Improving social sustainability in construction: a conceptual framework based on social network analysis

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Abstract

Along with the rapid sustainable development since the publication of the *Agenda 21 on Sustainable Construction* (CIB 1999), there have been increasing calls for social sustainability to be incorporated into construction. One promising, yet under explored direction is to take into account the context of temporal construction project-based organizations (PBOs), interconnected networked stakeholders and the longitudinal monitoring of organizational governance. The use of Social Network Analysis (SNA) to study various relationship-oriented phenomena is gaining popularity in organizational governance and project management, and has the potential to be applied to construction where PBOs prevail. This paper aims to develop a multi-layered conceptual framework for improving social sustainability in construction, where the link between the theories of social sustainability and construction can be advanced through network thinking and SNA. Based on the framework, effective operational methods can be derived to measure and analyze the working relationships involved and, in so doing, the social sustainability aspects can be better embedded. A building project is investigated as a case study to illustrate the application of the conceptual framework. By continuous monitoring of the network interplay and adjustments on institutional settings, construction can be more socially sustainable in the long run.

Keywords: Social Sustainability, Project-Based Organizations, Construction, Social Network Analysis

Introduction

Since the 1987 *Brundtland Report* and the 1992 Rio Earth Summit, in particular the *Agenda 21 on Sustainable Construction* (CIB 1999), there has been an increasing awareness that the construction industry, as a significant component of the global economy, must play an important role in the global sustainable development (Levitt, 2007). Social sustainability is one of the weakest sustainability dimensions (McKenzie, 2004; Labuschagne and Brent, 2006) and covers not only the social considerations of the final users but also those of the project delivery team of health and safety issues, and even the surrounding community of the impact on the environment and quality of life (Dillard et al., 2009). Following the definitions and arguments of Herd-Smith and Fewings (2008) and Dillard et al. (2009), social sustainability in construction in this paper refers to construction and its related management practices that could be beneficial to current and future stakeholders by providing a set of social outcomes, such as health, safety, self-identification, ease of access, and sense of belonging. Construction here is thus an inclusive term to refer to a constructed facility, physical constructing process, and the related management activities. A number of previous studies have discussed various indicators relating to social sustainability, including client satisfaction, noise levels, indoor air quality and employee skill training (e.g. Kolk, 2004; McKenzie, 2004; Gilchrist and Allouche 2005; Shen et al., 2007; Almahmoud and Doloi, 2015). It is important to recognize the strenuous efforts made towards improving social sustainability, together with the new requirements and challenges for the inception, building, operation and maintenance of constructed facilities. Consequently, it is necessary to introduce changes and innovative solutions at the industrial, organizational and individual levels, new effective methodologies in particular.

One potential methodology is to apply network theory and its analytic instrument of social network analysis (SNA) , as it is a potentially reliable and powerful approach for improving the social sustainability. On the one hand, acknowledging the significant role of inter- and intra-organizational networking in construction project delivery, it is able to utilize systems thinking and network theory (Winch, 1989; Chinowsky et al., 2008, 2010, 2012). A great deal of evidence demonstrates that construction firms that do not formally or informally foster cooperation networks to spread and exchange knowledge, which could easily lead to hazardous consequences in the long run (Pittaway et al., 2004). On the other hand, thanks to the contributions of many social network researchers over the recent three decades, the concept of a network as a collection of individuals and their interactions has been popularly and effectively adopted by a wide range of disciplines. These include sociology, anthropology, psychotherapy, biology, physics, the Internet, communication and criminology, as well as construction (Kilduff and Tsai, 2003; Scott and Carrington, 2011). SNA, in particular, is gaining popularity, with a view to mapping temporal construction project-based organizations (PBOs) as social networks to examine the formal and informal interactions between stakeholders within the network boundary (Winch, 1989; Nohria and Eccles, 1992; Loosemore, 1998; Pryke, 2012; Schweber and Harty, 2010; Chinowsky et al., 2008; 2010). Kilduff and Tsai's (2003) critical review of the theoretical foundations of contemporary SNA applications in organizational studies implies that further network-based organizational studies could incorporate the concept of social sustainability into the inter- and intra-organizational interactions that occur in the context of construction projects. In addition, various relationships have been examined for construction PBOs using SNA, such as contractual relationships, incentives to perform, communication relating to information exchange and instructions/advice, innovation diffusion and conflict resolution (e.g. Valente, 1995; Fritsch and Kauffeld-Monz, 2008; Almahmoud and Doloi, 2015). SNA is therefore a potentially feasible tool for modeling social considerations related to sustainability concerns in the construction management discipline.

SNA provides a powerful methodological instrument for improving construction social sustainability, as it is able to model formal (e.g. contractual relationships and organizational structures) and informal interactions (e.g. collaboration, communication and innovation diffusion) and examine their interplay. It is widely recognized in the business and organizational literature that the interplay of formal and informal working networks will affect organizational operations and, in turn, project performance

(Williamson, 1985; Zenger et al., 2002; Kogut, 2012). In the context of construction, social considerations can be incorporated into the examination of the social networks formed by organizational design and working relationships, and their dynamic interplay.

A comprehensive and feasible research framework is needed to realize the potential of SNA to improve social sustainability in construction management. This study aims to develop a multi-layer conceptual framework based on SNA theories and applications. The next section provides an overview of social sustainability and SNA applications in the context of construction management, followed by a section on the development of the proposed conceptual framework. Final remarks provide the implications and limitations of the work, and proposals for future research.

Literature review

Social sustainability in construction

Ever since the concept was coined, sustainable development has been heatedly discussed for its proposition of maintaining a balance between the social, environmental and economic 'pillars' of development. It has now been widely incorporated into most government and company discourses all over the world (Kunz, 2006; Knoepfel, 2010; Lu et al., 2015; Lu and Zhang, 2016). A number of research studies have been conducted to identify the interconnections between project management and sustainable development, such as developing sustainable corporate versions and strategies, updating procurement strategies, refining project performance assessment systems and after-sales service management (Eid, 2009; Silvius et al., 2012; Silvius and Schipper, 2014; Yung and Siew, 2016). More than ever, construction, as a global and long lasting industry, has a need to improve its social, economic and environmental dimensions of sustainability. However, in contrast to the considerable academic and political attention paid to the economic and environmental dimensions of sustainable development, the social counterpart is often ignored, or at most, of unequal importance (McKenzie, 2004; Kunz, 2006).

There are various definitions of social sustainability. As summarized by McKenzie (2004), social sustainability can be defined as a self-enhancing condition, a process, or a collection of best practices, for the same purpose of realizing better social outcomes. Although the definitions of social sustainability seems to be pluralistic, its social outcomes are commonly shared, including but not limited to, equity of access to societal resources, cultural diversity, social cohesion, a sense of belongings, quality of life, and democratic governance (McKenzie, 2004; Cuthill, 2010; Zuo and Zhao, 2016). Vallance et al. (2011) discussed the "chaos" in defining social sustainability and recommended to use categorized criteria to clarify it.

Although the importance of social sustainability criteria has been recognized in recent decades along with the developmental momentum of Corporate Social Responsibility, no consensus has yet been reached (McKenzie, 2004; Vallance et al., 2011). Contained in the vast literature on the subject of social sustainability criteria is a taxonomy that includes social capital, social infrastructure, social justice and equity, and engaged governance (Dillard et al., 2009; Cuthill, 2010; Dempsey et al, 2011). Social capital and social infrastructure are regarded as two preparatory aspects for achieving social sustainability through the provision of a variety of resources and corresponding facilities and institutions. Social justice and equity relates to the accessibility of resources and opportunities, such as education, decent housing, green space and recreational facilities, and the protection of rights and liberties of individuals or groups in the social context. Engaged governance focuses on the involvement of stakeholders in decision-making. These together constitute a comprehensive system for empirical testing and from which social sustainability indicators can be derived (Cuthill, 2010).

While many studies have been made of the economic and environmental dimensions of construction, academic and practical attention devoted to the integration of social sustainability and construction is particularly rare (Zuo et al., 2012; Valdes-Vasquez et al., 2013). Each construction project is unique, with requirements for a tailor-made set of social criteria, which makes the measurement of social sustainability often very limited in terms of applications, e.g. in recycled construction materials (Hossain et al., 2017) and in project supply chains (Saunders et al., 2015). This explains why the well-known Sustainability Reporting Guidelines by the Global Reporting Initiative (GRI) is criticized as lacking concern for contextualization and interdependence (Fonseca, 2010), and the Construction and Real Estate Sector Supplement was published by the GRI subsequently to make remediation. As illustrated in Figure 1, studies of construction sustainability need to take in account the multi-layered nature of the network boundary and dynamic features across the project phases. Shen et al. (2007) established a checklist of three dimensions of sustainability from the perspective of the project management team throughout the whole project life cycle. Valdes-Vasquez et al.'s (2013) interviews resulted in the categorization of social sustainability concerns at the design stage of construction projects into six groups, while Zuo et al. (2012) adopted a similar approach to identify 26 criteria of social sustainability for project design and construction from the perspectives of internal stakeholders, external stakeholders and macro level considerations (e.g. social-economic-technical contexts).

<<Figure 1. Multiple dimensions in construction project sustainability research >>

Current sustainability assessment systems cover different governance layers separately, e.g. at the project level, professional level and organizational level (Lu and Zhang, 2016). There are calls for the integration of multiple dimensions of sustainability assessment in the construction industry. Klewitz and Hansen (2014), for example, posit that sustainability-oriented innovations should be focused at varying levels of product, process and organization, and be integrated in serving the firm's strategic development. The differences from differing perspectives and foci call for corresponding assessment methodologies. Social network analysis (SNA) is therefore proposed in this paper as a potential method for achieving construction social sustainability.

SNA for sustainable construction

Social network analysis (SNA) is an analytic method based on the concept of social network; a set of social actors (e.g. individuals, groups, or companies) form a network through the interdependencies or relationships between them (Wasserman and Faust, 1994). SNA is concerned with the "structure and patterning" of relationships and its purpose is to identify both their causes and effects (Tichy et al., 1979). Techniques for describing and analyzing network structures and interpretative theories have already been established (Wasserman and Faust, 1994).

SNA has increasingly become popular in construction management studies over the last two decades. In the construction industry, project-based organizations (PBOs) have long been accepted as the norm across a significant range of activities (Winch, 1989; Gann and Salter, 2000; Söderlund, 2010; Morris et al., 2011). PBO refers to an organizational form, involving the creation of temporary systems for project delivery. One theoretical bridge to using SNA in construction is to view construction PBOs as a set of networks. Allee (2002, 2008) proposes a SNA approach to evaluate construction management initiatives, and his discussion of value conversion within networks provides much inspiration for construction management studies. A fruitful application of network theory to construction management materializing the EXPO 2010 project in Shanghai by establishing an organizational-level SNA model covering the main project stakeholders' information flows, project participant positions, clique formation, management power distribution and leadership within the network (Li et al., 2011). SNA approach is also suitable and efficient for mapping the knowledge flows in construction projects in order to improve the project sustainability (Schröpfer and Kurul, 2016)

Another underpinning theoretical stance is provided by institutional theory, where formal and informal institutions together form the "rules of the game" (North, 1990) and the institutional interplay is perceived to be influential in organizational performance (Zenger et al., 2002; Scott, 2014). Formal networks are designated in formal institutional settings, and informal networks are evolved by the interplay of formal and informal institutions over time, with informal relations playing an essential role in the distribution of organizational management power, leadership and progress control (Krackhardt and Hanson, 1993).

In summary, a popular theoretical perspective is to view PBOs as networks formed by formal and informal institutions. Their interplay portrays the dynamics of the formal and informal institutions in the PBOs that, in turn, determine project performance however it is defined. SNA provides a new "language" to represent and understand PBOs by translating them into social networks and allowing innovative studies of organizational relationships in a manner that inspires both academic and practical interest. It also provides a handy and powerful analytical tool for improving social sustainability in construction.

Conceptual framework of SNA implementation for improving social sustainability in construction

The conceptual framework shown in Figure 2 is proposed to illustrate how the analytic method of SNA can facilitate the achievement of social sustainability in construction. Compared to the economic and environmental dimensions, the social dimension of sustainability needs to be placed in the context of the inter-relationships between internal and external stakeholders, with the goal of improving their social capital, social infrastructure, social justice and equity, and engaged governance. One of the two axes on the left hand side of Figure 2 represents the multiple levels of social networks in a PBO, with the unit of analysis in inter-firm and intra-firm networks being the individual, task group and/or company. The other axis indicates the dimension of project phase to reflect the PBO’s dynamic and complex features.

<<Figure 2 Conceptual framework of SNA implementation for improving social sustainability in construction >>

On the right side of Figure 2 are the four aspects of social sustainability of both internal and external stakeholders. To be socially sustainable in the context of construction, the PBO needs to own the trust or commitment from the internal stakeholders (project team members) and external stakeholders (the government and the local community). The *social capital* for the project team is widely reported in the literature, such as the establishment of organizational versions and norms, the accumulation of experience and enhancement of professional skills of employees, and social networking with core project participants and peripheral stakeholders (Lin, 1999; Inkpen and Tsang, 2005; Li et al., 2011). The closeness of project team members and convenience in reaching their resources are also regarded as critical elements of social capital (Warde and Tampubolon, 2002; Inkpen and Tsang, 2005) and relate to the concepts of closeness and connectivity in SNA. For *social infrastructure*, the physical outcomes of construction projects, e.g. roads, bridges, tunnels, hotels, schools and commercial buildings, are important supporters of the sustainable development of society. Although commonly discussed at the macro level instead of within the boundary of the PBO, social infrastructure in construction can be understood as the facilitating equipment or mechanisms serving network reachability and efficiency, such as information communication technologies and an innovation encouraging organizational culture. From the perspective of external stakeholders, a high priority is often given to *social justice and equity* in the feasibility analysis of construction projects (Dempsey et al, 2011). From the perspective of project team members, the protection of rights, liberties and equity - one essential element of social justice – need to be considered through regulations and narratives. Freedom of thought - another element of social justice and equity –also needs to be respected, so that innovative ideas can be continuously proposed and efficiently practiced throughout the working networks (Easley and Kleinberg, 2010). The last aspect of *engaged governance* requires the involvement of both internal and external stakeholders in decision-making. Client requirements need to be highly prioritized and concerns of the local community are taken into serious consideration, while successful project delivery relies mainly on the knowledge and professional work of the project team (Kent and Becerik-Gerber, 2010; Chinowsky et al., 2008, 2010, 2012). Integrated design and construction processes and early involvement of engaged governance has been gaining increasing support in the construction industry over the past two decades (Sive, 2009; Kent and Becerik-Gerber, 2010).

In the middle of Figure 2, SNA serves as the bridge between the organizational study of construction PBOs and social sustainability. By visually presenting the networks and quantifying the network characteristics, the social sustainability of both internal and external stakeholders can be evaluated and enhanced through in-depth exploration and necessary interventions. There are two approaches for SNA to contribute to the improvement of PBO social sustainability. The first and static approach is to map the social networks in a PBO according to differing scenarios or organizational settings, and then to utilize the SNA method to characterize these networks for the comparison of social sustainability performance. This approach can refer to the work of Pryke (2012), where a survey is adopted to investigate six types of procurement related networks. Based on the survey data, graphical presentations are provided to visualize the social networks of interest, and SNA measures are calculated to investigate the differences of organizational concerns in procurement methods. The second approach is to compare the network design relating to social sustainability concerns with the actual working networks during the project delivery in a dynamic way. This approach can refer to the work of Pauget and Ward (2013), where a French hospital project is studied by SNA over two time-periods and a mismatch between the actual networks and the designated working relationships is found to be responsible for the project delay. The two approaches are not contradictory. The first approach involves a comparison of several specifically formed networks in a PBO, while the second one provides a longitudinal comparison of the networks of interest during project phases. If the two approaches well combined, SNA applications in construction can perform to be more comprehensive, dynamic and interpretable.

Improving social sustainability performance through SNA: a case study

In this section, a case project is investigated to illustrate the operationalization of the conceptual framework. Validity issues are considered in its design following Yin (2003). For the purpose of illustration, only the broad categories of social sustainability and the common SNA measures in organizational study are utilized. Internal validity is ensured through the aforementioned discussion on the relationship between the categories of social sustainability and network measures. External validity is concerned with the implications for the generalized theory domain, which refers to institutional theory in organizational studies. Particularly, the examination of formal and informal networks in this study can add value to the theoretical discussion of institutional interplay. Finally, reliability is ensured because of the repeatability of the data collection procedure and analysis.

Case description

The case is a private "turnkey" building renovation project. After renovation, the building will be a 4-story high professional training center with two underground floors and a total gross floor area of about 15,000 m^2. The project is piloted to implement Building Information Modeling (BIM) and green building technologies, including a geothermal heating water system and underground water proofing system.

The client is fully financing the project within a strict schedule and has assigned a task group to coordinate and control project progress, while the contractor is responsible for the project delivery. As shown in Figure 3, the project team comprises the client, the contractor, architects, planners, engineers and sub-contractors, e.g. building service specialists. The project manager leads contractor's six task groups; two service groups being responsible for centralized service provision and quality control, and four other groups on-site being responsible for planning, procurement, cost control, construction work, coordination, etc. An electronic planning company, a structural engineering company and a building services provider have joined the project team under the supervision of the project manager to provide professional services. The Government is an important external stakeholder that has a significant influence on the project management team's decision-making. The designated working network is interpreted and shown in Figure 3 based on these entities.

<<Figure 3 Designated working network based on organizational structure>>

Results and discussion

It is a twofold data collection process. For the data of the designated working network, a series of interviews were conducted with the project manager and representatives of six task groups, and a workshop was held to solicit information of internal stakeholders' roles and functions in the project. For the data of actual working network, an on-line questionnaire was designed and distributed to the project team members through the intranet. Site visits were arranged to survey those who missed to participate in the survey.

The aspects of social sustainability in the proposed conceptual framework can be examined based on the interviewers' reflections and survey results. The social sustainability concerns from the external stakeholders' perspective include the building facade embedded into the local architecture style, open green space and sidewalks for pedestrians, some facilities in the building open to the public, convenient access for disabled and the inclusion of representatives from the government and nearby community for engaged governance in project delivery. Most of the concerns, except for engaged governance, are beyond the scope of construction.

The social sustainability concerns from the internal stakeholders play important role in the scope of construction. Firstly, social capital can be understood as the professional capacities of individual team members and their ability to complete the assigned tasks cooperatively. For instance, the contractor has a good tradition of employee education and training to enhance the social capital of its employees. During project delivery, the contractor launches a monthly BIM education program to highlight good BIM practices. Secondly, the project team adopts information communication technologies (ICT) to increase teamwork efficiency and effectiveness, e.g. with the help of 3D visualization models of specific tasks, intranet to solicit opinions and remote technical assistance through graphs and videos. Secondly, these ICT applicants, and the encouraging atmosphere for innovations, function as social infrastructure for higher productivity in project delivery. Thirdly, the elements of social justice and equity are deeply embedded in the company culture. As reflected by most interviewees, their companies have regulations to protect employees' rights and freedom of thought, and they regard it a means of enhancing their trust relationship with the companies. Fourthly, engaged governance is highly valued by the project team in terms of decision-making. At the project level, the involvement of the client, government and local representatives is regarded as a prerequisite and good practice for the determination of project deliverables. As the project manager revealed, engaged governance is not just tailor-made for this project, but is a common practice for any construction project. At the company level, the interviewees indicate that they are more willing to take part in engaged governance because of the higher information transparency and trust in a BIM facilitated environment. At the specific task level, complex technical solutions are obtained through collective discussion of the relevant specialists on and off site. Collectively, those social sustainability concerns contribute to the initial organizational design and continuously affect organizational behaviors during project delivery.

All the data from interviews and surveys were coded as the adjacent matrices, which were then entered into the SNA software *Ucinet*, which is one of the most scholarly popular SNA toolkits (Anonymous, 2011; Wang, 2015). Figure 4 provides a graphical representation of the designated and actual working networks generated by *Ucinet*. The colored nodes indicate the actors from different firms or organizations. The node size indicates the actor's influence power measured by degree, which is a SNA metric. From the left network graph, it is easy to identify who are assigned to be the core members of the project team, e.g. project manager (PM), deputy project manager (DPM) and structural engineer in the construction management group (CM-ST). As expected in the original organizational design, the three core members are in the center of the network in the right network graph.

<<Figure 4 Graphical interpretations of both designated and actual working networks>>

With the help of *Ucinet*, the SNA measures at both the individual and network levels are calculated for the designated and actual working networks as shown in Table 1. The fit index for each SNA measure is derived by dividing its value (average value being used for the individual SNA measure) in the actual working network by that in the designated network. The results in Table 1 show a high consistency between the designated and actual working network, with a fit index of 1 indicating a perfect match.

<<Table 1 Statistics and fit indices of designated and actual working networks >>

Density relates to interaction intensity, and a denser network is perceived to be more cohesive and socially sustainable given the close fit between designated and actual working networks. The actual *density* is 1.04 times over the designated one in the case project. The density fit index can be lower than 1 in abnormal situations, e.g. with problems of “imploded relationships” or “irregular communication patterns”, as discussed by Krackhardt and Hanson (1993). The *average path length* and *diameter* indicates the level of interaction between the network actors. The fit index of an *average path length* is 0.94 indicating some new relationship is created to facilitate teamwork. If the actual *average path length* or *diameter* is larger than 1, it is probably because a gatekeeper is not transmitting information, which can be easily found in a “fragile structure” of low density and low reachability. *Degree centrality, closeness centrality* and *betweenness centrality* are the three measures of centrality in SNA. *Degree centrality* emphasizes the network position of an actor, with a higher degree of centrality leading to more opportunities in terms of acquiring information and resources from the whole network. *Closeness centrality* emphasizes connectedness, with a higher closeness centrality indicating a better capability of reaching other network actors. *Betweenness centrality* emphasizes the mediating function in controlling and transmitting information flows within the network. These three centrality measures are positively correlated with the influence and power an actor possesses in the network. The fit indices of the three centralities are 1.04, 1.05 and 0.94 respectively; being relatively close to 1 indicates a good match between designated and actual network features in terms of centrality. A closer look into the individual centrality can help reveal whether some members fail to maintain social connections with others for the sake of efficient information seeking or transmission. The last two SNA measures (global and local clustering coefficients) indicate the level of homophily, which means there is a tendency of individuals to associate or bond with “similar” others. The meaning of “similar” depends on the context; in this case, it is sociological affinity of working relationships. The fit indices of local and global clustering coefficients are 0.94 and 0.86, indicating a high level of working network cohesion that is conducive to the social infrastructure. Furthermore, most individuals have no obvious discrepancy between the clustering coefficient in the designated working network and that in the actual one; about 27% individuals have the discrepancy larger than 20%. A BIM coordinator with the largest discrepancy of 67% needs to own trust from team members, as it is found that others like to directly seek assistance from his superior.

Using the proposed conceptual framework, the social sustainability of internal stakeholders can be diagnosed by checking network graphs and SNA measures of both the designated and actual working networks. A high level of network structure fit, either at the individual or network level, indicates the project team is functioning as well as in the organizational design. The determination of the fit level depends on a comprehensive consideration of various factors, such as the network size, work intensity, social sustainability aspects, etc. For example, the extent of social sustainability can lead to tolerable intervals for the fit indexes of SNA measures, and attentions should be given to anything that changes dramatically beyond its tolerable interval. When an extremely low level of fit is found, the project management board needs to investigate the reasons and take necessary intervention steps. One intervention approach is to reflect on the original organizational design to see whether the task-oriented communications between corresponding professionals and specialists are sufficient and, if not, altering the missing or long-distance information channels by adjusting the organizational structure or enhancing ICT adoption. The other approach is to inspect current working relationships, especially where there is an obvious misfit of SNA measures, and remediate individual behaviors through individual contact or group social events to unify the team towards the primary goal of delivering construction projects in a more efficient and sustainable way.

Conclusions, implications, and limitations

There has been increasing interest in aligning construction – both as a constructed facility and the process of constructing it - with the emerging field of sustainable development and social sustainability in particular. However, the literature review shows that social sustainability has not yet been adequately addressed in construction, comparing with the other two dimensions of sustainability, and it calls for more methodological innovation. A conceptual framework is developed from the discussions of multi-layered construction project delivery networks and the network thinking for improving social sustainability in project-based organizations (PBOs). The conceptual framework highlights the methodological potential of SNA for improving social sustainability in construction. The two SNA application approaches, of static network analysis to compare alternative settings and the dynamic analysis to examine evolving networks over time, provide the fundamental stances for the methodological innovation needed to improve the social sustainability of construction.

The study also provides both theoretical and practical insights. Theoretically, consideration of the evolution of working networks could help shift management towards an informal institutional arrangement in the construction industry with a view to enhancing social sustainability. The proposed conceptual framework could be generalized into a broader, general management context and hence contribute to the development of mainstream management theory. This research further reinforces the theoretical view to treat PBOs as networks. In doing so, SNA can be linked to construction management research to allow innovative studies of organizational relationships in a manner that will inspire both academic and practical interest.

The study has a practical meaning for project managers or organization leaders to measure and analyze the interplay between the designated working networks according to formal institutional settings and the actual informal networks during construction project delivery. When an obvious mismatch is found, an adjustment can be made to the formal institutional setting or an intervention on informal working relationships in order to alleviate the mismatch. By continuous efforts of reflections on the network interplay and adjustments on formal and informal institutional settings, construction managers can better achieve social sustainability in construction.

This study can be regarded as the point of departure for the further examination of social sustainability in construction through SNA. One of the limitations is the methodological challenges of the SNA method; mapping social networks, especially in a longitudinal manner, is a costly and time-consuming process that demands an ingenious and thorough research design and ethnographical efforts thereafter. Future work is encouraged to explicate the bridge between social sustainability criteria and network measures, along with the theoretical development of sustainability development and network thinking. Further research is also encouraged to deepen the understanding of sustainability concerns in the network domain, in the context of construction and beyond.

Supplemental Data

Table. S1 is available online in the ASCE Library (ascelibrary.org).

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