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A COLLABORATIVE PERSPECTIVE IN GREEN CONSTRUCTION RISK MANAGEMENT

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ABSTRACT

Many risks existing in the supply chain of green construction projects are poorly managed by traditional non-collaborative approaches leading to problems such as higher prices, inappropriate indoor environment quality, technological failures and legal battles that in turn adversely affect all stakeholders. To reduce the cases of failure in the green construction industry, it is necessary for supply chain (SC) key players to collaboratively identify, analyse and treat risks, considering benefits and concerns of all stakeholders inside the network. This paper presents a method for collaborative risk management to provide informed advice to supply chain stakeholders to manage risks in the green construction industry. Contribution of the proposed collaborative approach is illustrated in a case study carried out in a green construction development project in Melbourne, Australia. The case study introduced in this research is sufficiently robust to provide evidence that collaborative approaches can add value to traditional methods of risk management and presents a modelling and analysis framework for assessing supply chain risks in the green construction.

Keywords: Australia, Green construction, Risk management, Stakeholder Collaboration, supply chain

1. INTRODUCTION

The growing awareness to go green in the construction industry has initiated the sustainable projects which aim to reduce greenhouse gas emissions, energy costs and water use in all building types such as residential, commercial and educational structures (Ball 2002). The surge in demand to implement smart and sustainable building technologies has pushed construction companies to act fast so as to maintain their competitive advantage in this emerging market. Many of these companies have in fact enjoyed multibillion dollar turnovers over the past decade (Bansal & Roth 2000).

On the other hand, the implementation of green building technologies is not always successful and often presents many risks. This is due to the ever-changing financial and environmental expectation on workplace and living environments, the technology advancement, the system adaptability issues associated with innovative technologies, as well as the management of multi stakeholders through supply chains. Understanding these challenges and managing these risks and related knowledge effectively is critical to the success of delivering green projects. Research to capture optimum collaborative approaches to manage key risks across the green construction supply chains is needed to ensure the stakeholders' benefits can be achieved.

The connection between collaborative risk management and benefits for supply chain key players in the green construction industry is a brand new concept and has not been the focus of much research. Collaboration can be extended to include greener practices in the SN in different forms such as fair allocation of risks and knowledge sharing. The work presented here highlights advantages of a collaborative approach by generating several stakeholder-risk pairs in order to prioritize critical failure modes in projects. This collaborative approach is validated in a case study in the Melbournian green construction industry.

2. RISK MANAGEMENT LITERATURE

Risk management process is the systematic application of management policies, procedures and practices to identify, analyse, evaluate, treat, monitor and review risks (ISO 31000:2009). Risk in construction projects is defined by Project Management Body of Knowledge (PMBOK) as an uncertain event or condition with a positive or negative influence on time, cost, span or quality about identified events and conditions. The process of risk management analyzes consequences of threats and advocates cost effective safeguards to mitigate risks (Pai et al. 2003).

Due to the aim of this research a methodological literature review can summarize the studies on different phases of the standard risk management. Methodological review deductively uses the risk management literature and can provide a framework for the current research for assessing and analysing the supply network risks in the green construction (Creswell 2009).

2.1. Risk identification

Risks in green construction management can be broadly classified into four categories- financial, operational, technological and legal risks (Dey & Ogunlana 2004). Examples for these risks are cost overrun, inappropriate indoor environment quality, unacceptable performance of modern technologies and legal battles among stakeholders. Different methods to categorise risks in the project management literature have been identified. For instance, according to customer and regulations related matters, risks can be grouped as external or internal (Olson & Wu 2010). In fact, these classifications can facilitate the next steps of risk management.

2.2. Risk analysis

Risk analysis involves three broad aspects of vulnerability assessment, consequence analysis and implementation (Pai et al. 2003). There are some risk analysis approaches widely used by practitioners in the construction industry. These include deterministic analysis by Project Evaluation and Review Technique) PERT (Hatush & Skitmore 1997), probabilistic analysis by Monte Carlo simulation (Dey & Ogunalana 2001), and Fuzzy set approaches (Lorterapong 1996). Risk analysis then can be followed by an implicit sensitivity analysis using neural network approaches (Abbasi 2009) or explicit sensitivity analysis using regression or correlation between risk variables (Woodward 1995).

However, traditional methods do not support collaborative risk management and this concept in the construction industry is relatively new. Until now, very few methods have been developed for the stakeholder analysis to identify interests and concerns of major stakeholders and consider multi period effects of social relationship on supply chain risks (Arashpour, M. & Farzanehfar 2011).

2.3. Risk response and risk allocation

To respond any project risk in the optimum way, risks should be allocated to the party which can handle them in the optimum way. In this process, considering the tolerance and capability of stakeholders is vital (Arashpour, Mehrdad & Arashpour 2010). Collaboration in this stage of risk management has some advantages to the project: fair risk allocation among stakeholders, improved team communication and wider engagement of greener practices in the supply chain, which reduce the amount of adverse effects of contingency plans employed by one stakeholder on others and also the number of repetitive actions.

2.4. Necessity of collaboration among stakeholders

To manage project risks, it is necessary to know the nature of threats for stakeholders and probability associated with risks. Failure modes can be caused by various risks and often response to risks triggers a set of events as in a chain network reaction. Collaborative approach adds a new dimension to traditional risk management methods. So far construction collaborative relationships have been customer driven with very little consideration for competitors, suppliers and subcontractors. Nevertheless, a true collaborative relationship should take into account all the parties involved in construction development supply and demand chains to reap the full benefits (Walker 2000).

Active inclusion of all stakeholders is an important influencer on the level of success in projects. There is a need in the construction industry to clearly communicate projects' performance and effects on the stakeholders (Ball 2002). Collaboration with external and internal stakeholders will provide a continuous stream of support to construction projects. Traditional top–down impositions cannot transfer numerous local influences, innovations and values, especially in the construction industry (Cruz & Liu 2011).

In recent years collaborative approaches in the construction industry have been brought into attention as companies need to decrease their costs and increase their opportunities in the market. The level of social relationship can directly affect the presence of disruption risk and opportunism risk (Cruz & Liu 2011).

Social network analysis is a specific method to analyse the relationships among any kind of stakeholder-risk nodes. It demystifies the underlying knowledge in the network. In terms of risk analysis, a few studies have applied this method to analyse the interdependent risks associated with various stakeholders in construction projects (Yang, Zou & Jin 2011). By this method the interrelations among the risks in the network will be considered. Here, the major advantage is to consider the multi-criteria decision-making behaviour of the stakeholders in a given construction project, which results in more profit and less risk by considering the social relationship (Cruz & Liu 2011).

Overall, social network analysis certainly look promising for the green construction risk management but detailed study is yet to be done to analyse the possible drawbacks.

3. Research design

Case study is the opted strategy of inquiry for this research project as collaborative risk management in the green construction is a new topic. Case study that is bounded by activity and time enables the researcher to use different data collection procedures to collect detailed information (Creswell 2009). A green construction development in Melbourne was selected to the large number of stakeholders involved and the contractual arrangement of project alliancing which facilitates the collaboration among supply network members.

The first phase of the case study is to identify the major stakeholders. Snowball sampling is used to find the boundaries of the network.

In the second phase, an extensive literature review assists to find the most significant risks affecting the network of the stakeholders in green construction projects. The focus is on Australia as well as other countries such as the U.S and Britain with established green construction markets and certifications. The findings of this phase help to map the stakeholder-risk nodes in the next stage.

Supply network is modelled in the third phase. Stakeholder-risk nodes and interrelation links are the model elements. To conduct the social network analysis of the model and due to the large number of stakeholders and risks within the network and time consuming data entering procedure, using capable software such as NetMiner is necessary.

In the fourth phase, risk managers within stakeholders' organizations are asked to prioritize critical failure modes. To reach this aim, questionnaires are designed and forwarded in order to obtain numerical measurements of severity, likelihood and detection for the case study and its network of stakeholders. Computerised means such as RAM Commander software are utilised for Risk Priority Numbers (RPNs) calculations. The results of phases three and four let countermeasures to be generated based on the risks associated with each risk-stakeholder pair. These countermeasures are then evaluated against each other and the suitable recommendations are compiled

4. Case study

The review of traditional risk management techniques reveals that traditional risk management methods do not support collaboration and consequently causes numerous failures in the industry. To address this problem, an initial case study with a collaborative approach in managing risks is proposed. This initiative considers relationship of stakeholders in construction projects. The initial case study provides a basis for understanding the data required for risk analysis and analysing the behaviour of system variables.

Green construction

The first phase of the case study consists of a realistic study of the supply chain for one green office building development in Melbourne CBD. The case study is sufficiently robust so that the lessons learned will be used to develop the system architecture, knowledge fusion structure and implementation strategy for analysing and managing risks. The snowball rolling method was used to identify the key payers in the stakeholder network. The supply chain for the initial case study consists of the following stakeholders (see figure 1):

- Two clients (one Sydney based and one Melbourne based), each has %50 of the project share
- One consultant company (designer)
- One general contractor
- Four subcontractors
- Nine suppliers
- 25 manufacturers

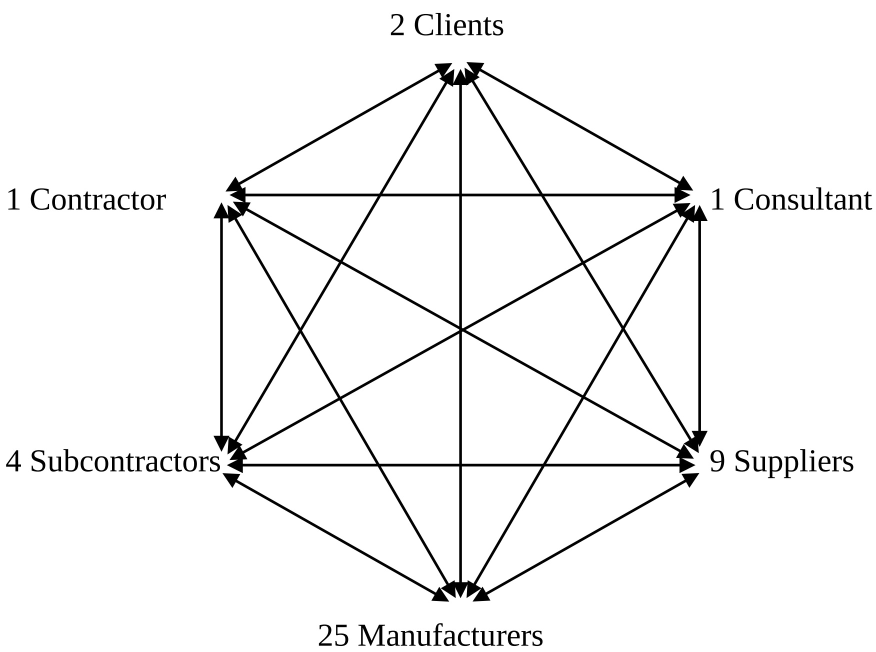

Figure 1 Stakeholder network and interactions in the green office building case study

In the second phase, an extensive review of the risk literature was undertaken to identify most significant risks in the green construction supply network. Examples for these risks are cost overruns, inappropriate indoor environment quality, time overruns, safety issues, unacceptable performance of modern technologies and legal battles among stakeholders (Mosly & Zhang 2010; Zou & Couani 2012). Forty important risks were identified to be most influential on the stakeholders. The selection of 40 risks was validated afterwards in the fourth phase of the research when the majority of stakeholders' identified those very significant in terms of severity and likelihood.

In the third step, the supply chain model was generated by NetMiner software that visualises the relationship network among stakeholders to map the meaningful and actionable relationships (Huisman and van Duijn 2005). Four types of relationships were analysed: collaboration in a network (e.g. communication, information exchange, problem solving, and innovation), the information-sharing potential of a network (e.g. knowledge awareness, access, engagement, and safety), rigidity in a network (e.g. decision making, communicate more, task flow, and power or influence), and well-being and supportiveness in a network (e.g. linking, friendship, career support, personal support, energy, and trust) (Yang, Zou & Jin 2011). The main problem was modelling the network of risk-stakeholder pairs. For the analysed case study with 42 stakeholders and 40 risks with 10 degrees of severity and likelihood more than 5000 nodes and links had to be assigned. This clearly identified the need to automate data entry process into the network.

All the elements of the green construction supply chain are modelled as being one of the following:

- Stakeholder-risk nodes
- Interrelation links among nodes

Different shapes of the nodes represent different risks, while different colours of the nodes stand for different stakeholders associated with a risk. The links in the network are the interrelations among the nodes, of which the thicknesses mean the influence degrees (severity * likelihoods) of the interrelations (Yang, Zou & Jin 2011). Figure 2 represents a schematic stakeholder-associated risks network in the case study.

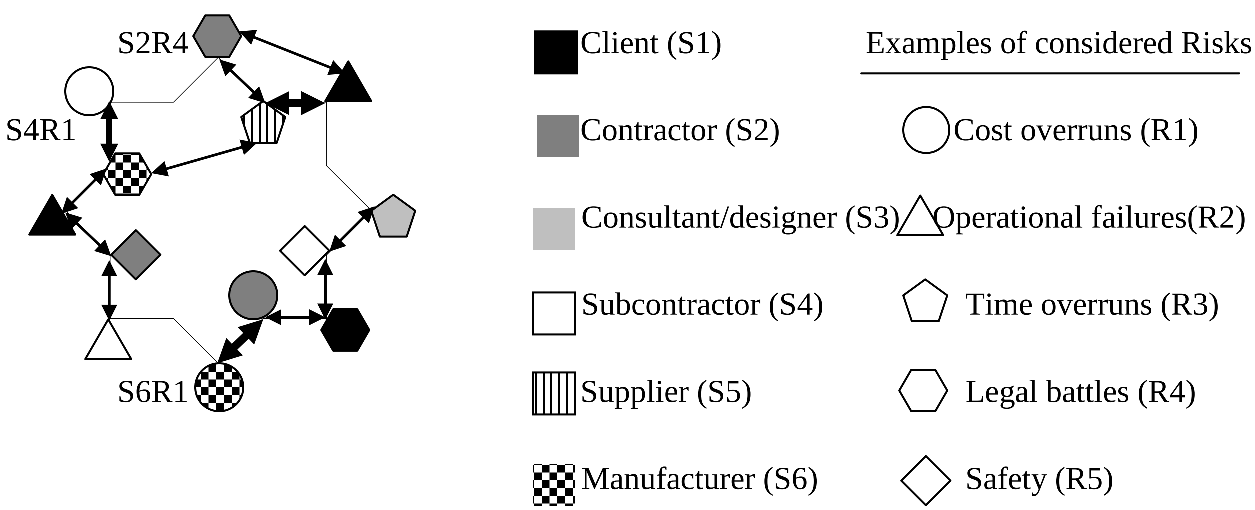

Figure 2 Schematic stakeholder-risks interrelations in the supply network of the case study

Combination of failure mode and effect analysis (FMEA) and social network analysis of the stakeholders in the case study

In the fourth phase and to prioritize critical failure modes associated with the case study, risk priority numbers (RPN) were calculated. This structured technique is one of the most beneficial approaches in identifying all failure modes, their impact and appropriate corrective actions (Abdelgawad & Fayek 2010). Risk priority number is multiplication of severity, likelihood and detection. RPN vary from one (best practice) to 1000 (worst practice). Severity is the subjective numerical measure of how critical a stakeholder would be affected by a failure mode. It differs from 10 (hazardous) to 1 (extremely minor). Occurrence is the likelihood of a failure mode because of a perceived risk. This subjective estimation differs from 10 (inevitable failure) to 1 (unlikely failure). Detection defines the effectiveness of planned controls to detect causes of failures before the impacts hit stakeholders. It varies between 10 (extremely ineffective control) and 1 (almost certain control).

Questionnaires were designed and forwarded to risk managers within stakeholders' organizations so as to obtain the numerical measures of severity, likelihood and detection. Then, RAM Commander Software assisted to calculate RPNs for the case study and its network of stakeholders. As a rule of thumb, failure modes with higher severity need to be considered critical regardless of their RPN value. The acceptable level of RPN varies from one stakeholder to another, depending on their risk tolerance . In the case study, whenever acceptable limits were passed, countermeasures were generated based on the risks associated with each risk-stakeholder pair. These countermeasures were then evaluated against each other and the suitable recommendations were compiled. After that, the risk priority numbers were re-evaluated with the new countermeasures in place. This iteration was repeated for several times. In the wake of new stakeholders, social network analysis is propagated along the NetMiner network.

5. Conclusions and future work

This article proposed a social network analysis of stakeholders for risk management in green construction industry. This work adds a new dimension to green construction management that is the collaborative risk analysis. This is a green practice itself, which has a complementary role to other practices such as using sustainable and smart building technologies. Contribution of the proposed collaborative approach was illustrated in a case study carried out in a green construction development project in Melbourne, Australia and provided an orientation for future work.

Critical failure modes differ from project to project as the stakeholder networks have different level of interrelations and risk tolerance. As a rule of thumb, contracting arrangements can hugely impact the influence degree of meaningful and actionable relationships. The initiative of project alliancing in the present case study facilitated the collaboration, information-sharing potential, flexibility and supportiveness in the network. Three critical risks in the case study were appeared to be: green construction premiums, lack of commitment to go green and changing certification procedures and obligations.

Identification and assessing meaningful and actionable relationships in larger stakeholder networks would be a challenge that needs to be scrutinised in future research. The authors also look forward to replication of this study in other regions of the world.

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