Available online at www.sciencedirect.com
ScienceDirect
International Journal of Project Management 34 (2016) 1183–1198
International Journal of Project Management
www.elsevier.com/locate/ijproman

Project Complexity and Risk Management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects

Abroon Qazi [a,*], John Quigley [a], Alex Dickson [b], Konstantinos Kirytopoulos [c]

[a] Management Science Department, Strathclyde Business School, 199 Cathedral Street, Glasgow, Scotland G4 0QU, United Kingdom
[b] Economics Department, Strathclyde Business School, 130 Rottenrow, Glasgow, Scotland G4 0GE, United Kingdom
[c] School of Natural and Built Environments, University of South Australia, City East Campus, Adelaide, South Australia 5000, Australia

Received 12 November 2015; received in revised form 28 April 2016; accepted 23 May 2016
Available online xxxx

Abstract

Project complexity has been extensively explored in the literature because of its contribution towards the failure of major projects in terms of cost and time overruns. Focusing on the interface of Project Complexity and Interdependency Modelling of Project Risks, we propose a new process that aids capturing interdependency between project complexity, complexity induced risks and project objectives. The proposed modelling approach is grounded in the theoretical framework of Expected Utility Theory and Bayesian Belief Networks. We consider the decision problem of identifying critical risks and selecting optimal risk mitigation strategies at the commencement stage of a project, taking into account the utility function of the decision maker with regard to the importance of project objectives and holistic interaction between project complexity and risk. The proposed process is supported by empirical research that was conducted in the construction industry and its application is illustrated through a simulation study.

Keywords: Project complexity; Project risks; Project objectives; Expected Utility Theory; Bayesian Belief Networks; Empirical research

1. Introduction

Long-term projects involving new product development (NPD) often result in major delays and cost overruns and therefore, bearing in mind the complexity of such projects, it is extremely important to consider interdependency between risks and involve different stakeholders in identifying key risks (Ackermann et al., 2014). Complexity in projects relates to structural elements, dynamic elements and interaction of these elements across the broad categories of technical, organisational and environmental domains (Botchkarev and Finnigan, 2015; Kardes et al., 2013). There are two schools of thought with regard to whether risk is an element of complexity (Bosch-Rekveldt et al., 2011; Geraldi et al., 2011) or the two are distinct concepts (Saunders et al., 2015, 2016; Vidal and Marle, 2008). Different methods have been proposed for evaluating project complexity (He et al., 2015; Lu et al., 2015; Nguyen et al., 2015; Vidal et al., 2011a, 2011b; Xia and Chan, 2012) that mainly isolate complexity from risk. Adopting such a disintegrated approach of evaluating complexity and risks in silos results in undermining the synergistic effect of interacting complexity attributes (drivers) and complexity induced risks and raises the possibility of selecting sub-optimal risk mitigation strategies.

It is not only important to understand and evaluate project complexity but also to visualise the complex interaction between project complexity and complexity induced risks in order to prioritise critical risks and select optimal risk

* Corresponding author. Tel.: +44 7435682387; fax: +44 141 552 6686.
E-mail addresses: abroon.qazi@strath.ac.uk (A. Qazi), j.quigley@strath.ac.uk (J. Quigley), alex.dickson@strath.ac.uk (A. Dickson), Konstantinos.Kirytopoulos@unisa.edu.au (K. Kirytopoulos).

http://dx.doi.org/10.1016/j.ijproman.2016.05.008
0263-7863/00/

mitigation strategies. Moreover, these risks must also be linked to the project objectives which in turn will influence the utility of the decision maker concerning the relative importance of each project objective. Although the standard risk management process (SA, 2009) comprising different stages – namely: risk identification; risk analysis; risk evaluation; risk treatment; and risk monitoring – is generally adopted in the literature of project risk management as it presents a systematic approach of modelling risks (Schieg, 2006), the interdependency between risks and complexity is not reflected in the framework.

Project complexity attributes (drivers) pose vulnerabilities to the successful conclusion of major projects involving NPD, resulting in cost and time overruns. An important aspect of establishing a link between the knowns (represented by complexity attributes or drivers in this paper) at the commencement stage of a project and the 'known unknowns' (Ramasesh and Browning, 2014) (termed as risks in this paper) that may potentially materialise within the life cycle of the project has not been given due consideration. As we are focusing on the commencement stage of a project, the risks and strength of interaction between risks included in the model represent the beliefs of experts developed through learning from past experiences. However, unexpected emerging risks introduced during the life cycle of the project and not envisioned at the commencement stage can have a significant impact on the project objectives and therefore, besides establishing an effective risk management process, there is a need to cultivate a culture of alertness to deal with such risks categorised as 'unknown unknowns' (Ramasesh and Browning, 2014). Through this research, we are contributing to the risk management body of knowledge by addressing the following research questions (RQ):

RQ1: How is the interdependency between project complexity and complexity induced risks associated with NPD in general and construction projects in particular treated in the literature?
RQ2: How can we develop a risk management process and an effective modelling approach for capturing interdependency between complexity and risk in order to facilitate the decision making process of prioritising risks and risk mitigation strategies at the commencement stage of a project?
RQ3: How is the interdependency between project complexity and risk managed in the construction industry?

Bayesian Belief Networks (BBNs) offer an effective modelling technique for capturing interdependency between risks (Nepal and Yadav, 2015) whereas Expected Utility Theory (EUT) is widely used in decision making under uncertainty (Ruan et al., 2015). Within the theoretically grounded framework of EUT and BBNs, we propose a new process namely 'Project Complexity and Risk Management (ProCRiM)' integrating all stages of the standard risk management process (SA, 2009) and establishing causal paths across project complexity attributes, risks and their consequences affecting the project objectives. The main merit of ProCRiM is its focus on the holistic interaction between complexity and risks without taking the extreme stance of either school of thought and therefore, the results do not depend on whether complexity and risk are treated as distinct concepts or not. Rather, we contend that it is the interdependency that must be given due consideration. We represent the project complexity attributes (known at the project commencement stage) as deterministic nodes, and risks and project objectives as chance nodes. We also characterise the preferences of a decision maker with regard to the project objectives by means of a utility function and demonstrate the application of ProCRiM through a simulation study.

We also present our findings from 13 semi-structured interviews conducted with construction industry experts from South Australia. The empirical research helped in assessing the current techniques/tools used in the industry and evaluating the viability of ProCRiM. An overview of the research focus and the methodology adopted is presented in Fig. 1. The rest of this paper is organised as follows: An overview of the relevant literature is presented in Section 2. The proposed process and modelling approach are described in Section 3. Details of the empirical research are presented in Section 4. The application of ProCRiM is illustrated in Section 5. Findings are discussed in Section 6. Finally, our conclusions and directions for future research are presented in Section 7.

2. Literature review

As the focus of our research lies at the interface of project complexity and interdependency modelling of risks in NPD in general and construction projects in particular, we present a brief overview of literature in each field in the following subsections.

2.1. Project complexity

Project complexity has been extensively explored within the literature on project management and a number of definitions have been proposed focusing on different dimensions including structural complexity, uncertainty, dynamics, pace and socio-political (Geraldi et al., 2011). For this study, we follow the definition proposed by Vidal and Marle (2008): '*Project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system*'. In order to gain insight into the emerging themes of project complexity, we classified the studies into three streams of conceptual frameworks/models, complexity measurement models and empirical studies investigating the constructs of complexity within different industries.

2.1.1. Conceptual frameworks/models

A number of frameworks have been proposed to conceptualise project complexity. The notion of project complexity as 'consisting of many varied interrelated parts' and its operationalisation in terms of 'differentiation and interdependency' (Baccarini, 1996) is replicated in most of the frameworks (Geraldi et al., 2011). There is a general consensus among the researchers that complexity must encompass