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An Analytical Network Process model for risks prioritisation in megaprojects

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Abstract

Megaprojects are complex and expensive projects that often involve social, technical, economic, environmental and political (STEEP) challenges to project management. Despite these challenges, project owners and financiers continue to invest large sums of money in megaprojects that run high risks of being over schedule and over budget. While some degree of cost and schedule risks are considered during project planning, the challenge of modelling risks interactions and impacts on project performance still remains. To tackle this technical problem, this research adopted the Analytical Network Process and combined it with a new Risk Priority Index as an innovative approach to model risks analytically based on data collected from the Edinburgh Tram Network project at the construction phase. The approach provides an interactive way for developers to prioritise risks across the project supply network and to initiate timely mitigation strategies against significant cost and time consequences of STEEP risks on megaproject performance.

Keywords: Risk assessment; Analytical Network Process; Megaproject; Decision making

1. Introduction

Construction, like many other industries is a free-enterprise system, and has sizeable risks built into its structure (Ball, 2014; Fulford and Standing, 2014; Guo et al., 2014). From the initiation to the closing stages, construction process especially that for megaproject development become complex and characterised by a number of uncertainties that can influence the project negatively, e.g see (Brookes, 2015; Dimitriou, 2014; Flyvbjerg, 2014; Flyvbjerg et al., 2003a; Mentis, 2015; Priemus, 2014; Renuka et al., 2014; Spirkova, 2014; Van de Graaf and Sovacool, 2014). For example, uncertainty about changes in weather conditions (Mentis, 2015), subcontractor delays (Diab and Nassar, 2012; Eizakshiri et al., 2015), community resistance (Jordhus-Lier, 2015), political interferences (Kennedy, 2015) and unpredictable site conditions (Adam et al., 2014; Boateng et al., 2012) can compromise the completion of megaproject development. Although certain risks from natural disasters are quantifiable using modern technology, they remain difficult to incorporate into the megaproject decision-making process. As a result, many construction projects fail to achieve their time, cost and quality goals (Brookes, 2015). Evidence suggests that large and complex projects such as highways, bridges, and airport expansion are usually money pits where funds are simply ‘swallowed up’ without delivering sufficient returns as a result of unbalanced subjective beliefs and information in assessing risks and uncertainties, and taking corrective actions to control and manage the identified risks. Poole (2004), asserts that the track record of transportation infrastructure industry is terrible during development and has lots of credibility problems. Salling and Leleur (2015) and Proost et al. (2014) emphasised that project costs for transportation megaprojects are often grossly underestimated, and traffic, often overestimated. For example, in Flyvbjerg et al. (2003b), as many as 258 highway and rail projects ($90 billion worth) in 20 countries did not perform well

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on budgets as estimated. Flyvbjerg et al. (2003b) revealed that nearly all (90%) of these projects suffered cost overruns, with the average rail project costing 45% more than what were projected, while it was over 20% in average for highway projects. Based on a continuous research, Flyvbjerg et al. (2003b)underscored that cost overrun has not decreased over the past 70 years and seems to be a global phenomenon. Other examples are the Boston's Central Artery/Tunnel (the Big Dig) and Virginia's Springfield Interchange. These projects have made practitioners in the construction industry and public taxpayers acutely aware of the problems of project delay and cost overruns in megaproject development. For example, the Big Dig was estimated at a cost of $2.6 billion but was completed at a cost of $14.6 billion. Additionally completion was delayed from 2002 to 2005. This indicates clearly that construction cost estimating on major infrastructure projects has not improved in accuracy over the past 70 years. According to Salling and Leleur (2015) and Flyvbjerg et al. (2002) the underestimation of cost today is in the same order of magnitude as it was then. Flyvbjerg et al. (2002) therefore regarded the main reason for cost and time overruns in megaprojects as simply the marginalisation of risks during feasibility studies and by assuming what the World Bank calls the "Everything Goes According to Plan" (EGAP) principle. (Davies et al., 2014; Flyvbjerg et al., 2002; Kwak et al., 2014) based on the EGAP assumptions and stressed on the need for new ideas and techniques to be developed to improve this area where no learning seems to have taken place.

With regard to the increasing complexity and dynamics of risks in megaproject construction and with new procurements methods, the tendency today is to use risk quantification and modelling more as vehicles to promote effective risk response planning amongst multi-disciplinary project team members. According to Giezen (2012) and Kardes et al. (2013) a simple but an effective risk management approach can provide a framework for project managers to identify and response to potential risk factors quickly and as well as to underpin effective and consistence communication throughout the construction supply chain. Giezen (2012) and Kardes et al. (2013) believe that a simple risk management framework can assist project members to implement early contingency plans to deal with problems resulting from the project environment. Mousavi et al. (2011) in a research argued that the proliferation of techniques and software packages purporting to provide project risk management facilities, have also failed and proposed non-parametric jack-knife resampling technique to rank risks in highway projects and to meet the needs of project managers.

Several researchers including Nieto-Morote and Ruz-Vila (2011) and Karimiazari et al. (2011) proposed the use of risk analysis techniques that are based on estimating probabilities and probability distributions for time and cost risk assessment in projects. However, these techniques do not encourage project participants to develop in-depth understanding of the underlying elements and structures which constitute megaproject risk systems and to render explicit latent concepts and assumptions which are implicit to current risk assessments. The techniques do not allow for risks and uncertainties remedial measures in a complex environment. Also the techniques do not permit lessons learned from previous projects with similar environments to be captured and re-used when developing new projects, and as a result do not facilitate continuous learning and improvement.

Against this background, the authors employed a combination of quasi-ethnography, questionnaire survey and the literature to identify different STEEP risk factors that impacted on the performance of Edinburg Tram Network (ETN) project during construction. The identified factors were then prioritised using the Analytical Network Process (ANP) method to establish the most salient risk variables on the ETN project and to demonstrate the potential benefits of the ANP approach in assessing risks in megaproject construction. The purpose of this research is to establish a logical framework that incorporates ANP method to develop a comprehensive approach to risks prioritisation for megaprojects. The interest of prioritising risk at the construction phase of megaproject development is because the risk management assessment processes in construction project development implementation literature, while acknowledging adaptation as one phase in construction process and delivery, offers inadequate theory to address the problems faced during its implementation in megaproject delivery (Charvat, 2003). Therefore, aiding risks assessment at the construction phase with an analytical tool such as the ANP can remove a number of constraints and impart a sense of fairness into the decision-making process overtime. Also, the approach will enhance the capabilities of existing tools such the over 30 risk management techniques contained in the British Standards codes of practice (BS 31100:2008 Risk management – Code of practice; BS ISO 31000:2009 Risk management – Principles and guidelines, and BS EN 31010:2010 Risk management–Risk assessment techniques) during risk management. It will further lead the construction industry to establish a self-sustaining and grounded risk management procedure for megaproject development and construction.

The objectives of this research are to:

- Identify and describe significant risks across the entire set of social, technical, economic, environmental and political (STEEP) issues related to megaprojects at the construction stage,
- Develop a framework that incorporates ANP for STEEP risks assessment in megaprojects during construction, and
- Prioritise these risk factors based on cross-STEEP interactions.

The research was conducted on the ETN project from 2001 to 2014. Based on data collected on the project, a pairwise comparison of STEEP risks was performed with the Super Decisions® software to derive the risk priority values also known as Risk Priority Index (RPI). The RPIs are values which indicate the level of impact of risks in preventing project success. The RPI was used as an innovative method to rank the level of identified risks influence on the objectives of the ETN project. The risk priority values have been summarised through further discussions. In conclusion, the RPI was proven to be a useful tool for megaproject managers

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