction contractors. The criteria for selection of cases were: that the company was a major UK company with multiple projects being currently delivered simultaneously; and one or more of the projects included an integrated contract type. The unit of analysis was the complex projects delivered by the organisation. The analysis of the cases was dependent on using the theoretical framework as a prior proposition and the evidence gathered either used to revise or confirm the framework. This paper presents the results of the pilot case study and semi-structured interviews which were conducted as part of the investigations carried out for the study.

Pilot Case Study

To gain feedback on the theoretical framework and also test the research methodology adopted, a pilot case study was carried out. The pilot case study refers to a major UK construction contractor with employees over 1500 and turnover over two billion pounds. In 2008, the company won a PFI multi-projects made up of 4 primary schools; 4 secondary schools and 4 special needs schools. The company set up a special purpose company to deliver the multi-projects with its own Chief Executive Officer and Board to oversee the delivery. Although set up as a self sufficient company, the new company relied partly on the main company's processes, people, and resources to meet its objectives set by the Board. The delivery of the individual projects were also carried out with project managers whose main aims were to execute their projects without much regard to what was happening with the other projects. Some subcontractors employed on the projects had more than one project to work on. Similarly, the planning of the works was carried out in isolation of the other projects. The main company has been successful in delivering this kind of integrated procurement over the years and pride themselves in being able to create value by their drive for innovation and constant quest for change and improvement. Their company's delivery system consists of in-house governance structures that includes decision-making, people and processes. However, this delivery system is carried out in isolation without considering the interrelationships that exist and how they may impact the delivery of complex projects. Using the framework developed interrelationships were mapped out and dependencies shown which provided a different way for the company to view its delivery approach.

In working with the framework, the company identified which factors influence complex project delivery. The interrelationships between these factors were easily linked and monitored to learn the appropriate actions to be taken. The emphasis of the

framework on factors such as people, process, product, decision-making, resources and goals together with the risk factor of each of them were highly accepted by the company. The overall alignment of the framework to construction was also a favourable trait encountered as feedback. The underlying relationships and logic were seen as important tools for interpreting complex construction environment and identifying possible outcomes and also showing management the probable future consequences for the company.

EMPRICAL EVALUATION AND REVISED FRAMEWORK

Feedback was gained from the semi-structured interviews and pilot case study. The feedback helped to revise the framework to provide better understanding of the dynamic factors at play in the delivery process. It showed how conceptually the factors may interrelate to affect the delivery or management of complex projects. The feedback arising from the evaluation of the interviews and pilot case study are summarized below:

- The framework was perceived as very simple and easy to understand. It provided at a glance the multiple interdependent factors which are at play at any given situation. The Project Director referred to it as being a “a very good tool for capturing all the issues one deals with in delivering projects of this nature.”
- The underlying relationships among factors were identified as naturally intricate and not necessarily causal by the practitioners. Risk was therefore identified as a fundamental factor that would result from such interrelationships. According to one of the interviewees "complexity drives risk which is also at the heart of each factor of complexity. What makes it (complexity) extremely difficult is when they tend to combine and come against you with full force".
- The framework was seen as a tool for capturing lessons learnt and helping to plan and manage future projects. By populating the issues affecting the project around each factor, managers and all parties involved in the delivery process could find ways of coping with the unique combinations of factors coming together in ways unanticipated.
- The evaluation of the theoretical framework through the semi-structured interviews and pilot case study resulted in revising the framework to include risk as shown in Figure 2.

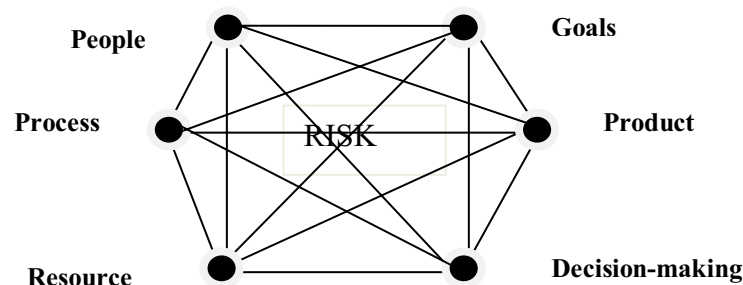


Figure 2 – The revised framework

- Using the framework it was possible to elucidate the differing objectives of the multiple organizations involved in the delivery system. This provided a better understanding of the wider effect of the project objectives on individual organisational objectives.

Risks as identified in this framework will deal with what may be associated with any individual factor in relation to others, and also enable the construction contractor to consider contingency plans for the combinatorial risks which may be at play.

DISCUSSION

The revised framework provides a more robust framework for understanding and identifying key prominent factors which require managing to deliver complex projects. According to Clegg and Shepherd (2007), any change that is driven by technology without consideration given to the social and organisational factors could result in failure. The framework not only focuses on tools, techniques, procedures, skills, or knowledge but also considers the people in the organisation, their relationships and expectations of the organizations delivery mechanism. This is in contrast to other frameworks for managing projects advocated by professional bodies such as Association of Project Management and Project Management Institute (APM, 2006, PMI, 2006) which essentially dwell on processes. The factor of process in managing projects is well articulated in project management body of knowledge as the established procedures used by organisations to deliver projects. However used on its own, it ignores the context, interactions or interrelated actions necessary for achieving the desired project or product.

The inclusion of risks is central to the way construction contractors manage complex projects. Specifically, risks that may seem minor on their own such as logistics, stakeholder expectations, etc could occur simultaneously with say city centre construction and environmental issues to result in major risks. Having a framework that can map these factors and their interdependence is a helpful step towards effective delivery. The analysis of results highlight the importance of managing the factors outlined above in the delivery of projects. These factors should not be considered in isolation as all the parts including the organizational units, subsystems or components fit together as a functioning unit and integrated whole in line with the project and organizational goals (Stuckenbruck, 1983). Viewed as a system, the contractor organisation can be considered as comprising a range of interrelated, co-dependent subsystems in a state of dynamic interplay to achieve desired goals (Clegg and Shepherd, 2007). The framework therefore provides a means for evaluating the whole project to gain better understanding. The advantages of using the framework include:

- Relative ease of use and understanding, as well as its suitability for use in construction organisations.
- Enabling the conceptualisation of the relationships among the varied factors as not simple cause and effect, but non-linear which should be managed differently.

CONCLUSION AND FURTHER WORK

The aim of this paper has been to develop a conceptual framework for understanding and managing complex construction projects by the contractor. A theoretical framework had been developed in previous work that formed the basis of a conceptual complex project delivery framework in construction. The work conducted in this research empirically evaluated and revised the framework to produce a more robust framework. Twenty-one semi-structured interviews with practitioners and a pilot case study were conducted to assess the robustness and underlying logic of the framework. The empirical interviews and case study resulted in revising the framework to include another factor (risk) in the framework. The framework was found to be easy to use,

understandable, and of good fit to the construction industry. Based on the discussions above, the potential implications for using this framework by practitioners for effective delivery of complex construction projects are: 1) for construction contractors to embrace the concept that when delivering complex projects, it is critical to focus on and manage both the interdependent technical and social factors at play in order to be effective; 2) focus of research and practice to shift from single towards multi-project delivery; 3) shift from viewing projects as stand alone entities towards a systems approach that recognises the interrelationships that exist between inter and intra project elements. The conceptual framework developed and the research conducted open up several areas for further research. The difference between client, consulting and contracting organisations, with respect to the framework need to be further researched. The nature of relationships among various combinations of factors needs to be measured in order to quantify their outcome. Additionally, socio-technical systems approach could also be applied to offer deeper understanding of how time delays due to project complexity can be managed in the delivery of complex construction multi-projects.

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