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Integrated management of on-site, coordination and off-site uncertainty: Theorizing risk analysis within a hybrid project setting

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Abstract

Hybrid infrastructure projects are defined as triads of on-site/coordination/off-site project dimensions. Interaction of uncertainties in such settings result in deviations from project objectives by causing time and cost overruns, safety issues, quality deficiencies, technical problems, and lack of client satisfaction. To address these, a holistic approach in identifying and analyzing risks in hybrid (multi-dimensional) projects is proposed. Towards this aim, three research hypotheses are developed and tested using data from seven projects in Melbourne, Perth and Adelaide, Australia. Practical implications of triadic risk analysis in hybrid infrastructure projects suggest executives and managers to put more emphasis on risks associated with coordination of on-site and off-site project dimensions. This approach significantly decreases the chance of deviations from project objectives.

Keywords: Decision making; Delay; Integration; Empirical research; Performance measures; Prefabricated building elements; Project Management Body of Knowledge (PMBOK); Project management success; Risk management theory; Stakeholder communication; Workflow variance

1. Introduction

Infrastructure projects provide necessary services and facilities for the economy of a country or region to function (Van Os et al., 2015). Such projects include but are not limited to building bridges, roads, tunnels, pipelines, electrical and telecommunication networks. Off-site construction processes have been increasingly used to deliver infrastructure projects (Construction, 2011). A side-by-side progression of site-built and off-site activities in hybrid infrastructure projects provides many benefits such as schedule improvements (Dzeng and Lee, 2007), project cost savings (Arashpour et al., 2014a, 2014b), quality enhancements (Kim et al., 2014), site accident reductions (Blismas et al., 2006), and sustainability improvements (Xu et al., 2012).

However, activities in hybrid infrastructure project are often undertaken under uncertainty. Within the on-site dimension of such projects, there is uncertainty associated with weather conditions (Chan and Au, 2007), quality of assembly and installations (Gibb and Isack, 2003), and safety of heavy crane operations (Li et al., 2012). Within the off-site dimension of hybrid infrastructure projects, uncertainty is present in equipment failure rates (Ren et al., 2013), continuity of material supply (Arashpour et

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al., 2013), and precision of prefabrication (Yung and Yip, 2010). Furthermore, there is a third coordination dimension to hybrid projects that consists of transportation and communication activities with relevant associated uncertainty. Fig. 1 illustrates a simplified work breakdown structure for hybrid infrastructure projects as off-site/coordination/on-site triads.

The interaction and integration of uncertainty in the three dimensions of hybrid infrastructure projects result in the risk of deviations from project objectives (Zhao et al., 2013). Project management literature has reported many examples of time overruns (Hwang et al., 2014; Arashpour and Wakefield, 2015), cost overruns (Cooper et al., 1985; Nasirzadeh et al., 2014), safety issues (Nieto-Morote and Ruz-Vila, 2011; Wang and Yuan, 2011), and quality problems (Zeng et al., 2007) as results of underestimating the extent of risks in different project dimensions. However, there are very few examples of integrated management of interacting risks across different dimensions of hybrid projects (Acebes et al., 2014; Marle, 2015; Arashpour et al., 2016a, 2016b, 2016c).

In order to bridge this gap, the current study identifies most significant risks in three hybrid project dimensions of on-site, off-site, and coordination. It then conducts both dyadic and triadic analysis of risks in hybrid infrastructure projects. The main objective of the research is to investigate whether risks associated with off-site and on-site dimensions have similar probability of occurrence and also impact on project objectives. Furthermore, the paper seeks understanding on risk dynamics in hybrid projects as on-site/coordination/off-site triads by scrutinizing the significance of deviations from project objectives caused by risks associated with the three dimensions.

The paper consists of developing a conceptual framework and three research hypotheses based on empirical research. After testing the hypotheses, conclusions are drawn and opportunities for future research are suggested.

2. Conceptual framework

Uncertainty in projects is defined as the state of information deficiency related to knowledge of an event, its likelihood, or consequence (ISO31000, 2009) and risk is the effect of uncertainty on project objectives (PMBOK, 2013). Management of risks in contemporary projects is becoming more complex as a result of strongly interrelated risks (Zwikael and Ahn, 2011; Krane et al., 2012; Marle, 2012). The mainstream research in the project management domain proposes the use of classic project risk management (PRM) processes for risk identification, evaluation and analysis (Shen, 1997; Barki and Suzanne Rivard, 2001; Fang et al., 2012). More innovative risk management approaches aim to depart from the individual management of risks and break the propagation transitions among interrelated risks (Billio et al., 2012; Arashpour et al., 2016a, 2016b, 2016c; Bredillet and Tywoniak, 2016).

Project risk management is a systematic approach to identify, analyze, respond, and control risks with the aim of increasing the impact and likelihood of positive events, and reduce those of negative events (Raz and Michael, 2001; Ward

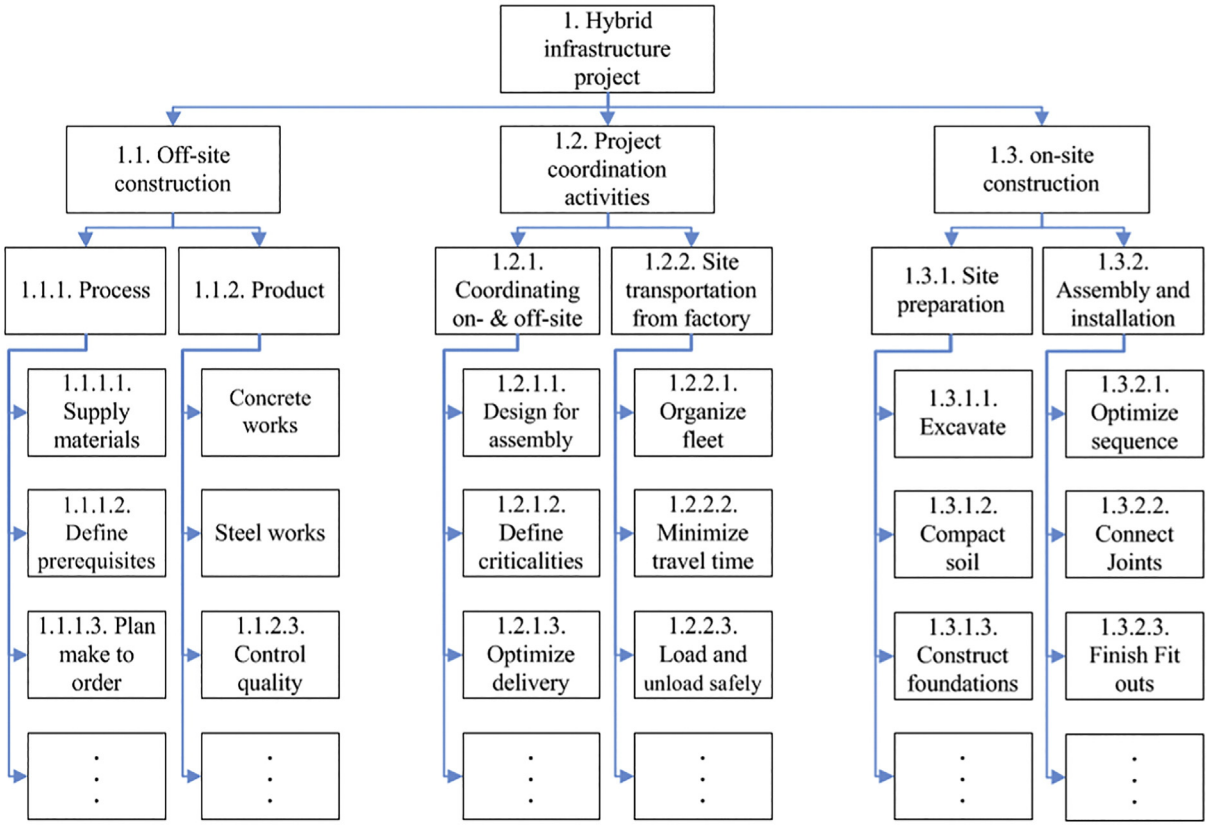

Fig. 1. Simplified subdivision of work in hybrid infrastructure projects.