Analysing Stakeholder-associated Risks in Green Buildings: A Social Network Analysis Method

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Abstract

In the research of risk associated with developing energy and water efficient green buildings, previous studies had mainly focused on "what the risks are and how the risks may impact on project objectives", which were from an inward looking self-perspective and treated the risks in isolation from one another. While intensive research efforts have been dedicated to risk identification, assessment, classification, prioritisation and mitigation, a research gap exists, that is previous studies had ignored the fact that most risks are interrelated and associated with internal or external project stakeholders. To remedy the gap, this current research developed and presented a SNA (Social Network Analysis) based stakeholder-associated risk analysis method to assess risks in green buildings and the interactions between the risks. A case study has been conducted to demonstrate and validate this method. This research contributes to the development of a new theory to model the interdependent and interactive relationships of risks by using SNA as a methodology. This research should broaden project managers' awareness of the influential risks in green building and enhance their ability to perceive, understand, assess, and mitigate the risks in an effective and efficient way; thereby achieving higher performance in strategic risk management and stakeholder communication in green building development.

Keywords: Green building, Risk analysis, Stakeholder relationship, Social Network Analysis

1. Introduction and Research Aims

Industrial ecology urges industries and organizations to apply ecological theory to "industrial systems or the ecological restructuring of industry" (Rejeski, 1997). Practitioners in the construction industry are also making great efforts on the development of green buildings in order to maximise the construction ecology concept. Similar with the other industries, the implementation of construction ecology encounters the same, if not more, risks and barriers due to the traditional conservative and reactive behaviour of parties/stakeholders in the building environment (Bullen and Love, 2010), and the transient relationship of project teams and stakeholders (Larsson and Cole, 2001).

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Many previous studies have focused on identifying and assessing the risks and barriers regarding various green building development issues. A review of these risks will be presented in the following section. By examining the risks identified in the previous studies, most of, if not all, them are associated with one or several stakeholder(s). As Prum and Del Percio (2009) stated that, risk sources should be analysed and each stakeholder in a green building project needs to assess its risks and take measures to mitigate the possible damages by risk eventuation.

Although previous studies have been conducted to analyse green-related risks and stakeholders, the majority limited themselves to a linear impact analysis which was to assess the impact of risks or stakeholders on green building development without consideration of the association of risks and stakeholders, and the interdependency of risks/stakeholders. The reality is that most green-related risks are associated with different players (i.e. stakeholders) in the construction industry (Cole, 2011) and risk source analysis is an indispensable component in risk management plan/register (PMI, 2010) to facilitate the risk response and mitigation actions. Nevertheless, in green building research, limited effort has been conducted to demystify the risk interrelationship. Discussion about stakeholder interdependency is not a recent topic. However, in green building development, questions imperative to be answered are “who associates with whom and in what ways do these stakeholders depend on each other” for green-related decisions (Van Bueren and Priemus, 2002). The aforementioned studies formed different paradigms regarding risk and stakeholder analysis in green building development.

The aim of this research is to develop a method for analysing the stakeholder-associated risks in green building development from a network perspective. It is in this context, that SNA (Social Network Analysis) based method is used. To demonstrate the application and validation of the proposed method, a real green building project case is studied. It is anticipated that the research outcomes presented here provides an innovative risk and stakeholder analysis method for researchers and practitioners to manipulate and simulate the green reality.

2. Literature Review

2.1 Risks in Green Building Development

Studies on the risks, barriers and critical factors in delivering sustainable building development are aspiring in recent years. Both researchers and practitioners accept the fact that green building development is more complex and problematic because the construction industry is “extremely conservative, and subject to slow rates of change due to regulatory, liability and limited technology transfer from other sectors of society” (Kibert et al., 2000). Therefore, the understanding of barriers in sustainable building project development is critical for industry players to proactively analyse risks, thresholds and develop strategies. Table 1 summarises the risks/barriers identified in previous studies.

The risk identification presented in the current literature usually classify risks into different categories, such as financial, political, and technical risks (Tiong, 1990); internal and

external risks (Yeo, 1990); elemental and global risks (Walker and Smith, 1995); general/country and specific project risks (UNIDO, 1996), technical, commercial, political and regulatory, and economic and financial risks (Medda, 2007), and time, cost, quality, safety, and environment risks (Zou et al., 2007) as well as supply chain risk (Zou and Couani, 2012).

Table 1: Risks/Barriers identified in previous studies

Authors	Barriers/risks	Related stakeholders	Risk category
Hoffman and Henn (2009)	Egocentrism	General stakeholder	Ethics/ reputation
	Internal structure and interaction	General stakeholder	Organization / Management
	Rewards	General stakeholder	Ethics/ reputation
	Organizational inertia	General stakeholder	Organization / Management
	Language and terminology	Government/Professional association	Policy/ standards
Shi et al. (2013); Lam et al. (2009)	Additional costs caused by green construction	Client	Cost
	Incremental time caused by green construction	Client	Time
	Reduction of structure aesthetic	Consultant	Quality
	Uncertainty in the performance of green materials and equipment	Supplier/subcontractor	Quality
	Imperfect green technological specifications	Government	Policy/standards
	Misunderstanding of green technological operations	Contractor/Supplier/ subcontractor	Quality
	Restrictions of new green production and technology	Government	Policy
	Regional ambiguities in the green concept	General stakeholder	Organization / Management
	Conflicts in benefits with competitors	General stakeholder	Organization / Management
	Dependence on promotion by government	Government	Policy
	Lack of support from senior management	General stakeholder	Organization / Management
	Limited availability of green suppliers and information	General stakeholder	Organization / Management
	Lack of quantitative evaluation tools for green performance	Government/Professional association	Policy
	Additional responsibility for construction maintenance	User	Quality
Love et al. (2012)	Clients' knowledge and willingness	Client	Organization / Management
	Communication and relationship among the participants due to the temporary nature of construction projects	General stakeholder	Other
	Regulations / standards	Government	Policy
	Organizational resources	Client	Organization / Management

Although there is no standard classification of risks, in this paper, we tried to group the risks into different categories, as shown in Table 1, mainly because the category names can assist industry practitioners to identify risks in the proposed SNA based method. The identified risk categories include: time (risks related to time management), cost (risks related to cost management), quality (risks related to the product quality), organization/management

(risks related to organizational structure, knowledge, and relationship management), policy/standards (risks related to regulations and standards), safety (risks related to occupational health and safety), ethics/reputation (risks related to social and ethical issues), and environment (risks related to environment protection). It should be noted that the categorisation here is not to exhaust the risk groups, but rather to facilitate the researchers and practitioners' thinking for risk identification.

Another notable point about Table 1 is that most risks identified are associated with different stakeholders (Refer to the third column of Table 1). To mitigate the risks, it is important to indicate the risk sources. However, the difficulties of using the risks listed in Table 1 to track the risk sources are that: (1) many risks are too general and related to different stakeholder organizations. This increased the difficulties for practitioners to develop risk response strategies; (2) the stakeholder groups used by previous studies were not comprehensive, which means that many risks associated with external project stakeholders (except government bodies) were not identified. Stakeholders in the construction industry are far more than those being identified in the table. External stakeholders, such as competitors, Non-Government Organizations (NGOs), media and communities, can also cause problems (hence risks) to green building development (Cronin et al., 2011). Therefore, it is worthwhile to review the stakeholder groups in the construction industry in order to help practitioners and researchers to identify the possible risk sources. This will be conducted in the next section.

2.2 Stakeholders in Green Building Development

Buildings, particularly green buildings, not only affect their immediate users but also impact on a broad range of other stakeholders (Robichaud and Anantatmula, 2011). Several scholars have developed green-related stakeholder lists for possible use in practice. Rivera-Camino (2006) proposed four stakeholder groups in the green project market, where Group 1 includes end user, competitors, distributors and suppliers, who have greatest impact in determining the success of the project. The feedback of end users can highly impact on the client reputation for good or bad environmental management. Qualified suppliers' involvement can positively influence the performance of environmental products (Pujari et al., 2003). Collaborations with distributors will increase the credibility of a firm's actions. Competitors create competitive threats in the green market. Group 2 includes the press and media, environmental organizations, and the local population. As Clarkson (1995) stated, these stakeholders can affect the project reputation by "mobilizing public opinion for or against" the project performance". Group 3 is the "providers of critical inputs" (Rivera-Camino, 2006), which include clients, financial organizations, labour unions and professional institutions/associations. Group 4 and also the last group is governments at different levels, who are responsible for publishing regulations and voluntary agreements. This classification is comprehensive as it identified most of the external stakeholders in green building development.

Similarly, Lorenz and Lutzkendorf (2008) focused on external green-related stakeholder identification. Several groups are added to Rivera-Camino's list, such as insurers who can grant better insurance conditions for sustainable buildings, assessors/certifiers who assess

the sustainability performance of buildings, and researchers/educators who can study and spread the knowledge on sustainable buildings. Theaker and Cole (2001) and Henry and Paris (2009) concentrated on the role of government in fostering green building. Qi et al. (2010) and Cronin et al. (2011) also developed stakeholder lists in green development. Although they used different terms (for example society and community are used to refer to the public and environmental NGOs), the stakeholder groups are basically the same with Rivera-Camino (2006). Although scholars have started to examine external stakeholders, majority studies still emphasized on internal stakeholder analysis (see for example, Van Bueren and Priemus, 2002; Riley et al., 2003; Dammann and Ellet, 2006; and Prum and Del Percio, 2009).

Based on the review of current literature, a stakeholder group list is developed for the use in the SNA-based method proposed in this research. This list includes client, consultant, contractor, subcontractor/supplier, end user, financial organisation, government, environmental organisation, professional association, media, public, labour unions, assessors/certifiers, researchers/educators, and others. Similar with the risk categories, the stakeholder list is only to assist researchers and practitioners to identify stakeholders. In practice, new categories can be added and some organisations may be recognised in multiple-groups.

3. Research and Analytical Methods

3.1 Social Network Analysis Method

Social network is a specific set of linkages among a defined set of nodes, with the additional property that the characteristics of these linkages as a whole may be used to interpret the impact of each node in the network (Mitchell, 1969). The social network theory views a green building project as a system environment, which is joined by various relationships. In the green building project system, stakeholders and risks are connected by anfractuous lines, which represent the relationships among them. The purpose of network analysis is to examine how relationship structures impact on behaviours, and this theory is concerned with the “structure and patterning” of these relationships and seeks to identify both their causes and effects (Scott, 2000).

The network perspective differs in fundamental ways from standard social and behavioural science research and methods (Scott, 2000). Rather than focusing on risks’/stakeholders’ attributes, the social network views characteristics and interdependencies of risks/stakeholders as arising out of the social structural environment in order to better understand the decision-making process. The application of the social network perspective to stakeholder and risk analyses the patterns of stakeholder-associated risk networks which emerge in response to the project missions over time, investigating the forces which shape these patterns, and unlocking risk interactions inside the whole relationship network, all of which are intended to provide a rationale for stakeholder communication and risk response strategies, and facilitate the decision-making process.

3.2 Processes of SNA Method

The general steps of SNA include: (1) identifying the boundary of the network; (2) assessing meaningful and actionable relationships; (3) visualising the network; (4) analysing the network data; and (5) presenting the analysis results (Wasserman and Faust, 1994; Scott, 2000; Cross and Parker, 2004). The method proposed in this paper will follow this general process, which include:

1. Developing a complete list of risks and identify their associated stakeholders in green building development. The stakeholder groups identified in previous sections are used to facilitate stakeholder identification process. Questionnaire survey will be used to identify green-related risks and their associated stakeholders. The risk categories proposed in previous section are used. The outcomes of this stage are a complete list of stakeholders, and risks associated with them. At this stage, the nodes in the risk network can be identified.
2. Interpreting the impacts and likelihoods of stakeholder-associated risks on each other and define the links in the risk network. Interview and workshops were used to obtain consensus of risks interrelationship, impacts and likelihoods on each other. The outcomes will be the defined links in the risk network.
3. Visualising and analysing the stakeholder-associated risk network. Since the nodes and links are identified, a risk network for green building projects can be developed. A conceptual network is shown in Figure 1 (where *R* means risk and *S* means stakeholder). The links in the network are the interrelations among the risks, of which the thicknesses of the lines mean the influence degrees (impact * likelihoods) of the interrelations. Based on the risk network, SNA method can be used to identify critical risks and the ways to mitigate them by communicating with associated stakeholders. Various software packages can be used for visualising and analysing the relationship networks, including UCINET, NetMiner, NetDraw, Pajek. Two methods are useful for risk network analysis: (1) *Centrality*: A key measure that reflects the distribution of relationships through the network; and (2) *Brokerage*: A measure to classify risks into: coordinators (who broker connections within the same group); representatives and gatekeepers (who broker connections between their own group and another), and liaisons (who broker connections between two different groups).

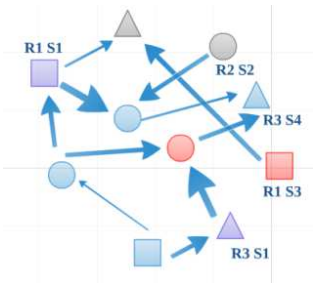


Figure 1: A conceptual stakeholder-associated risk network (Yang et al., 2011)

4. Case Study and Results

4.1 Project Summary

Due to the expansion of a university, additional office space was required. The FF Building (FF is an anonymous name for confidential considerations), three storeys, contract sum over AU$10 million, was constructed using World Leading practises as required by the Green Building Council of Australia to target 6 Stars in both As Design and As Built. The FF Building project presented considerable difficulties to the project team, requiring the adoption of a relationship based collaborative approach to management and project delivery.

4.2 Case Data Collection and Analytical Results

The data was collected through surveys with key project participants together with desktop-studies on the project information provided by the design-and-construct head contractor. The key information obtained includes: project scope, cost, time; the stakeholders in the project; the risks related to each stakeholder; the interdependencies among the risks. In total, 127 risks associated with 20 stakeholders were identified, and a risk interrelation matrix was developed. The data gathered from the survey was analysed by a SNA tool NetMiner (Cyram, 2009). Figure 2 shows the stakeholder associated risk network in this project. To estimate the degree of risk impact, the status centrality concept was used as this considers every connection (even up to infinite length connections) between each node in Figure 2 (Cyram, 2009). If a node has many connections, it may have a large centrality score. As the length of a connection increases, however, influence attenuates exponentially (attenuation factor was 0.5 in this study). Due to the space limitation, only the top 10 risks and their status centrality scores are listed in Tables 2 and 3. The status centrality map, including all risks, is shown in Figure 3. The in-status centrality indicates the extent to which a risk is affected by others; whereas, out-status centrality indicates the extent to which a risk can affect the others (Katz, 1953). Regarding the influence of a risk, the out-status centrality is used as the outcome measure. The higher the out-status centrality values, the greater the impact of the risk. In this analysis, the most significant risk is S5R19 “Reputation affected if Greenstar not achieved”, which is associated to the head contractor. In Figure 3, the risk impacts decrease along with the distance between the risk (node) and the central of the circle. Figure 3 (a) shows the risk locations in the status centrality circle with different shapes to demonstrate the stakeholder groups; while Figure 3(b) shows the locations with shapes to demonstrate the risk categories.

Some interesting findings were identified from Figure 3. As shown in Figure 3(a), the risks related to internal stakeholders, such as client, head contractor, consultant and end user, were located relatively in the central. This indicated higher influence of internal stakeholders in the green building development process. The role of government was not as important as expected by the project team. This finding was also similar to that found in Henry and Paris’s study (2009) where they considered that the change of policies and standards were not sufficient to break down the numerous barriers in sustainable constriction. In Figure 3(b), the ethic/reputation risks related to different stakeholder groups seem to be more significant comparing to other risk categories. This finding is different with the facts in non-green

building project in which the cost, time and quality (triple bottom line) related risks are considered as more important. The significance of ethic/reputation related risks in green building highlighted the change of construction practitioners' behaviours and attitudes within the framework of industrial ecology.

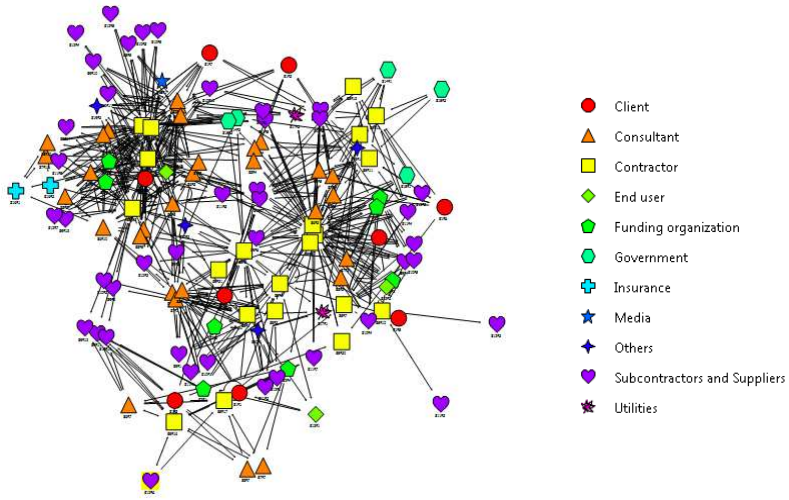


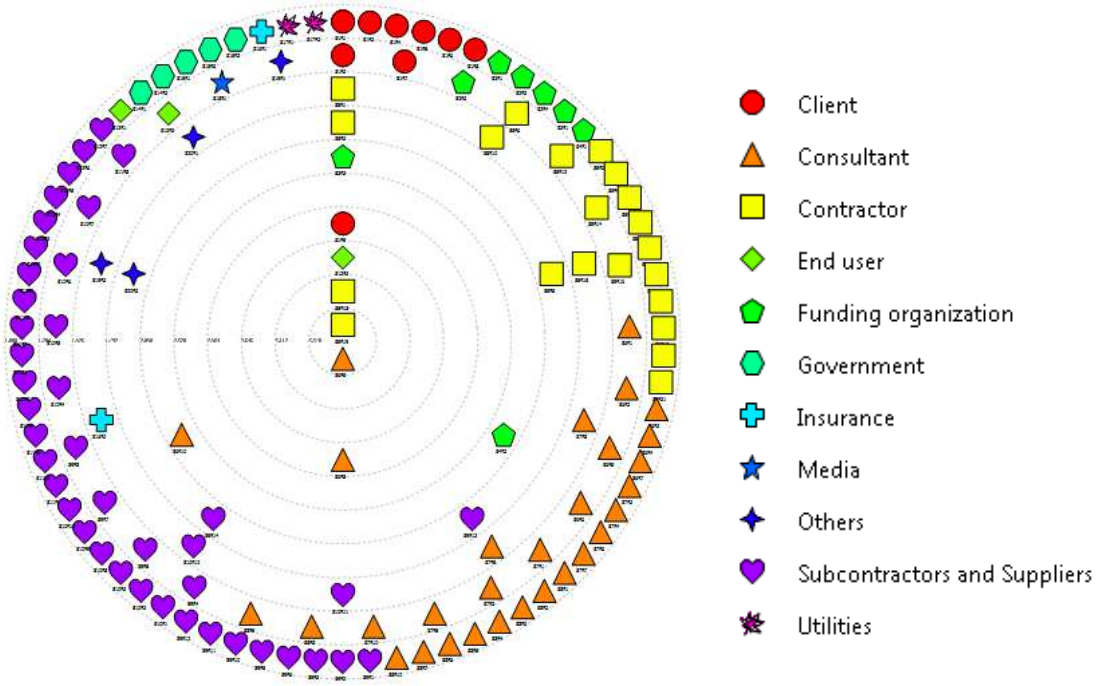
Figure 2: Stakeholder-associated green risks in the case project

Table 2: Top 10 risks in the case project

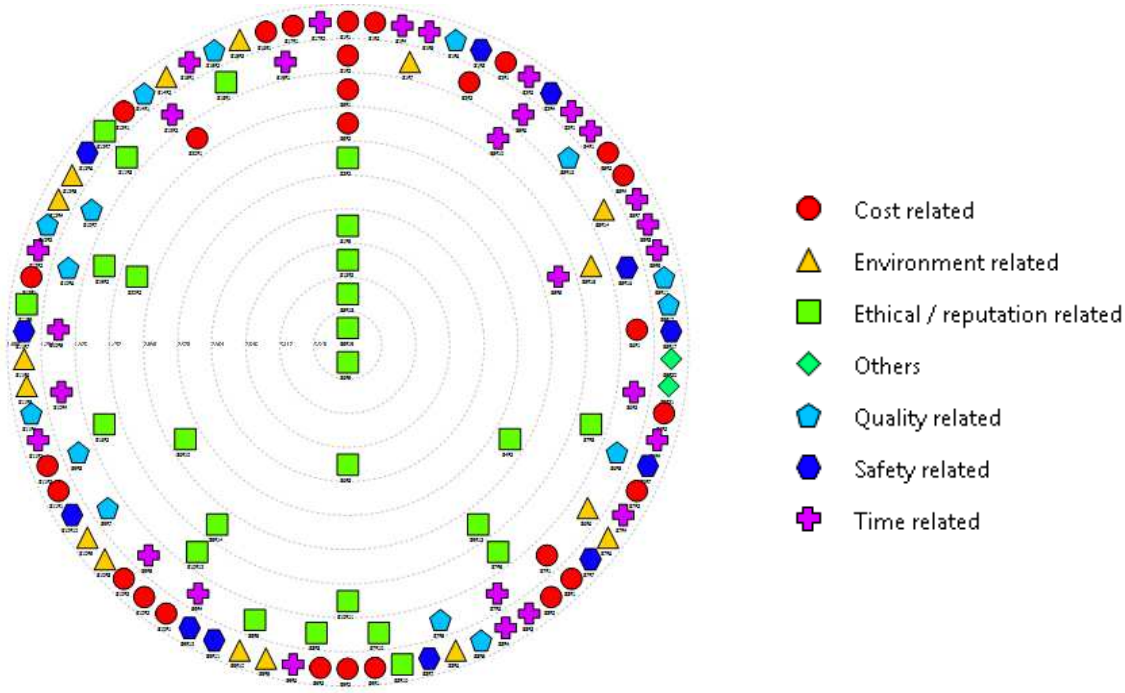
	Risk description	Stakeholder category	Risk category
S1R9	Reputation affected if Greenstar not achieved	Client	Ethical / reputation
S3R2	Reputation affected if Greenstar not achieved	Funding organization	Ethical / reputation
S4R2	Reputation affected if Greenstar not achieved	Funding organization	Ethical / reputation
S5R5	Responsible to ensure project is delivered on time	Contractor	Time
S5R18	Non performance affects repeat business opportunity	Contractor	Ethical / reputation
S5R19	Reputation affected if Greenstar not achieved	Contractor	Ethical / reputation
S6R8	Reputation affected if Greenstar not achieved	Consultant	Ethical / reputation
S6R9	Non-performance affects repeat business opportunity	Consultant	Ethical / reputation
S6R10	PI insurance risk on non performance	Consultant	Ethical / reputation
S13R3	Significant reputation risk if greenstar not achieved, though little responsibility	End user	Ethical / reputation

Table 3: The status centrality scores of the top 10 risks

Risk ID	In-Status Centrality	Out-Status Centrality
S5R19	2.145413	**3.63997**
S6R9	1.55115	**3.604947**
S5R18	2.172007	**3.281075**
S13R3	1.393447	**2.927108**
S6R8	1.55115	**2.822252**
S1R9	1.833032	**2.697951**
S6R10	1.18535	**2.31679**
S3R2	1.143452	**2.085579**
S4R2	1.052875	**2.070235**
S5R5	2.012313	**2.031348**



(a) Different shapes demonstrating the stakeholder groups



(b) Different shapes demonstrating the risk categories

Figure 3: Risk locations in the status centrality map

5. Conclusion

This paper leverages the collective knowledge of risks and stakeholders in a network to generate better risk management solutions in green building development process. The main outcome in this paper is an innovative and practical stakeholder-associated risk analysis model for green building projects from a social network perspective. The proposed method can improve the effectiveness and accuracy of stakeholder and risk analysis by overcoming the limitations of the traditional linear analysis. A case study was conducted to validate the proposed method. Two important findings from the case study are that: (1) internal stakeholders play more important roles in green building as compared to external stakeholders; and (2) ethical/reputational risks are considered more significant for different stakeholders in green development. Although the findings need to be generalised with more case studies, the outcomes of this study are expected to be of interest to decision-makers from both public and private sectors, who are involved in green building projects.

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