The interplay between formal and informal institutions in projects: A social network analysis

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Abstract

In projects, various kinds of formal and informal institutions are crucial for imprinting and controlling behavior. The interplay and potential conflict between these two types of institutions have attracted increasing scholarly and managerial attention, but conventional institutional analyses are hampered by the lack of effective methodological instruments for understanding these types and examining their fit (or misfit). This study employs the methodology of social network analysis (SNA) to capture institutional interplay. We use four construction projects to illustrate the interplay between formal and informal networks in projects and to show how this interplay affects project performance. Our findings reveal that, in general, such performance is better when there is better fit—which indicates the extent of interplay—between a project's formal and informal guiding institutions. We also show how project managers can use SNA to diagnose formal and informal institutions or networks, enhancing their fit and thereby improving project performance. Results presented here have implications for the role of these two institutional types and for how the fit between them can be improved through conscious effort.

Keywords: institutions, networks, project network, formal–informal fit, social network analysis

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Introduction

The main purpose of project management is to maximize, in the most effective and efficient way, the value created by a project. Central to such management is the attainment of both cooperation and coordination regimes (Söderlund, 2011) that often transcend organizational boundaries (Sydow & Braun, 2017). For these reasons, current theory on organizing and managing projects emphasizes the importance of understanding how such regimes can be established and maintained. Scholarly work has noted in particular the importance of addressing the institutional features of projects that cross sectoral and organizational boundaries (see e.g., Engwall, 2003; Dille & Söderlund, 2011; Scott et al., 2011), and research has recently started to explore how formal institutions interact with informal ones. This paper contributes to that ongoing conversation by emphasizing a key aspect—the *fit* between formal and informal institutions—and by describing a framework suitable for further analysis of the formal and informal features of complex projects.

Institutions are created by humans to establish 'rules of the game' (North, 1990); within an organization or even a project, we can roughly divide them into formal and informal types. On the one hand, *formal* institutions comprise organizational structures, explicit incentives, and contractual arrangements; in most cases they are readily observable and also are typically stable over time (Zenger et al., 2002). On the other hand, *informal* institutions affect the behavior of players in ways that are relatively subtle and 'softer'—for example, through social constraints, social preferences, customs, traditions, and taboos (North, 1990; Jepperson, 1991; Zenger et al., 2002). The project management literature clearly recognizes the importance of both formal and informal institutions for understanding complex projects and their performance. Yet scholars have, for the most part, analyzed these two kinds of institutions independently and so have not fully grasped their interplay (Zenger et al., 2002; Scott, 2013).

Moreover, research on project-based organizing has been hampered by the absence of effective methods for capturing the often nebulous aspects of institutions and for explicating their dynamics in a way that enables meaningful subsequent analyses. Scholars tend to conceptualize project networks in a general sense (as in Hellgren & Stjernberg, 1995), although recent research has characterized them more specifically as social networks. These developments

motivate our analysis of the interplay between formal and informal institutions via the well-established *social network analysis* (SNA) approach.

As an academic discipline introduced by Moreno (1960), SNA has matured over the past decades (Wellman & Berkowitz, 1988). This discipline addresses the structure and patterning of relationships over time, and it seeks to describe how those relationship structures influence behavior and to identify both the causes and effects of such structures (Scott, 1991; Wasserman and Faust, 1994). Thus, SNA can be viewed as a new 'language' for representing and understanding projects (Pryke, 2012). Mead (2001) underscored the value of SNA in visualizing project organization. Matinheikki et al. (2016) identified activities that facilitate the development of interorganizational project networks and that augment value creation among these networks. Zheng et al. (2016) reviewed 63 papers—published between 1997 and 2015—on the use of SNA in construction management; they identified an emerging trend of SNA-based research designs and methodologies. When project organizing is described in terms of social networks, the mathematical and sociological techniques of SNA can be applied to study project relationships in a way that inspires both academic and practical interest (Hughes, 2012).

Our paper employs SNA methods to investigate the interplay between formal and informal institutions that arise and evolve during interorganizational projects and also to assess how this interplay affects project performance. This research focuses on the interfirm or interorganizational project (cf. Hellgren & Stjernberg, 1995; Dahlgren & Söderlund, 2001; Sydow & Braun, 2017). At the heart of our methodology is viewing formal and informal *institutions* in terms of formal and informal *networks*. Thus, we echo Kratzer et al. (2008) in defining a formal network as one that results from prescribed working relationships, which are expected and routine, and an informal network as one arising from work-related communications that are more immediate and relatively spontaneous. Our paper's main proposition is that the fit between a project's formal and informal networks is positively correlated with the performance of that project. Once substantiated, this proposition can serve as theoretical guidance for project managers who seek a better understanding of their project organization toward the end of continuously improving its performance.

The rest of our paper is organized as follows. After reviewing the literature on projects, networks, and organizational fit, we explain the methodology we use and discuss why and how the topic is viewed in terms of social networks; this development is the background behind our examination of how the *interplay* between formal and informal networks is related to project performance. Then, after briefly describing four real-world construction projects, we present our data analysis and discuss the findings that result. The paper concludes with a summary and suggestions for future research.

Literature review

Institutions and networks

To view a tangible and observable organization as a set of intangible and latent institutions was a significant theoretical advancement in management and organization studies. Scott (2013, p. 57) defined institutions as "multifaceted, durable social structures, made up of symbolic elements, social activities, and material resources." North (1990) described institutions as socially devised rules that shape human interactions. Formal institutions may include explicit incentives, contractual terms, and firm boundaries as defined by equity positions (Zenger et al., 2002). They are rules that are readily observable in terms of positions, such as authority or ownership. Whereas formal institutions define the "normative system designed by management" or a "blueprint for behavior", informal institutions define the actual behavior of players (Scott, 1981). Thus, informal institutions include taboos, customs, and traditions (Jepperson, 1991) as well as social norms, codes of conducts, routines, and political processes (North, 1990; Zenger et al., 2002). Zenger and colleagues argued that informal institutions are rules based on implicit understandings, which—because they reflect social conventions—are not readily accessible through written documents or necessarily sanctioned through formal positions. Both formal and informal institutions help to imprint human behavior by enabling and constraining social activities.

Project organizations are a particular form of organization and so can be viewed as being governed by a set of institutions (Engwall, 2003; Dille & Söderlund, 2011; Biesenthal et al., 2017). The structures of such organizations are observable, formal institutions per se that follow from the "rational, conscious and institutionalized arrangement of the division of labor" (Mintzberg, 1988). As summarized by Li et al. (2011), formal institutions in these project

settings include contractual relations, formalized outsourcing relations, and project alliance agreements. Such settings were specifically addressed by Akintoye et al. (2003) and Akintoye and Beck (2009), who investigated how the formal institutions (e.g., ownership) shaped by public-private partnerships can mitigate opportunistic behavior and encourage project participants to be more collaboratively oriented.

There has been far less research on informal institutions in projects, yet that body of literature is growing in response to the realization that the "soft" aspects of such institutions can make a significant difference in project management and performance. For example, Rowlinson and Root (1996) explored the effect of culture on project procurement, a topic that has gained more attention following the work of Scott et al. (2011) on global projects and the institutional conflicts that stem from contrasting interpretations of the "rules of the game". Focusing more specifically on trust and the establishment of cooperation regimes, Kadefors (2004) detailed the centrality of trust in project relationships, a notion that Swärd (2016) expanded upon in her study of trust development in interorganizational projects. There is additional evidence for the importance of informal institutions (e.g., relational contracts, trust, *guanxi,* project manager charisma) for ensuring the stability of business relationships and supply chains in projects—that is, irrespective of whether strong formal institutions are present (Kwan & Ofori, 2001; Reed, 2001; Gale & Luo, 2004; Winiecki, 2004; Ibrahim et al., 2017).

Along with this increased scholarly attention to both formal and informal institutions, researchers have begun to examine the importance of their interplay. But, as noted by Zenger et al. (2002), informal institutions—in contrast to their formal counterparts—have not been well documented. Thus, informal institutions are often simply treated as a passive response to formal institutions and without recognizing, much less describing, what other dynamics might be involved. According to Helmke and Levitsky (2004), there are four types of 'institutional interplay': complementary, substitutive, accommodating, and competing. In line with the proposed complementary type of interplay, Piotti et al. (2006) found that an increased *overlap* between formal and informal institutions facilitated organizational changes. Keikotlhaile et al. (2015) addressed the *balance* between formal team settings and communities of practice in a project, and Solli-Sæther et al. (2015) reported that the *misalignment* of strategic structure and organizational culture jeopardizes knowledge sharing within a project organization. Krackhardt

and Hanson (1993) described the informal network metaphorically as "the central nervous system driving the collective thought processes, actions, and reactions of its business units"; these authors argued that it must be *matched* with the formal network, or the "skeleton of an organization." In the context of projects, empirical research by Pemsel et al. (2016) led to the development of a governance framework that emphasizes the tasks of addressing formal and informal institutions and of evaluating their alignment as a means to improve management practice. Oliveira and Lumineau (2017) examined the effects of interplay between integrators and contracts on the performance of interorganizational project networks.

The fit between formal and informal institutions

The different terminologies (e.g., overlap, balance, misalignment, and matching), as the works just cited employ to describe the interplay between formal and informal institutions, lead us to examine the fit between those institutions. Hence, we propose that this notion of fit can subsume the various terminologies while helping to distinguish their complementary, substitutive, accommodating, or competing relationships. In particular, we believe that it is critical not only to seek alternative ways of studying formal and informal institutions but also to examine—which is a key concern in this paper—the relationship and fit between them.

The idea of fit has been widely discussed in the literature of organization theory. Yet despite its importance, this notion still "lacks the precise definition needed to test and recognize whether an organization has it or not" (Galbraith & Nathanson, 1979, p. 266). Strong and Volkoff (2010) found six misfits in an enterprise system domain—namely, those involving "functionality, data, usability, role, control and organizational culture". In a project context, these six areas could be grouped into formal institutions (i.e., functionality, role, and control) and informal ones (i.e., data, usability, and organizational culture). In a study of strategy and organizational structure, Venkatraman (1989) identified six types of fit: "moderation, mediation, matching, gestalts, profile deviation, and co-design change". Thus, the concept of fit is used in strategic management as an indicator of the extent to which an organization is matching its resources and capabilities with opportunities in the external environment (Grant, 2007; Lu, 2010) or of the extent of complementarity among parties' strengths and weaknesses in a strategic alliance or in mergers and acquisitions (Brouthers, 1995).

However, only limited research has been undertaken that addresses the fit between formal and informal institutions. A rare exception is the work of Kratzer et al. (2008), who documented both fit and misfit—between formal and informal networks—in global product development collaborations. These authors discovered that formally specified design interfaces and informal communication networks are only marginally correlated, with the latter being much "denser" than the former. In the context of our research on complex projects, fit can be understood as the level of complementarity between formal and informal institutions.

Management literature tends to emphasize that the fit between formal and informal institutions is correlated, directly or indirectly, with superior organizational performance. This assumption is implicit in contingency theory, according to which organizational performance depends on whether organizational characteristics are appropriate for or congruent with particular situations (Donaldson, 2001). Along these lines, Pennings (1987) argued that there is an effectiveness-maximizing value of the fit between a structural dimension and each environmental dimension. Chorn (1991) similarly emphasized that the strategic fit of four elements—the competitive situation, the firm's business strategy, the organization's culture, and leadership style—can lead to competitive advantages that eventually are translated into superior organizational performance.

Several empirical studies have shown that a proper fit typically leads to favorable and pertinent responses whereas the *lack* of fit can result in negative perceptions and behaviors. For instance, Tushman's (1979) classic study reported that high performance is associated with the alignment between task requirements and the extent of a communication structure's decentralization. Dewar and Werbel (1979) likewise establish that a good fit between technology and structure has a positive effect on performance. In their meta-analysis of 26 previously published studies, Miller and Cardinal (1994) found that strategic planning to achieve 'organization–environment alignment' (Armstrong, 1982; Ansoff, 1991) does improve the focal organization's performance. In light of these theoretical and empirical studies, it is reasonable to suppose that projects—as a special type of organizational form—admit our analogous claim: *A better fit between a project's formal and informal institutions is correlated with better project performance.*

Methodology development

Formal and informal institutions as social networks

We must establish a theoretical linkage between institutions and networks in order to understand how formal and informal institutions interact to affect project performance. As a point of departure, we remark that organizations, and therefore the projects they undertake, are socially constructed phenomena (Berger & Luckmann, 1966). Hence it is noteworthy that, when conceiving project networks in a general sense (Hellgren & Stjernberg, 1995), researchers have described projects as social networks consisting of a finite set of actors and the relations defined on them (Scott, 2013). Thus, relationships among project team members are viewed as a socio-technical system in the systems approach to complex organizational design, which builds on the interaction between people and technology in workplaces (Tavistock Institute, 1966; Allen, 1984). A crucial tenet of this approach is that production organizations are not only technical systems of machinery and techniques but also social systems of personal and group interactions; although these two systems are described as being independent, they must be jointly optimized to ensure efficient production. So far, however, there has been little use of the systems approach to analyze complex projects (Winch, 1989).

The idea of treating projects as social networks can perhaps be better understood by placing this notion in the context of projects' social embeddedness (Jones & Lichtenstein, 2008) and then relating it to prior research on project networks (Hellgren & Stjernberg, 1995). Although projects are temporary organizations, they do not proceed in a vacuum and do not operate in either an isolated or loosely coupled way (Engwall, 2003). Rather, projects succeed by enhancing relational embeddedness (Jones & Lichtenstein, 2008; Bakker, 2010) via linking back to their corresponding companies and/or developing connections between them. Thus, for instance, the 'project network' approach (Hellgren & Stjernberg, 1995) reflects the formal relationships between organizations as well as the relatively informal practices that stabilize and reproduce their respective structures and practices (Windeler & Sydow, 2001; Braun et al., 2012). In a similar vein, the idea of 'project ecology' stresses collaboration in temporary social settings (Grabher, 2002) and the 'platform economy approach' (Kenney & Zysman, 2016) fosters open innovation (Chesbrough, 2003) while transforming the business strategies of both temporary and permanent organizations (Van Alstyne et al., 2016). In this context, the concept of project organizations as social networks has a fairly long history and a solid theoretical basis.

Indeed, researchers have long employed social network analysis (SNA) to enhance our understanding of projects. Loosemore (1998), for example, used SNA to investigate interpersonal relationships in projects facing crisis conditions. The SNA approach was also intimated by Pryke (2005; 2012), who suggested that a construction project can be represented as a layering of interdependent networks. In a similar empirical context, Chinowsky et al. (2008; 2010) likewise emphasized that the understanding of complex projects could benefit substantially from viewing them as social networks.

Project analysis can be related to the SNA method by exploring how the interplay between formal and informal institutions affects project performance. Liu et al. (2015) pointed out that translating project organizations into social networks enables one to analyze them mathematically—and to present them visually—in a way that makes it easier to grasp project relationships. Hence this approach should be of considerable interest to academics and managers alike.

Methods

The first task when applying SNA to complex projects is *mapping* the relevant social networks. Various techniques can be used for collecting the data necessary to reproduce these networks. Traditional approaches include active solicitation by way of surveys, interviews, and/or participant observations (Hartmann & Fischer, 2009). Scholars have more recently been tempted to use big data of a passive nature—for example, meeting minutes, GPS records, time sheets—for the purpose of reconstructing social networks as they transpired (Wang & Lu, 2014). In this approach, the collected data are edited, coded, and translated into the SNA language. Subsequent analysis proceeds in two distinct phases. The first phase is the graphical and mathematical presentation of social networks to characterize the formal and informal institutions. The graphical presentation gives researchers a preliminary sense of the network structure, while the mathematical presentation includes a set of metrics (e.g., network diameter, average path length, density, centrality, and clustering) that can be used to uncover patterns and trends in the data. It is widely acknowledged that the meaning of particular SNA metrics is a function of the specific project to which they relate (Loosemore, 1998; Pryke, 2012).

The second phase of analysis, and the focus of this study, involves the application of SNA metrics to the project or case study at hand. Here we use eight such metrics to model institutional fit and test our theoretical proposition. In particular, our analysis is based on the metrics of: diameter, average path length, density, degree centrality, closeness centrality, between centrality, global clustering coefficient, and local clustering coefficient (cf. Wasserman & Faust, 1994). Since these SNA metrics are commonly used in organization studies (Mead, 2001; Hartmann & Fischer, 2009; Tortoriello et al., 2012) and since we wish to conserve space, in this paper we refrain from elaborating on their definitions, required calculations, and specific implications for the fit between formal and informal institutions.

That being said, we can calculate an *index* of these metrics as follows:

$$Fit\ index' = Informal\ /\ Formal \tag{1}$$

So for a given SNA metric X, we use *Informal* (resp. *Formal*) to represent the value of X in the informal (resp. formal) network. A fit index may be greater or less than 1. If we take density as an example, then an index > 1 indicates that the informal communication network is denser than the designed formal network while an index < 1 indicates that the former is sparser than the latter; when the index = 1 there is a perfect fit between the actual communication network and formally prescribed network. Thus, the closer a fit index is to 1, the less discrepancy (better fit) there is between the informal and the formal network. We can derive a more accurate measure of fit by making a linear transformation of equation (1); the result is

$$Fit\ index = |\ Fit\ index' - 1\ | \tag{2}$$

Under this formulation, we are less concerned about whether an index is less than or greater than 1 and instead focus our attention on the *discrepancy* between the two institutional or network types. So now we can postulate that, the closer a fit index is to 0, the less discrepancy (the better fit) there is between the informal network and the formal network.

Our next task is to measure the dependent variable: project performance. Shenhar et al.'s (2001) multi-dimensional framework for assessing project success is in wide use by both scholar and project managers. The three criteria posited by these authors—completing the project on time, within budget, and while meeting the quality standard—have become a project management maxim. However, those three have been usefully extended to five criteria: time (C1), cost (C2),

quality (C3), environment (C4), and health and safety (H&S) (C5); this extension accommodates the importance of the environment and of H&S issues in project management. Shen et al. (2006) argued that all five project success criteria are seldom fully satisfied. Hence trade-offs among them are often necessary to ensure a project's overall success. Lu et al. (2006) was the first to suggest the approach, which is now commonly used, of evaluating trade-offs via weighting values that capture the relative significance of different criteria for the focal project's success. Their formulation is as follows: $Performance = \sum_i w_i C(i)$. Here $C(i)$ is the score of project performance criterion i, the weights w_i are set according to the opinions of academic and professional experts, and the weights of all criteria sum to unity (i.e., $\sum_i w_i = 1$).

Given the methodology described in this section, the proposition we seek to verify can be divided into eight testable sub-propositions; see Table 1.

Table 1: A summary of sub-propositions to be substantiated in this study

P_1	The higher fit of *density* between formal and informal networks in a project is correlated to better project performance.
P_2	The higher fit of *average path length* between formal and informal networks in a project is correlated to better project performance.
P_3	The higher fit of *diameter* between formal and informal networks in a project is correlated to better project performance.
P_4	The higher fit of *global clustering coefficient* between formal and informal networks in a project is correlated to better project performance.
P_5	The higher fit of *degree centrality* between formal and informal networks in a project is correlated to better project performance.
P_6	The higher fit of *closeness centrality* between formal and informal networks in a project is correlated to better project performance.
P_7	The higher fit of *betweenness centrality* between formal and informal networks in a project is correlated to better project performance.
P_8	The higher fit of *local clustering coefficient* between formal and informal networks in a project is correlated to better project performance.

Case studies

Case descriptions

The construction sector is often used as the industrial setting for addressing inter-organizational project relations. It is an industry in which projects have a major role in ensuring economic

exchange and collaboration among partners (Winch, 1989; Gann & Salter, 2000; Morris et al., 2011). We therefore investigated four separate construction projects; see Table 2 for a summary of key project information. Three of the projects (A, B, and C) were publicly funded infrastructure or housing projects based in Hong Kong; the fourth (Project D) was located in Germany and funded by a private client. The operation of each project involved a mix of so-called solid- and dotted-line (i.e., formal and informal) reporting structures (Davis & Lawrence, 1978).

Table 2: Overview of the four cases

Project Ref	**A**	**B**	**C**	**D**
Project type	Infrastructure	Housing	Housing	Building
Duration	8 years	3 years	4 years	1.75 years
Procurement models	Design & Build (D&B)	Design-Bid-Build (DBB)	DBB	DBB
Financial size	US$ 4,625 million	US$ 60.6 million	US$ 78.8 million	US$ 23.3 million
Finance	Public	Public	Public	Private
Physical size	7.5 km (road) 3.7 km (tunnel)	11,950 m^2	11,870 m^2	14,800 m^2
Time of data collection	3rd year	Completed	Completed	7th-8th month

We did not have a particular comparative strategy (Eisenhardt, 1989) in mind at the start of this study; rather, we were mainly interested in identifying patterns across several cases (Yin, 2013). Our aim was to generate some empirical breadth and variety—for instance, in terms of project size, project type, project duration, project location, and project funding—that would help explain our findings.

Data collection and processing

For our SNA, the network boundary (Butts, 2008) was set as active interorganizational projects. The actors are the project's main participants, and the links consist of their formal or informal interactions.

There were two parts in our data collection process, one each for the formal and informal networks. The procedure used to collect data about formal networks was the same across all four cases. Here the information on contracts and organizational structures, including both solid- and dotted-line reporting, were retrieved from our contact persons and publicly available reports and also through interviews with two key project members with in-depth knowledge of

the respective projects. These informants were asked to validate the formal network of each case project included in our study. We found that Project A adopted a *design and build* (D&B) procurement model whereas the other three were building projects that adopted a *design–bid–build* (DBB) model. We expected that the reporting structures would differ among the four cases. However, the nature of construction is such that clients remain in close contact with design and contracting firms—though sometimes separately (even when those firms have formed a D&B consortium). Hence, we expected that the projects' formal networks would not differ by much.

We adopted three distinct methods for collecting the data used to map the projects' informal networks. The combination of a survey and interviews was not possible in Project A, so we adopted a compromise method: we approached knowledgeable 'persons in charge' (PICs), who were recommended by the on-site human resources officer, to plumb their understanding of the actual working relationships among members in their task groups. These PICs were asked to identify two members of the organization whom they had contacted frequently (weekly in the past three months), contact that presumably reflected informal (dotted-line or spontaneous) work-related communications.

In Projects B and C, the time sheets of tasks and participants had been archived and so could be retrieved. Gathering this potentially sensitive information relied on the client's trust in and support of our research team. In Project D, a survey via the company's intranet was distributed among all project members, and this data collection was augmented by interviews with key members of the project. With the client's support and encouragement, two researchers were dispatched from Hong Kong to Germany and stayed with the company for a month in order to collect data. In all four projects, only the intrafirm structures of the clients and main contractors were examined in detail; the other participant firms were treated as individual actors in the networks. More details of the data—and of the form used to collect it—are given in Appendix A. That form was adapted from the SNA questionnaire survey reproduced in the appendix of Pryke (2012); the survey collected information on sending and receiving relationships to infer informal networks. To assist participants in completing the questionnaire, we categorized communication patterns into four types: orders, commands, or regular meetings; protocol files, notes, or e-mails for records; casual talk or idea exchange; and "other". However, we observed

that informants often found it difficult to make clear distinctions between some of the categories (e.g., “idea exchange” vs. “regular meeting”). We therefore ended up using all the data collected to construct a single, inclusive informal network (namely, work-related communications).

The data were translated into the SNA language by using either FoR2M (formal relationship to SNA matrix) conversion or InR2M (informal relationship to SNA matrix) conversion, as applies. In using FoR2M, the first step in constructing the formal network was to translate the organizational structure—including both solid- and dotted-line reporting—into adjacent matrices, which is the SNA data input format used by both the *Ucinet* and *R* software (see Appendix B). We similarly constructed the informal adjacent matrix by feeding the data collected from the four projects into the InR2M conversion. After this preliminary data processing, the adjacent matrices for both formal and informal networks in all four projects were imported into *Ucinet* for the purpose of network visualization and calculating the various SNA metrics. Figure 1 gives a graphical overview of the formal and informal networks, where the size of a node is proportional to its “degree”. This illustration of the networks shows the relative positioning of network actors: those in the middle of a network are regarded as more influential or powerful than those at the periphery. A general observation is that informal social networks (i.e., actual relationships) are denser than the networks based on formally prescribed relationships. This method of processing the data allowed us to make detailed comparisons between the formal and informal social networks in individual projects.

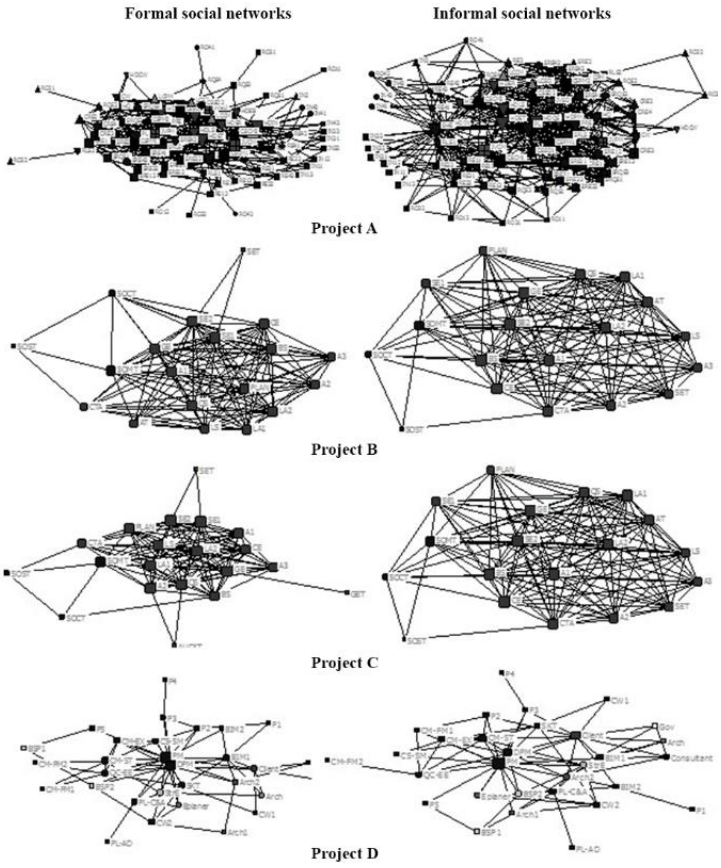

Figure 1. Graphical presentations of formal and informal networks in the four studied projects.

Another virtue of SNA is that it facilitates a mathematical description of networks. Thus, we can develop a more comprehensive understanding—from both the micro and macro perspectives—of formal and informal networks by examining fit the indexes derived from SNA metrics related to the individual and network levels. These fit indexes are derived in accordance with equation (2) and are presented in Figure 2 and Table 3.

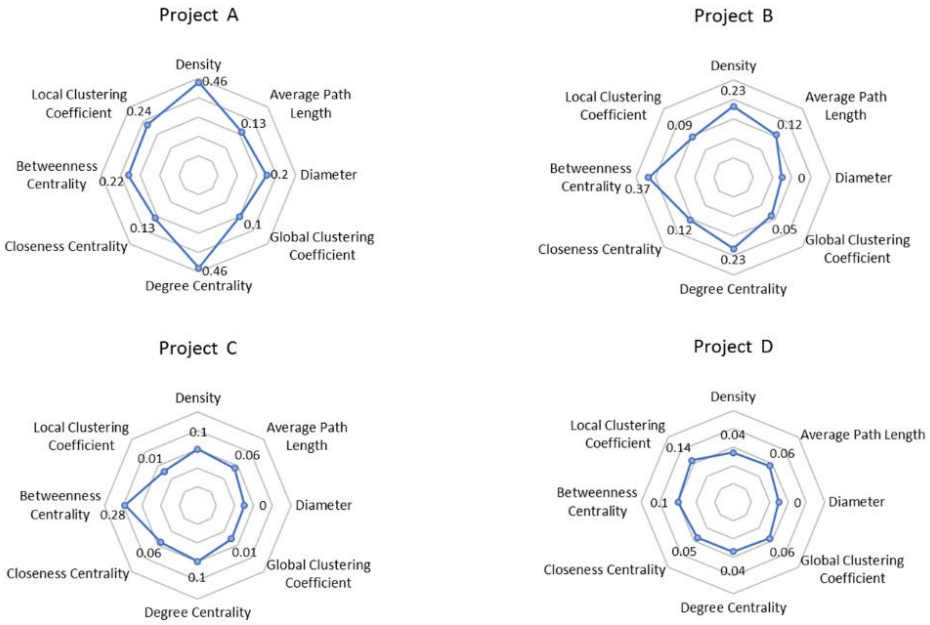

Figure 2. Spider diagrams of the fit indexes in the four studied projects.

Table 3: A summary of fit indexes and project performance

			Project			
			A	**B**	**C**	**D**
Fit index*	**Network level**	Density	0.46	0.23	0.10	0.04
		Average Path Length	0.13	0.12	0.06	0.06
		Diameter	0.20	0	0	0
		Global Clustering Coefficient	0.10	0.05	0.01	0.06
	Individual level	Degree Centrality	0.46	0.23	0.10	0.04
		Closeness Centrality	0.13	0.12	0.06	0.05
		Betweenness Centrality	0.22	0.37	0.28	0.10
		Local Clustering Coefficient	0.24	0.09	0.01	0.14
Performance		Time	4.00	4.25	4.50	4.10
		Cost	3.75	4.25	4.50	3.86
		Quality	4.13	4.25	4.50	4.44
		Working Environment	4.00	4.00	4.00	4.89
		Health & Safety	4.00	4.50	4.50	5.00
		Total Performance	3.96	4.25	4.43	4.36

* The smaller the fit index here, the fitter.

As mentioned previously, project performance was measured along five dimensions: time, cost, quality, environment, and H&S. Data on project performance were collected from secondary empirical data and subjective assessments. The secondary empirical data from archival documents (e.g., payment records) and published materials (e.g., news reports) were preferred for devising an objective measure of project performance. Descriptive results of project performance for the four case projects are presented in Table 3, where overall performance is calculated using weights of 25%, 25%, 25%, 15%, and 10% for, respectively, time, cost, quality, environment, and H&S (Lu et al., 2006). Of course, these weights assigned to the various performance indicators are somewhat arbitrary. Yet they reflect industry beliefs in the greater importance of time, cost, and quality in comparison with the emerging emphasis being placed on the environment and H&S (Lu et al., 2006; Shen et al., 2006).

Analysis and results

We carried out a correlational analysis to examine the interplay between the formal and informal social networks and to assess how well that interplay correlated with project performance. Table 4 reports the correlations between fit indexes of SNA metrics and project performance scores. The table footnote describes the specific *t*-test process. For most SNA metrics there is a *negative* correlation. Some metrics exhibit a high correlation at the 90% or 95% confidence level. In these cases, less discrepancy between the formal and informal networks (i.e., the closer a fit index is to 0) is correlated with better project performance. Because we examined only four case projects, these results should be viewed as being suggestive but not as statistically significant. Nonetheless, we shall next interpret the results regarding the different SNA metrics in turn.[5]

Table 4: Correlations between the fit indexes of SNA metrics and project performance

Sub-propositions	SNA metrics	Time	Cost	Quality	Environment	H&S	Total
P_1	Density	-0.53	-0.45	-0.93 (*)	-0.60	-0.92 (*)	-0.96 (**)
P_2	Average Path Length	-0.51	-0.36	-0.97 (**)	-0.57	-0.76	-0.87
P_3	Diameter	-0.65	-0.65	-0.78	-0.33	-0.82	-0.93 (*)

[5] In the rest of this section, we streamline the presentation by using Initial-cap italics to signify SNA metrics

P_4	Global Clustering Coefficient	-0.96 (**)	-0.93 (*)	-0.83	0.09	-0.44	-0.90
P_5	Degree Centrality	-0.53	-0.45	-0.93 (*)	-0.60	-0.92 (*)	-0.96 (**)
P_6	Closeness Centrality	-0.43	-0.28	-0.95 (*)	-0.65	-0.80	-0.84
P_7	Betweenness Centrality	0.49	0.65	-0.26	-0.84	-0.43	-0.03
P_8	Local Clustering Coefficient	-0.96 (**)	-0.95 (*)	-0.77	0.14	-0.42	-0.88

*Note: * stands for significance at confidence level of 90%; ** stands for significance at confidence level of 95%; formula for the t-test for the coefficient is p=TDIST(r*SQRT(df)/SQRT(1-r^2), n-2,2), where p is the p-value of significance test, TDIST is the t-test function in EXCEL, SQRT is the square root function, r is the correlation coefficient, and n is the sample size.*

The network *Density* measures the overall connectivity of a project network. A fit index closer to 0 is equivalent to better fit between formal and informal social networks in terms of this metric, which is positively correlated with project performance. That finding supports our claim that a higher *Density* of formal or informal social networks need not entail better project performance, which depends also on the extent of fit between the two. This metric's fit index between the informal communication network and formally prescribed working relationships varies among projects, with the German building project (D) exhibiting the best fit and the infrastructure project (A) the worst fit (see Table 3). Project A was a complex infrastructure project that required more effective communication—in line with the formal network constructed to streamline the communication between client and D&B consortium. Project D was a relatively simple building project undertaken in the efficient and self-disciplined German construction context, which therefore manifested the best fit between its formal and informal networks. As confirmed by the values reported in Table 4, fit indexes based on *Density* are closely related to overall project performance.

Both *Average path length* and *Diameter* reflect the level of 'interaction convenience' for actors within networks. These metrics have similar implications in organizational research: A smaller value is indicative of interactions that are more convenient. The major difference is that *Average path length* measures average 'reachability' whereas *Diameter* is the distance between the two most separated nodes. For each of these metrics, a fit index closer to 0, i.e., a better fit between formal and informal networks, is correlated with better project performance. Observe that projects C and D had the highest fit indexes as measured by *Average path length* and the

Diameter. The reason is that both projects adopted the emerging technological platform of building information modeling (BIM) so as, in part, to improve communication. The BIM approach yields a single truth platform on which the communication among all major stakeholders is based. The better match—between formal and informal networks—that is facilitated by BIM does imply better project performance (see Table 4).

Degree centrality, *Closeness centrality*, and *Betweenness centrality* are SNA's three individual-level metrics of centrality, a notion that relates to an individual member's influence and power within the network. For each of these metrics, an individual who is more central plays a more important role in the focal project network. As with all other metrics, a fit index closer to 0 is equivalent to a better fit between formal and informal social networks in terms of that metric—and especially so, in this case, when one considers average effects. Table 4 shows that our sub-propositions P_5 and P_6 are supported whereas the one related to *Betweenness centrality* (i.e., P_7) is rejected. Recall from Table 3 that Project D (resp. A) had the lowest (resp. highest) fit index in terms of these centrality metrics. Firms that adopt D&B as a procurement model typically do so as a means of internalizing communications between design and construction teams (Lu et al., 2012). Here, however, that desired end was seldom achieved because—as revealed by observations and interviews—it was often difficult to determine just who, designer or contractor, would have the final say. The resulting mismatch between formal and informal communication evidently compromised project performance, especially in terms of overall quality. We remark that *Betweenness centrality* reflects the mediating effects of controlling and transmitting information flows within social networks, which means that a smaller value on this metric is not necessary for maintaining a large number of direct links yet is necessary for mediating the most important ones. To improve the *Betweenness centrality* fit between formal and informal networks, extra attention must be paid to managerial effects at the individual level. That dynamic explains why this metric's fit index might increase even as the fit indexes of the other two centrality metrics remain unchanged.

Both *Global clustering coefficient* and *Local clustering coefficient* reflect the level of 'homophily', or the tendency of individuals to associate and bond with similar individuals. Here 'similar' is interpreted as sociological affinity—for example, having similar work tasks, engaging in the same types of nonwork pursuits, and/or having experienced comparable

circumstances. The implications of these metrics are expected to match those in organizational studies, where a value closer to 0 indicates a more 'cohesive' neighborhood or network and hence will benefit project performance; our results confirm that expectation. It is interesting that the two public housing projects (Projects B and C) had clustering coefficients that were better (i.e., closer to 0) than did projects A and D. The public housing clients examined the track records of potential contractors, and only a few were eligible to participate. The client has a long-term and relatively stable work task-oriented clustering with suppliers that exhibit superior time and cost performance. Contractors consciously maintain a close cluster among the involved parties toward the end of ensuring their own longevity as a business. The two clustering metrics can be used together, at both the network and individual level, to explore whether such work task-oriented clusters are formed at the behest of formal institutions.

Discussion

This paper advances previous literature pertaining to the institutional analysis of projects by (a) recognizing the importance of formal and informal networks and (b) emphasizing in particular that improving the fit between these two should lead to better project performance. As we document, the interplay between formal and informal institutions is a driver of project success. Within the boundaries of a project, formal networks constitute the organizational basis for interaction and information exchange among project members whereas informal social networks reflect actual communication patterns and information flows. There is no guarantee that formal institutions will affect their desired ends, but they are assisted in that goal by informal institutions that facilitate communication, improve morale, reduce transaction costs, and thereby lead to superior project performance. This research thus supports and builds on Zenger et al.'s (2002) arguments for the complementarity between formal and informal institutions as well as on Helmke and Levitsky's (2004) typology of complementary, substitutive, accommodating, and competing institutions. As described by Krackhardt and Hanson (1993), the interplay between formal networks (an organization's "skeleton") and informal networks (its "central nervous system") is critical because only when these two networks exhibit a good fit does the organization become fully productive. However, we certainly do not mean to suggest that a *perfect* fit is possible or even desirable for project governance. In their study of enterprise management systems, Strong and Volkoff (2010) point out that institutions are intended to satisfy generic rather than specific requirements and so an

imperfect fit is most likely in any particular instance. This observation is echoed by contingency theory (Donaldson, 2001), according to which project managers do not seek a static, perfect fit between formal and informal institutions but rather look to manage them continuously to achieve a congruence that is appropriate for the project situations at hand.

The research reported here has several important managerial implications. Using the analytical tool proposed in this study, a project manager could assess organizational effectiveness by checking the fit between formal and informal networks. After observing a poor fit, the project manager could undertake to intervene. On the one hand, a manager could investigate the *formal* institutions to see whether task-related communication among the professionals involved is both sufficient and efficient; if not, then missing or long-distance information channels could be bridged at the organizational level by way of facilitating technologies or even changing the organization's structure. In the construction industry, for instance, the use of BIM is widely promoted as a platform to facilitate communication and information interoperability (Eastman et al., 2008; Chen et al., 2015). Pauget and Wald (2013) described the instructive case of a French hospital construction project in which a project manager's maladaptation was detected only through two-period SNA surveys. On the other hand, it may be easier or more productive to adjust *informal* institutions—for example, by implementing experience-sharing schemes (Bresnen et al., 2004) or project team camps (such as the Certified Project Manager "boot camp" program). Such activities can increase project members' sense of belonging and hence the development of trust among the actors involved (Swärd, 2016). However, adjusting informal institutions to overcome project-related shortcomings awaits sustained scholarly exploration.

Our paper also makes significant methodological contributions, of which one is the translation of projects into social networks so that social network analysis—and especially its graphical, mathematical, and sociological methods—can be applied to the study of project organizations and project networks. Employing SNA enabled our representation of projects' formal and informal networks in a series of instructive graphs and quantitative expressions suitable for further analyses. Our FoR2M and InR2M conversion routines were designed to translate a project's (respectively) formal and informal structures into adjacent matrices, the preferred data

input format used in SNA software programs such as *Ucinet* and *R*.[6] Another methodological contribution is our development of a simple instrument to quantify the fit between formal and informal institutions and networks. Unlike previous project management studies that treat managerial intervention as more art than science, our paper uses a set of instruments to guide this process and thereby demonstrates that the diagnosis and subsequent improvement of organizations and projects can be portrayed graphically, longitudinally analyzed, and thus easily monitored.

Conclusions and future research

The design of this study reflects a series of rigorous processes. Our paper began with a review of the literature on formal and informal institutions and on how their interplay, in the context of project organizing, affects project performance. It then discussed the feasibility of adopting social network analysis approaches to represent institutions and to explore their dynamics. This paper references four distinct case studies of construction projects in Hong Kong and Germany. The techniques of SNA were used to characterize, both graphically and mathematically, the interplay between formal and informal networks in those cases. Fit indexes were estimated based on SNA metrics, and a quantitative analysis was conducted to measure the correlation between formal–informal fit (i.e., network interplay) and project performance. The quantitative analytical results were then linked to qualitative assessments of the project's social networks. In prior research, these methodological processes have been employed separately. Yet using them in combination, as in this paper, yields a contribution that is original in terms of both methodology and the resulting testable propositions.

This research confirms that the fit between formal and informal institutions is positively correlated with project performance. A central corollary is that a higher metric of formal or informal networks need not, in itself, result in better project performance; of equal (if not greater) importance is the extent of *fit* between the two. These results have both theoretical and practical significance. Research that has traditionally focused on rigid, hierarchical formal institutions in project management can now be redirected toward pursuing a new angle: the interplay between formal and informal institutions. Project managers can use this research to

[6] Space limitations preclude our elaborating on these conversions in this paper; details are available from the authors upon request.

guide periodic and systematic diagnoses of their project networks with the aim of continually improving project performance. By using the metrics available through SNA to quantify and visualize network interplay, project management—especially as regards diagnosis and subsequent intervention—can wield a powerful tool for improving project management practices.

Future work could address and transcend some limitations of the research design and methods used here. First, because the number of case studies is small, the generalization of our findings will require more evidence on the interplay between formal and informal networks and its effect on project performance. Second, the statistical significance of this paper's analysis is marginal, which means that it is more appropriate to view our results as indicative than as decisive—although the quantitative analysis is bolstered by the qualitative analysis. Third, SNA is a promising research method that offers a toolkit for organizational scholars, but a stronger connection still needs to be made between the graphical and mathematical representations of SNA and their practical implications for organizational studies. Finally, collecting data on the evolution of informal networks is extremely time-consuming. This process needs to be upgraded so that the benefits of SNA-enabled project management approaches can be more easily realized. For instance, scholars should consider incorporating the relational factors derivable from big data (e.g., time sheets, records) instead of relying solely on curated small-data samples.

In short, the research reported in this paper is a leap forward in the institution-related analysis of project management practice because it focuses on the *interplay* between a project's underlying formal and informal institutions—and the effect of their *fit* on project performance—and because it realizes and exploits the potential of *social network analysis* for profitably addressing this topic.

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Appendix A: Data collection form

Your Name _____ Position _____

Division/Dept._____ Company _____

<table>
<tr><td colspan="8">With whom do you recently frequently exchange information, regarding the delivery of your project?</td></tr>
<tr><td rowspan="2">Ref.</td><td rowspan="2">Name</td><td rowspan="2">Position</td><td rowspan="2">Company</td><td colspan="4">Communication pattern(s)*</td><td rowspan="2">Rank coding
Please rank the communication pattern(s) in the terms of frequency and quality.
Frequency:
1. Monthly even less
2. Bi-weekly
3. Weekly
4. Daily
5. Several times per day
Quality (Accuracy and Timeliness):
(a) not satisfied;
(b) satisfied yet need to be improved;
(c) satisfied</td></tr>
<tr><td>Orders, commands, or regular meeting</td><td>Protocol file, notes, or emails for records</td><td>Casual talk, or idea exchange</td><td>Others (please specify)</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">5</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

* This data collection from is used to record work-related communications. Differences of these communication patterns are not counted in developing informal networks.

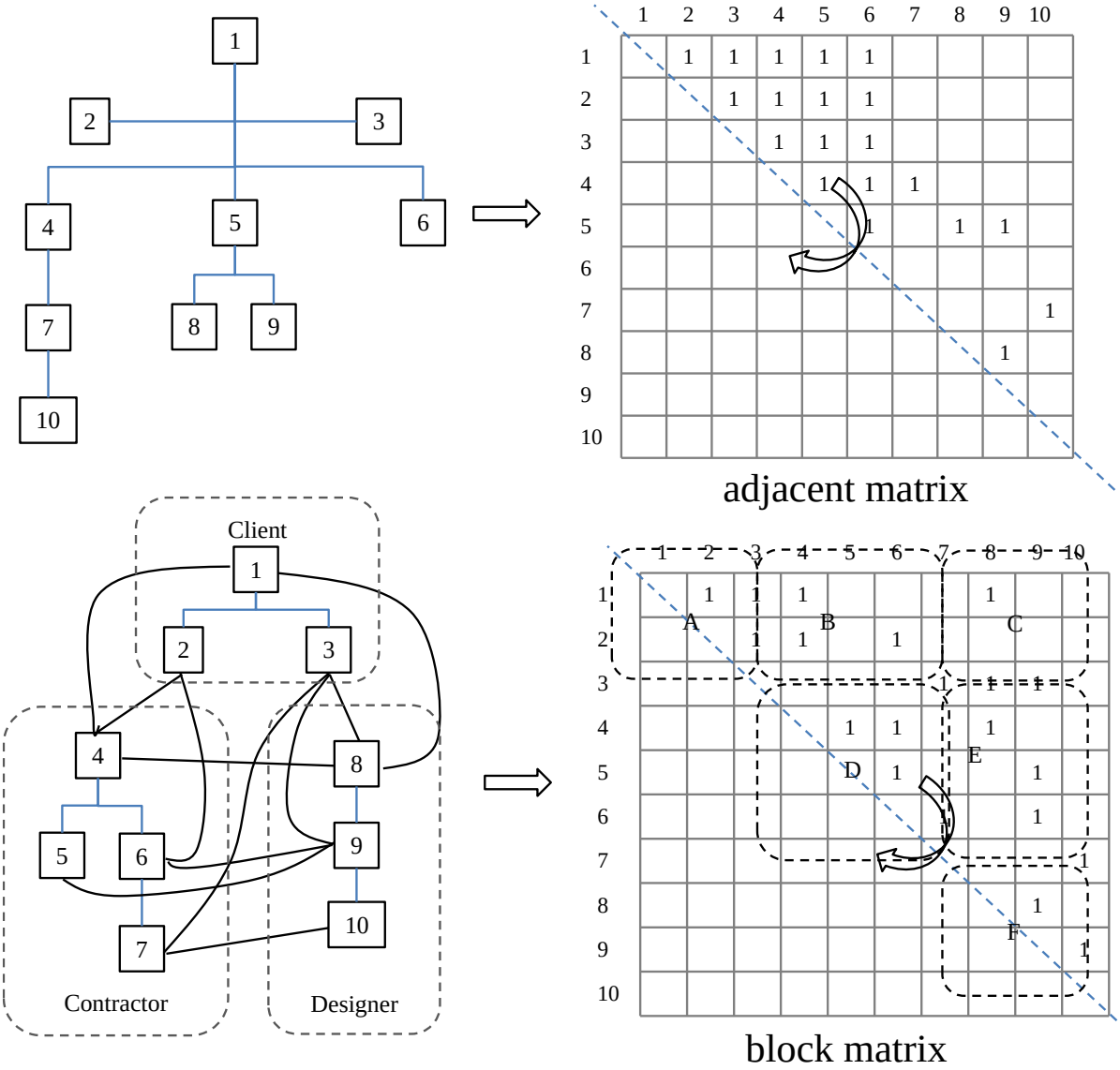
Please make assessment of the current project performance based on your expertise knowledge.

Likert scale: 1 stands for being very much dissatisfied and 5 stands for very satisfied.

Items	Time	Cost	Quality of the completed work	Working environment	Health & Safety
Rank					
Remarks					

Appendix B: FoR2M Conversion and InR2M Conversion Methods

The first part of the FoR2M Conversion method is to translate the organizational structure into an adjacent matrix. As shown in the following figure, if an actor in the network can directly reach another actor without passing through other actor(s), it is assigned a "1" in the corresponding cell of the adjacent matrix. The second part of the FoR2M Conversion method is to integrate the interfirm relationships into formal organizational structures. The information of contractual relationships (the main skeleton), organizational structures (organs), and the proposed interactions among specialists were combined to become a block matrix. A block matrix is still an adjacent matrix in nature. For example, the sub-matrixes A, D, and F in the following figure represent the organizational structures of the three firms, namely, the client, contractor, and designer. The sub-matrixes B, C, and E stand for the inter-firm connections developed from the contractual relationship between the client and the contractor, between the client and the designer, and between the contractor and the designer, respectively.



The InR2M Conversion method is to convert data format for the informal institutions into the adjacent matrix. The informal institutions are characterized by work relationship related communication. The original data from interviews, survey/questionnaire, and archival studies are unified to the same SNA language, in a similar vein that has been seen above in dealing with the formal institutions, i.e., FoR2M. The steps are as following: (1) editing and coding the original data to identify the information about actors and relations in SNA language; (2) translating the information into adjacent matrix, organized as block matrix, by assigning values in the corresponding cells without the operation of transposition; and (3) validating the data by checking the symmetry of the adjacent matrix, and examine those cells with contradictions through further enquiry by email, phone or face-to-face interviews.