Journal of Global Information Management
Volume 30 • Issue 1

Exploring Communication and Networks Using Social Network Analysis:
A Case Study of a Utility Company's Asset Management Programme

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ABSTRACT

Programme management's importance is increasing, particularly in the public sector, because of government promotion of PM. However, its novelty means PM is an under-researched organizational form. This is particularly the case with the application studied here of PM for asset management in the utility sector with its unique setting of a heavily regulated monopoly. This study focuses on an asset management programme that comprises a utility company and its eight contractor partners and explores how communication networks are influenced by organizational affiliation, seniority, technical nature of the work, and geographical proximity. Social network analysis is used in a participative, cross-sectional study of communication networks. The study reveals that association with technical work content has a noteworthy influence on the individual's positioning in the communication network.

KEYWORDS

Asset Management Programme, Collaborative Networks, Communication Networks, Programme Management, Social Network Analysis

INTRODUCTION

Recent years have witnessed companies paying growing attention to project and programme collaboration arising from the challenges they face in increasingly competitive environments. Programme management (PM) is a novel and growing application of management that enables multiple, inter-related projects to be managed collectively in contrast to traditional project management where projects are managed individually and in isolation. However, the more recent form of programme management has not yet been explored that often in the literature. In programme management a group of organisations collaborate to manage an inter-related set of projects(Pellegrinelli, Murray-Webster, & Turner, 2014). This form of organisational collaboration is growing in economic importance, partly because of governments, such as in the UK, promoting programme management for the delivery of

DOI: 10.4018/JGIM.301198 *Corresponding Author

their policies. Successful collaboration in this and other contexts depends on good communication between the collaborating parties to underpin the required positive relationships.

The literature on inter-organisational relationships (IORs), networks and, collaborative forms (e.g., partnerships and alliances) is well established. However, empirical studies of IORs within a complex network of multiple organizations, as in the context of programme management, are rare (Pellegrinelli, 2011). In particular, research on IORs is limited in the utility sector - the setting for the research reported here. Unlike many other sectors, the UK utility sector is monopolized, geographically based, and heavily regulated. The nature of the sector means that the ongoing requirement to construct new and refurbish existing capital assets via a managed program creates a major focus for the utility company and its contracting partners. In this unique context, relationships, in general, and communication, in particular, between the partners are key determinants of program success.

This study focuses on a recently established asset management program that comprises a utility company (UC) and its eight contractor partners, some of which have a long history of collaboration with the UC (e.g., 10-15 years) while others are more recent connections (18 months or less). However, these previous collaborations among the nine organizations vary in terms of integration and interdependence. The UC has introduced in the current program cycle a new approach to working with their contractor partners that has two components: (1) work is organized into five streams, each containing projects of a similar technical nature and (2) key personnel from all nine organizations are co-located in a new multi-storey office block.

The study sets out to investigate how individuals affiliated to the various organizations form new and extend existing, collaborative relationships within this revised commercial and physical context. Supply chain research (including the behaviour of the physical supply network) often adopts a quantitative, e.g., simulation approach (Bezuidenhout, Bodhanya, Sanjika, Sibomana, & Boote, 2012); however, accuracy is severely compromised where data are omitted or more nuanced, such as the interplay of personal relationships within a supply network. We believe progress in understanding this little-studied but key economic context of a utility's supply chain requires empirical results based on a robust, multi-disciplinary, theoretical perspective. Hence, the approach taken here is to use Social Network Analysis (SNA) aided by a particular software tool. The research aims not only to contribute to the theoretical and empirical literature but also aims to assist the UC's asset management team in understanding the evolving relationships in the programme's early phase. Specifically, the study seeks to understand how aspects such as organisational affiliation, project work content, seniority, pre-existing relationships, and geographical location affect communications network structure and an individual's position within the network. The research also sought to help management identify appropriate strategies to develop inter-organizational networks. The study presents empirical research of inter-organizational collaboration in the context of programme management. It also contributes to the academic literature on network performance and development. The empirical nature of the study also has a direct contribution to practice, both for the UK utility sector, regulated industries, and programme management practice in general.

The rest of the paper outlines relevant literature, then moves on to outline the methodology. The results are then presented and discussed before the summary and conclusions.

LITERATURE REVIEW

This section first reviews the topic of networks in general, then covers collaboration and next communication in networks. Finally, the literature on the study context is introduced.

Networks

One of the difficulties with the word "network" is that it is used in a variety of contexts and to mark out different concepts. For example, in the field of biotechnology, in order to map out the structure of interorganizational collaboration, Powell et al. (2005) apply analysis of network degree distributions

and network visualizations to estimate dyadic relationships and demonstrate affiliation shapes network evolution(Powell, White, Koput, & Owen-Smith, 2005). In Social Network Analysis (SNA) a social network is formed from a set of relational data that usually describes the social relationships between individuals.

The economic and business literature on networks often emphasizes the motivations behind activities related to establishing or maintaining business relationships (Ford, 2012) and other forms of inter-organizational relations (Cropper, Huxham, Ebers, & Ring, 2009). Research in inter-organizational relationships (IOR), networks, and collaboration is also contributed by Powell et al. (1996) through their work on the number and diversity of a firm's IORs and its centrality within its network positively impact upon its growth(Powell, Koput, & Smith-Doerr, 1996), by Gulati (1995; p.86) on the "relationship between transactions and trust", and by Doz (1996; p. 56) on the "management of collaborations in technology-based product markets"(Doz, 1996). The literature also deals with the internalization theory and its focus on industries as well as firms on using formal multi-actor collaboration(Buckley & Casson, 2019). Underpinning all of this is the extreme complexity of such networks because of the numbers of suppliers and transactions, different work structures and the inevitable evolution of networks through a complex interplay of the network's structure and function(Surana, Kumara, Greaves, & Raghavan, 2005). A Causal Loop Diagram (CLD) can be used to analyze the key factors and interactions among the diverse stakeholders(Choi & Kim, 2020).

An exchange network can be characterised as sets of two or more exchange relationships between individuals and organizations (Cook, Cheshire, & Gerbasi, 2020). In the international business context, a firm's network typically includes a variety of organizations such as suppliers, buyers, regulators, rivals, and financial agencies that comprise the "economic organization of production"(Ghoshal & Bartlett, 1990), often across a number of industries(Pathak, Day, Nair, Sawaya, & Kristal, 2007).

Research about networks can also be linked with the work of the international marketing and purchasing (IMP) Group (see https://www.impgroup.org/about.php) whose main focus was buyer-supplier relationships (Håkansson & Gadde, 2018). Although vertical buyer-supplier relationships were important in industry, other relationships gradually emerged. Through long-term business relationships, innovations and learning developed in other projects can be used in the focal project, so it is possible for the construction company to use a core network of individuals and organisations to enhance overall renewal among actors(Ingemansson Havenvid, Håkansson, & Linné, 2016). Although the process of forming network relationships is similar to the creation of social capital; networks, relationships and social capital are not the same concept. As Todeva and Knoke (2005 p.126) state, corporate social capital "originates in macro-level processes that are more than aggregated interpersonal ties". Therefore inter-organizational networks can promote organizational prestige, status and reputation which are forms of social capital(Todeva & Knoke, 2005). Conversely, if the relationship fails to facilitate attaining an actor's goal and instead impedes performance, it is called "social liability"(Leenders & Gabbay, 1999).

In addition, the trend towards developing informal networks within and between organisations (Rob Cross & Parker, 2004) requires a better understanding of such networks, which "gives a very granular means of promoting team effectiveness", including whether the team is connected effectively for the work being carried out rather than relying on the establishing of ad hoc relationships across the network (R. Cross, Ehrlich, Dawson, & Helferich, 2008).

Collaborative Networks

Different views on network structures and types that can be identified have been described above. Similarly, different views exist on the nature of relationships between firms constituting a network. The trend recently in various parts of the literature has been to prescribe, and present evidence for, collaborative relationships as superior to adversarial, or arm's length relationships. The level of cooperation between organizational participants is much influenced by external factors rather than internal costs, such as the history of the partnering relationships between organizations; joint-

resourcing abilities; and information asymmetries in arm's-length market transactions(Dietrich, 1994). That is to say, economic rationalities are not taken for granted as the driving force to form inter-organizational relationships, instead, the long-term and relational aspects drive the formation of network relationships. Morton et al. (2006) focus upon the importance of collaboration to forming and maintaining productive relationships within and between organizations (Morton, Dainty, Burns, Brookes, & Backhouse, 2006).

Inter-organizational linkage features prominently, both in practice and research, given that companies search for efficiencies and try to gain competitive advantages to survive in a market with uncertainties and rigidities; particularly when collaboration is seen as a key to delivering such advantages. Thirteen forms of inter-organizational relationships are classified from hierarchical relations and joint ventures to subcontractor networks and market relations(Todeva & Knoke, 2005). The collaboration level increases and the governance of IOR becomes more formal as organisations move from hierarchical, to market relations.

While collaboration is usually seen in a positive light, risks as well as benefits arise from collaborative activities. Relationships cost money. Organizations pay relational cost arising from the partnership to overcome uncertainties, for example, Todeva and Knoke (2005) contend that relational cost comprises not only expenditures to maintain an informal relationship with partners, but also includes the commitments and investments partners make. When a relationship dissolves, the company has to terminate the existing business relations to accept a new partner.

Extensive literature has focused on strategic alliance as a typical partnership creating value for partners (Gulati, 2007). From the literature that focuses on the propensity of relationship formation, and as Surana et al.(2005) note, an intriguing point is: how do relational and structural features of a network influence the quality of collaboration? For instance, prior ties with a partner increase the likelihood of future ties with that partner to a certain point since such ties take time to form, even if the tie strength may diminish later. Gulati (2007) argued that those contemplating R&D collaboration or engagement with foreign partners usually have to consider formal governance, yet prior ties can nurture inter-organizational trust, which allows less hierarchical forms of relationship. Similarly, the proximity of partners has a bearing on the degree and effectiveness of collaboration (Knoben & Oerlemans, 2006). Wu et al. (2016) state that proper and planned control for the communication among team members is crucial for the success of projects(Wu, Goh, Li, Luo, & Zheng, 2016).

Communication and Networks

The importance of communication within an organization and between organizations has prevailed over the decades. With the development of information technology and the increasing emphasis on relationships across groups with multi-organization members, the communication networks of organizations become more and more permeable. Although many scholars have examined the impact of communication and information technology on organization's productivity(Morrar, Abdeljawad, Jabr, Kisa, & Younis, 2019; P. Yin, Zheng, Duan, Xu, & He, 2019), or performance(Hung, Chang, Chen, & Ho, 2019), Cross et al. (2015) highlight the importance of cross-boundary networks that let groups throughout an organization achieve economies of scale and enable the combination of diverse knowledge and experience (Rob Cross, Ernst, Assimakopoulos, & Ranta, 2015). Literature on social network analysis (Wasserman et al., 1994); Jackson, 2008) emphasizes that the structure of a communications network and the interaction are closely related to information flow. For example, a hierarchical communication structure may confer a disproportionate information advantage on the headquarters of a multinational rather than divisions. A recent study concludes with the result that every individual obtains the same outcome independent of their network position, and this outcome depends on the peripheral (least connected) individuals in the network via a lab experiment (Gallo, 2020).

Bolton and Dewatripont (1994) state that three principles determine the efficiency of a communication network: (1) specialized agents in a communication network help coordinate agents'

activities; (2) number of communication links between agents; (3) the average number of agents used to transmit information. They propose those principles would aid the design of a communication network in terms of seeking information, sending information, when information overload occurs, and layers of an efficient network(Bolton & Dewatripont, 1994).

Social network theory is well known for studying patterns of communication among members of a social group (Tichy, Tushman and Fombrun, 1979). Communication takes place through actors who maintain links with one another via information flow. Networks of communication at the organizational level are normally classified as intra- or inter-organizational (R. Cross et al., 2008). While intra-organizational relates to links within the organization, inter-organizational networks look at links between different organizations.

Programme Management

Programme management as a particular form of management received only scant attention until the 1990s. Although different interpretations of the phrase exist, one of the key views is that programme management is argued to be better able to deal with emergence, ambiguity and changing goals (Pellegrinelli et al., 2014). A definition popularized by Pellegrinelli (2011) defines a programme as "a framework for grouping existing projects or defining new projects, and for focusing all the activities required to achieve a set of major benefits. These projects are managed in a coordinated way, either to achieve a common goal, or to extract benefits which would otherwise not be realised if they were managed independently(Pellegrinelli, 2011). Programme management has been developed from project management but moves beyond the approach whereby individual projects are managed in relative isolation. According to the UK Office of Government Commerce (2010), programme management exists to relieve the tension between strategic direction, project delivery and operational effectiveness. The OGC, as an independent office of the UK Treasury, has done much to foster the application of programme management within the public sector, e.g., through publicising its Managing Successful Programmes (MSP) guidelines ((OGC), 2010). Although sometimes construed as a single organisation, a programme often involves the coming together of multiple organisations that collaborate and communicate, thereby forming various networks through the interaction of the participants, especially for public sector organizations(Rouibah, Dihani, & Al-Qirim, 2020).

It has been stated that in a major project-based organization the relational norms of collaboration (e.g., alliances) is fostered upon the client invests in mechanisms supportive of governance, culture, and trust in order to establish collaborative, rather than opportunistic behaviors (Galvin, Tywoniak, & Sutherland, 2021).To avoid fragmentation and ensure coordination, governance mechanisms are put in place that coordinate activities and practices across the organisational spaces whilst maintaining their compartmentalization (Frederiksen, Gottlieb, & Leiringer, 2021). In general, the perspective in the literature above is to see networks as an organisational form, whereas the social network perspective takes a broader view. Traditionally social network analysis focuses on relational and structural properties of networks (Granovetter, 1985) and considers the position of the firm as well as the nature of the ties. An organization's inter-organizational network is very important for it to produce, disseminate and transfer information to facilitate collective action (Monge et al., 1998). Communication in inter-organizational networks breeds trust, which influences the type of collaboration and quality of communication (Gulati, 1995).

METHODOLOGY

Research Context

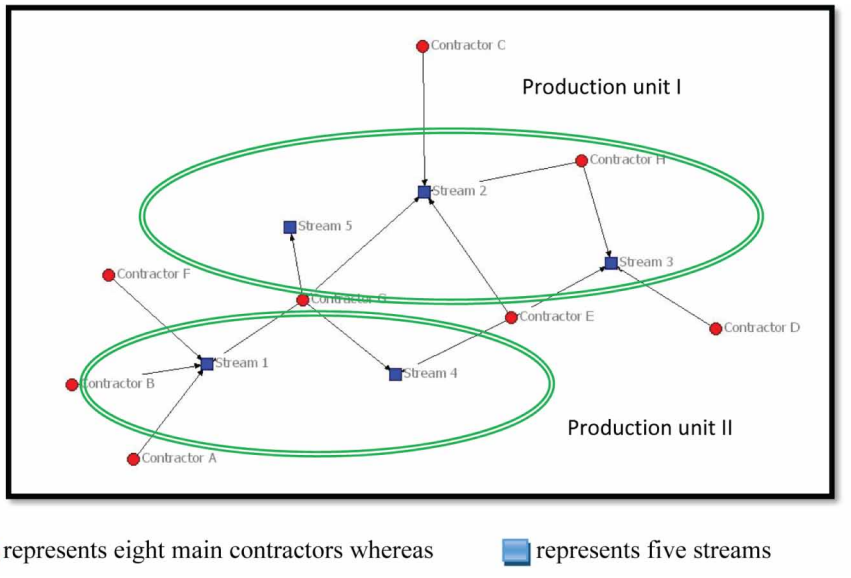
A UK utility company (UC) with its contracting partners delivers programmes of work to maintain and renew capital assets as agreed with the regulator; these are called asset management plans (AMPs). The UC's expressed philosophy of working with its contractors is through a partnership approach that

stresses collaboration between partners. As is typical of programme management(Pellegrinelli et al., 2014), the time-limited programme comprises a bundle of related projects which have to be managed individually but also collectively as an integrated unit. Each programme cycle lasts five years and can involve substantial innovation in the intra-organisational and inter-organisational arrangements to deliver the thousands of projects in the programme. Project values range from less than £2 million to £15 million. The aggregated outcomes of the inter-related projects contribute to the overall programme results. The studied cycle is the fifth programme (2010-2015) that has gone through the early stage of network formation. In this programme the UC has adopted two major changes. First, the programme's projects are arranged in five main streams of work, each aggregating technically similar projects whereas in previous programmes the projects were managed on a geographical basis. Contractors in the previous programme were allocated to four geographical sub-units comprising the UC's overall region. Each stream has a UC manager, and the five streams are grouped into two areas described as production units, reflecting some similarities in the work content within the streams within a production unit. A senior UC manager is responsible for each production unit. In the coding used for this study, the first production unit (I) comprises streams 2, 3 and 5 while the second unit (II) covers streams 1 and 4. In the new arrangements, eight main contracting partners are allocated to work on the streams (see Figure 1). In a second major innovation key personnel from the partners are co-located into a regional hub, whereas the previous programme arrangements relied on a distributed approach based on geographical subdivisions.

The study that we describe here arose from an ongoing research collaboration between the UC, a consultancy partner, and the university academics involved. The intention was to explore how collaboration developed between and within the UC and its contractor partners in the early stages of a programme cycle. Through a field study and initial interviews with UC senior managers, we observed that an important reason for co-location was to increase the sharing of ideas and information for innovation between UC and contractor partners. A research question to frame this study is "How do a UK water company and its contractor partners communicate and share information in the programme?"

The UC's staff and those of the eight contractor partners comprise a complex network of collaboration both originating from the process of creating new relationships and extending prior

Figure 1. Contractor-Stream Relationships



relationships where these exist. The complex network is therefore a result of past collaboration and collaboration being developed for the future, and the network acts as a repository of information, ideas, and knowledge. Lahdenperä (2012) states that the formation of a highly-connected project network can reduce project parties' reliance on claims and litigations (Lahdenperä, 2012). Furthermore, a particular relationship can be established to ensure good communication by appointing team members who have previous experience (Badiru, 2019).

A longer-term view of collaborative activity than just looking at the current programme recognizes that two of the contractors had worked with UC for 15 years. Such a period enables trust to develop between the partners and, to some extent, the trust may replace the need for formal control mechanisms. For example, informal negotiation may replace the need for strictly defined contract terms. A further by-product of a long-term collaboration is that it reduces the transaction cost such as searching for information to make a deal and monitoring to make sure obligations have been met (Gulati, 1995). It has also been stated that there is a growing need to examine what relational bonds parties might rely upon when they come from contexts with different institutional governance structures and different cultural understandings of trust in the research on cooperative inter-organizational relationships (CIORs) (Ring & Van de Ven, 2019)

METHODS

The scale and scope of the research reported here warrant a case study approach (Eisenhardt, Huberman, & Miles, 2002; R. Yin, 2017) not least because of its participative approach and the intention to investigate longitudinal developments(Pettigrew, 1990) within the network. Social Network Analysis (SNA) (Scott & Stokman, 2015) was also identified as an appropriate method because of its ability to help understand both the static position and the dynamic development of networks (Cross and Parker, 2004). SNA's capability to help participants visualize networks using the software was considered particularly useful given it would facilitate engagement with industrialists (Rob Cross et al., 2015).

Initial Interviews

Six initial interviews were held, with the UC manager of each of the five work streams and with one of the two production unit managers responsible for the stream managers, both to refine the research scope and establish what resources would be required to facilitate questionnaire administration. Each interview lasted approximately one hour and elicited information regarding the nature of work within the stream, the contractors involved within the stream, the value of work overall and the general approach to contractor management and expectations for collaboration.

SNA Questionnaire

From these interviews, a social network analysis questionnaire was subsequently developed to capture people's communication activities both formally, i.e., for reporting purposes, and informally, i.e., preferences to converse with certain people over others. A roster was developed for the questionnaire recipients co-located within the regional hub: this comprised senior and mid-level managers within the UC and within the contractors. This roster totaled 110 individuals. The questionnaire comprised four questions concerning:

1. Who people talked to at work.
2. Who they sought information from.
3. Who they provided information to.
4. Who they preferred to share ideas with.

Respondents were asked to indicate who of the 109 (i.e., excluding themselves) they communicated with on a scale of 0 (not at all) to 3 (a great deal). Questionnaires were distributed as an Excel file and gathered over seven weeks, during which various individuals (identifiable initially as non-respondents due to the roster of named questionnaire recipients) were chased for their responses. Overall, a 93% response rate was achieved, which is considered acceptable in this type of situation. The response rate required for an SNA survey to reliably represent the network under investigation is substantially higher than in conventional survey work. The SNA methodology literature acknowledges that response rates in social science research are often compromised and that everything possible should be done to attain the highest response possible (Burt, 1987; Scott & Stokman, 2015). Recommendations of at least a 90% response rate have been identified which was clearly achieved in this case (Molina & Borgatti, 2019).

The data were coded to present the results anonymously. A well-recognized issue with sociograms, namely the standard visualisation technique for networks within SNA, is the sensitive status of personal data and the aversion to even minimal risk by "moral bureaucracies" thus compromising anonymity (Molina & Borgatti, 2019). To counter this, permission was obtained from the most senior managers, i.e., those who were most likely to become identifiable within the sociograms, for the need for anonymity to be relaxed in their case. However, sociograms were still presented anonymously and the researchers did not identify individuals.

The data were analyzed using visual sociograms and other SNA techniques such as centrality and density. In the first instance, analyses were by question and by workstream. Results were reported to the UC stream managers and their managers during which active discussion took place between UC managers and the research team. The prospect of a longitudinal study was discussed and agreed upon.

Centrality Analysis

SNA uses proxy measures of interactions between individuals to identify network structure and evaluates structure through network metrics such as centrality. Studies of network structure indicate a positive relationship between centrality measures and performance at the individual level (Bulkley & Van Alstyne, 2006) and the group level (X. Yin, Wu, & Tsai, 2012). Jiang and Chen (2015) pointed out that while friendship network centrality was beneficial for creative members implementing their novel ideas, advice network centrality was detrimental for creative members to accomplish collaborative performance.

The concern with centrality is motivated by the idea of positional status discussed by several scholars. A person who is close to other people is supposed to have access to greater information (Rob Cross & Parker, 2004; Leavitt, 1951), able to become powerful (Coleman, 2017), and have greater prestige or influence (Burt, Reagans, & Volvovsky, 2021) than other people. Centrality is primarily a characteristic of an actor in the network derived by aggregating the connections to others in the network. Centrality implies an actor's position and in the case of a network of firms, can signal the firm's strategy. For a network of individuals, network centrality can imply a managerial position in the hierarchy; it can also indicate the various individuals that have access and control to valuable resources (Burt, 2015). In-degree refers to the number of directional links to the actor from other actors (incoming links), while out-degree refers to the number of directional links from the actor to other actors (outgoing links). Question 1 ("who do you talk to at work") and Question 4 ("who do you prefer to share ideas with") reflect different research focuses. Question 1 reflects the breadth of the communication networks, formal and informal, whilst Question 4 is used as a proxy for "trust", indicating individuals' communication preferences. Therefore, they are bi-directional. In order to capture the information seeking and providing behaviour, Question 2 relates to "who do you seek information from" and Question 3 relates to "who do you provide information to" with directional information flow.

The measure of betweenness centrality is applied in communication when it is assumed information has to be passed from one to another along the geodesic path connecting them.

Researchers indicated that people who stand between other people when they are central could facilitate or impede communication (Freeman, 1977) because they are in the position to mediate the access of others to information.

A number of applications employ centrality measures but mostly for binary datasets (Brandes, Borgatti, & Freeman, 2016). While conceptually prevalent, such a binary structure is criticized since it can only represent qualitative relationships. When addressing binary modelling, Peay (1976, p.56) commented: "…it encompasses only qualitative relationships. This precludes the possibility of considering such variables as strength of relationship [or] amount of social interaction…". Therefore the binary approach is questioned because of its failure to capture the important variability in the strength of ties that exist in interpersonal relationships (Brandes et al., 2016).

Group Centrality Analysis

Often centrality measures have been applied to individual nodes. Yet, it may be advantageous to have centrality measures applied to a set of nodes. The sets can either be determined by attributes of nodes (e.g., ethnicity or membership) or be emergent groups identified via network analysis (e.g., cliques). Such group measures can answer questions such as "are the salespeople more central than R&D people in the company's social network?" or "is one particular group more integrated into the research team than others?" If a project is charged with promoting innovation among a set of organizations, we can either examine the formal groups which are organization-based, or the informal groups comprised of individuals from various organizations and attempt to examine their innovation influence. The more that a group is central in this influence network, the more individuals/ groups in the networked organizations regard it as being innovative.

Everett and Borgatti (1999) contend that a group centrality measure is a measure of centrality of a specific group that consists of the same type of result as a standard individual measure, but with respect to the centrality of the group rather than to individual actors (Everett & Borgatti, 1999). Group degree centrality is defined as "the number of actors outside the group that are connected to members of the group" (p.59) and are only counted once if multiple ties exist to the same actors by different group members (Everett & Borgatti, 2003). Obviously, the maximum score is when every actor outside the group is connected to an actor in the group. Normalization of this measure refers to dividing the degree of the group by the number of actors outside the group. In group centrality analysis, different groups in the same network can have different sizes, therefore normalization is important to compare scores.

RESULTS

For its low age (i.e., the programme was only 12-18 months old), the network of individuals within the UC and contract partners appeared particularly well-connected when considering density. For Question 1, "who do you talk to?" a density of 0.88 was recorded (i.e., 88% of all possible ties between individuals were active at that time) and the sociogram could only be usefully interpreted at the highest strength of tie (see Figure 2).

In the sociogram the UC individuals, who are portrayed in yellow, are visibly located toward the centre of the network and the contractors' groups more toward the periphery, as could be expected.

Figure 2 also indicates a good number of staff with long organizational tenure (of the order of >20 years) clustered near the centre of the network; UC staff are particularly well-represented in this category. One may conclude that an environment in which colleagues are very familiar with one another, and patterns of working and communicating are also well entrenched. In Figure 2, for a few individual actors who locate centrally but have relatively short tenure in the organisation, it might be the case that they had spent quite a long time in the utility sector and they have many prior relationships with UC. Hence, tenure is not automatically a proxy for prior relationships.

Figure 2. Sociogram for general communication

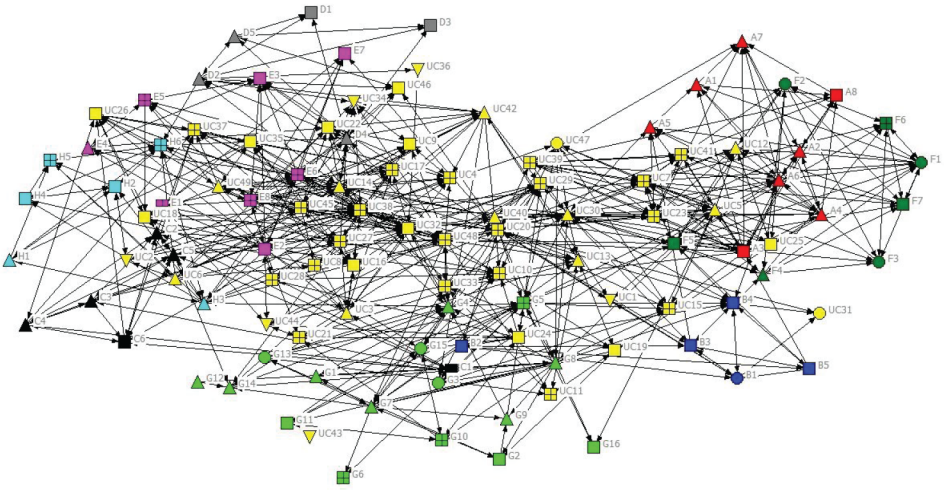


Table 1. Figure 2 key

Organization	*Colour*
A	Red
B	Blue
C	Black
D	Grey
E	Pink
F	Dark Green
G	Light Green
H	Light Blue
UC	Yellow

Table 2. Figure 2 key

Tenure Attribute	
○	<1 year
□	>1 and <10 years
△	10-20 years
⊞	>20 years
▽	Missing information

Regarding the more formal communication networks (i.e., relative to Q1), it can be clearly seen in Figure 3 that the responses to the question "who do you seek information from?" favour the staff of UC in general, but also in general favour the senior managers (denoted by the square nodes) of both UC and the contractors as key information sources. Node UC20 appears to be very centrally located which, as a non-senior manager, is more unusual within this network; closer inspection reveals that the

Figure 3. Sociogram for acquiring information

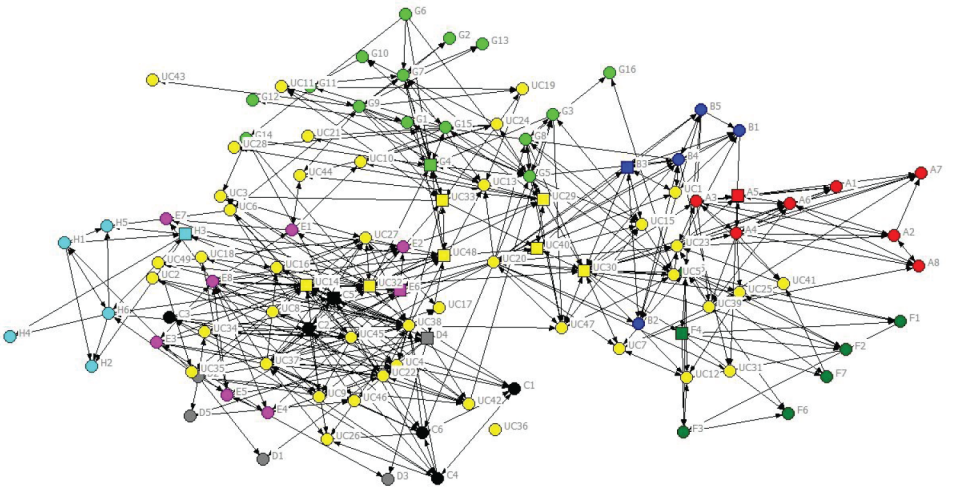


Table 3. Figure 3 key

Organization	*Colour*
A	Red
B	Blue
C	Black
D	Grey
E	Pink
F	Dark Green
G	Light Green
H	Light Blue
UC	Yellow

(strength of tie="a great deal" and organization attribute display)

Table 4. Figure 3 key

Key Contact Attribute	
□	Key Contacts in Contractors, UC Stream Managers and UC Production Unit Managers
○	Other Staff

majority of directed ties emanate from UC20 rather than to it, thus these are 'out-degrees'. UC20 is likely to be located centrally because at all strengths of tie, he/she indicated that they seek information from proportionately many people within the overall network. In this situation 'in-degree' is the more reliable measure of an individual's role, given the potential for self-report bias. Q3 describes actors' behavior of information providing, known as out-degree. It's important to distinguish the level of centrality based on the connections sent to them (in-degree) and connections toward other people (out-degree). If a person receives many ties, he or she is regarded as a prominent person. This is because people often choose such a person to seek information for general communication.

Sociograms of more informal communication yielded interesting results; see Figure 4 which is for individuals that respondents would prefer to share ideas with. The UC senior management was keen to mitigate the risk of the five individual work streams becoming silos, which would inevitably limit opportunities for innovation dissemination and, at a more informal level, the sharing of ideas. Structurally 'ideas sharing' took place (among other more formal business) via a formal weekly meeting between the UC senior managers. But since no formal mechanisms existed very

Figure 4. Sociogram for preferred ideas-sharing – all staff

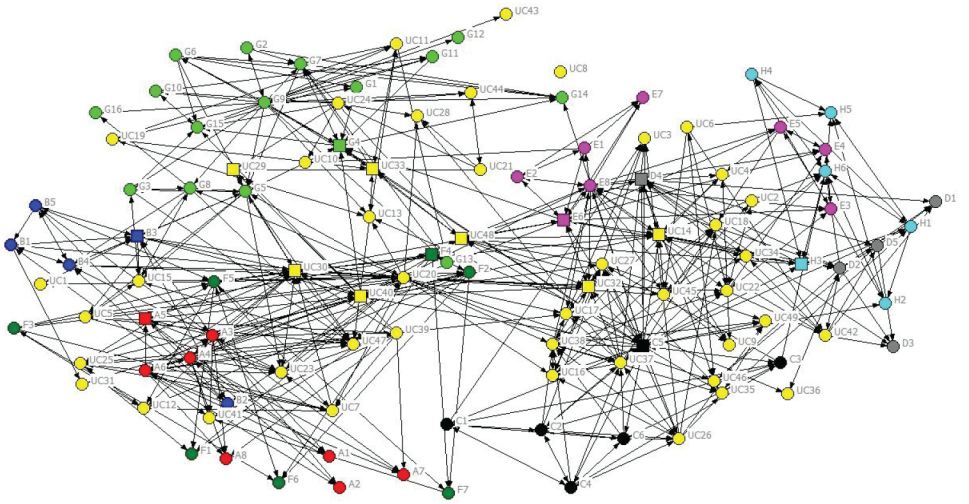


Table 5. Figure 4 key

Organization	*Colour*
A	Red
B	Blue
C	Black
D	Grey
E	Pink
F	Dark Green
G	Light Green
H	Light Blue
UC	Yellow

(strength of tie="a great deal" and organization attribute display)

Table 6. Figure 4 key

Key Contact Attribute	
□	Key Contacts in Contractors, UC Stream Managers and UC Production Unit Managers
○	Other Staff

little was known of ideas-sharing taking place among lower-level staff within the UC or any of the contract partners, or even between staff in different partner organisations. Figure 4 hints at two to three cliques, or groups of the network, being apparently better connected than to those outside of the group. In Figure 5 the majority of the UC staff are removed from the sociogram to show just the senior managers; thus, bringing out more clearly the contractor-based cliques. The right-hand side of the figure comprises staff from three contractors (coloured pink, blue, and grey– E, H and D)

Figure 5. Sociogram for preferred ideas-sharing–for UC senior managers only included

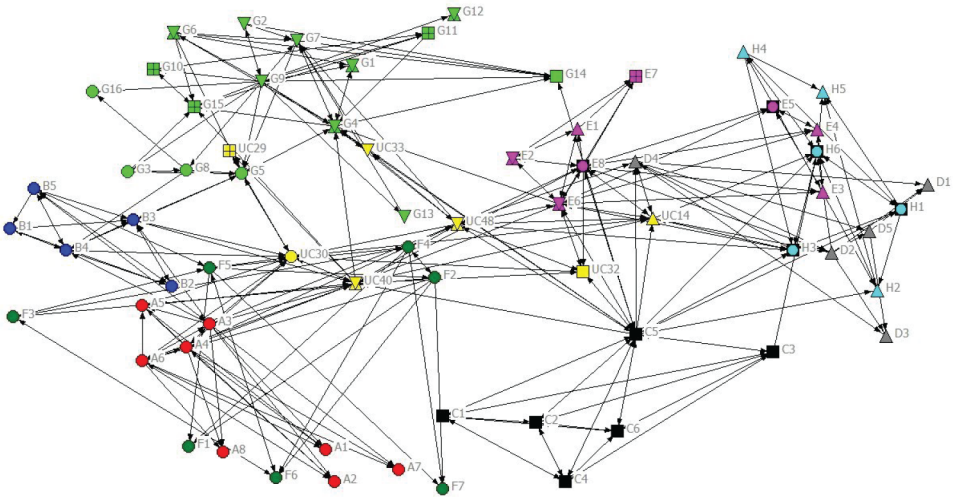


Table 7. Figure 5 key

Organization	*Colour*
A	Red
B	Blue
C	Black
D	Grey
E	Pink
F	Dark Green
G	Light Green
H	Light Blue
UC	Yellow

(strength of tie=3 and organization and stream attribute display)

Table 8. Figure 6 key

Individuals' Stream Membership Attribute	
Shape	*Stream*
○	Stream 1
□	Stream 2
△	Stream 3
⊞	Stream 4
▽	Stream 5
◘	Stream 2and3
⧖	Others

who are closely connected, while the left-hand side comprises another closely-connected group of staff from three other contractors (coloured red, blue, and dark green – A, B and F). A group of staff from a lone contractor (light green - G) are toward the left-hand side, but slightly detached. Mapping this into contract membership by stream is also illustrated in Figure 5. Whilst the streams are clearly visible, the cliques are actually divided by the two types of production unit, i.e., the higher order of work organisation within the UC.

The UC management had overt expectations of sharing and collaboration between contractors and across streams. By removing all the UC nodes from Figures 4 and 5 above, one can more easily observe the ideas-sharing between contractors only (see Figure 6). The cross-contractor links appear more tenuous. A feature of this sociogram is that the main bridges between contractors are the key contacts in six (B3, C5, D4, E6, G4, H3) out of eight of the contractors (the other two bridges are A3 and F5). Separate demographic data indicated that there is no apparent difference in communication pattern between contractors new to the UC AMP process and those involved for more than 15 years, which perhaps illustrates that all are proactive to the same extent in sharing ideas. Cross-contractor links primarily occur between those within the same stream, as would be expected, apart from the

Figure 6. Sociogram for preferred ideas-sharing – contractor staff only

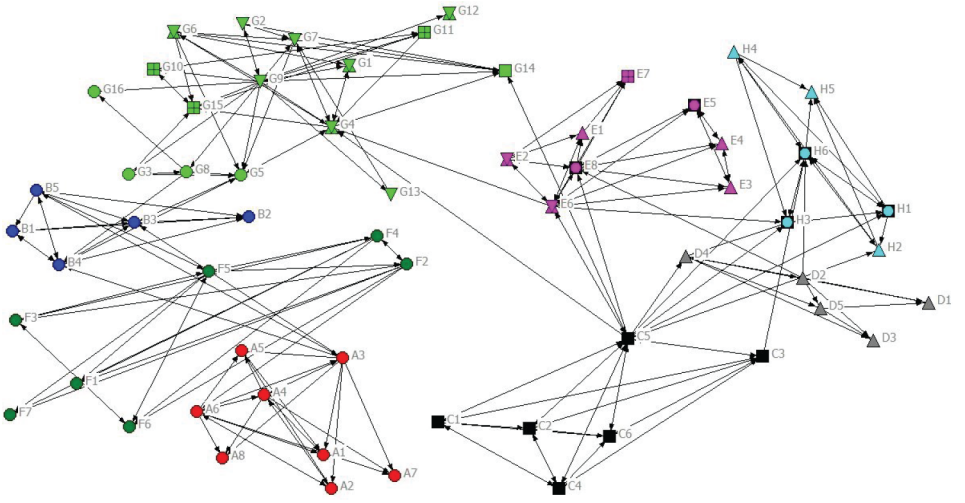


Table 9. Figure 6 key

Organization	*Colour*
A	Red
B	Blue
C	Black
D	Grey
E	Pink
F	Dark Green
G	Light Green
H	Light Blue

Individuals' Stream Membership Attribute	
Shape	*Stream*
○	Stream 1
□	Stream 2
△	Stream 3
⊞	Stream 4
▽	Stream 5
◘	Stream 2 and 3
⧖	Others [α]

[α]Others refer to various minor combinations of streams
*The nodes have been moved slightly to enable the connections to be seen more clearly (strength of tie=3 and organization and stream attribute display)

triangular relation between nodes E6, C5 and G4. All three are located within stream 2 but contractors E and G are also in stream 4. Were C5 to be removed from the sociogram, technically contractors E and G would be unconnected at this strength of tie. Contractors E and G both have longstanding relationships with the UC, so they have established track records and performance histories. However, it is still surprising that they are not better inter-connected for ideas sharing when compared to contractors recently introduced to the programme.

Table 10 presents the group degree centrality for groups based on organizational attributes and for the four questions: Q1 (general communication), Q2 (seek information), Q3 (provide information) and Q4 (trust communication). The data records 110 actors from the nine organizations- eight contractor partners and the utility company. The data are non-symmetric and valued, so they are dichotomized. Tie strength is measured on a scale from 0 to 3 therefore 0 on this original scale is treated as "0" (i.e., no tie) on the new scale and the values of 1,2 and 3 are transformed to "1" (i.e., presence of a tie).

Table 10. Group Degree Centrality Results for Contractors and UC

Group	Streams	Group Size	Q1 General Communication		Q2 Seek Information		Q3 Provide Information		Q4 Trust Communication	
			Group Centrality		Group Centrality		Group Centrality		Group Centrality	
			Degree	Normalized Degree*	Degree	Normalized Degree	Degree	Normalized Degree	Degree	Normalized Degree
Contractor A	1	8	85	0.83	102	1	78	0.76	81	0.79
Contractor B	1	5	88	0.84	105	1	76	0.72	80	0.76
Contractor C	2	6	79	0.76	104	1	71	0.68	75	0.72
Contractor D	3	5	77	0.73	105	1	71	0.68	74	0.70
Contractor E	2, 3, 4	8	83	0.81	102	1	72	0.71	78	0.76
Contractor F	1	7	84	0.82	103	1	72	0.70	78	0.76
Contractor G	1, 2, 4, 5	16	88	0.94	94	1	76	0.81	78	0.83
Contractor H	2, 3	6	81	0.78	104	1	72	0.69	76	0.73
UC		49	60	0.98	61	1	60	0.98	58	0.95

For the networks generated from the four questions, the UC is the most central group (using the highest degree centrality normalized measures) thus demonstrating its powerful position as the client of the contractors. Among contractor partners, contractor G is consistently the most central group across the four questions. For general communication (Q1), contractor B and contractor G tie with the highest raw group centrality score, but contractor G is more central once the data have been normalized. (Note this uses dichotomized data, i.e., the strength of ties 1, 2 and 3 are aggregated). It is apparent that it is easier for larger size groups to achieve higher un-normalized centrality scores than smaller size groups. The larger the size of the group, the more connections the group members can make with members of smaller other groups. Everett and Borgatti (2003) reflect that normalization is significantly important because it takes account of varying group sizes.

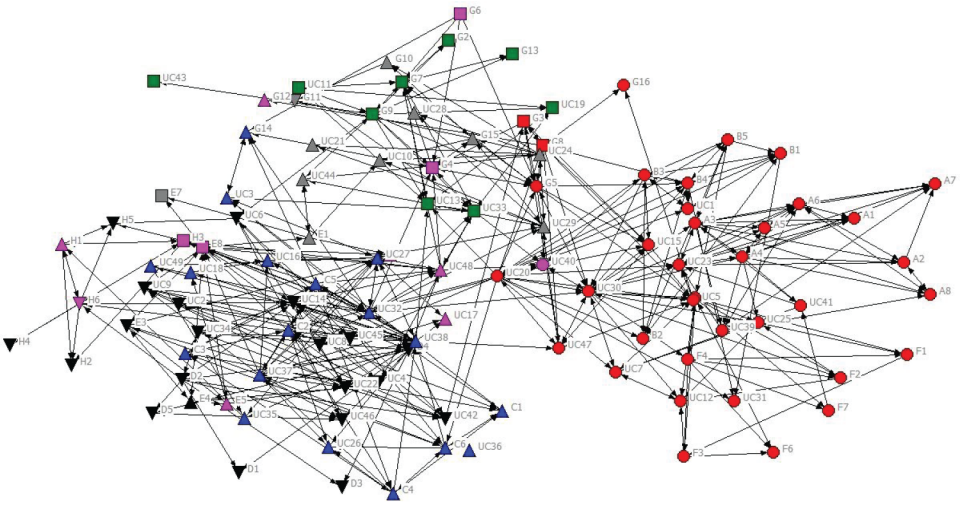
When the contractors are organised by the membership of production units, then some interesting patterns can be observed (see Table 11). Those contractors in both production units have the highest normalized degrees while the next highest grouping is for unit II with unit I having the lowest scores. This pattern is repeated across all the questions except for question 2 where all groups have equal scores.

As indicated, the co-location of the partners was in four story of a multi-story office block. In general occupants were allocated so as to keep stream personnel physically close together. The top two floors contained staff from the streams of one production unit while the bottom two floors were dedicated to staff from the streams belonging to the other production unit. Figure 7 illustrates this element of the analysis by showing the network for Q2 (information-seeking behaviour with the attributes of location and stream). The locational division of staff is evident in the network

Table 11. Group Degree Centrality Results for Production Units

Production Unit	Contractors in Unit	Mean normalized degree for stated question			
		Q1 General Communication	Q2 Seek Information	Q3 Provide Information	Q4 Trust Communication
Unit I only	C, D, H	0.757	1	0.683	0.717
Unit II only	A, B, F	0.83	1	0.727	0.77
Both I and II	E, G	0.875	1	0.76	0.795

Figure 7. Sociogram for acquiring information



structure; the network is divided into two elements that lie above and below the dashed diagonal line that has been added to the figure to accentuate the division. In general, above the diagonal contains the nodes of staff located on the bottom two floors, while those below are in the top two floors. As expected, the disposition of stream attributes is also correlated with this partitioning of the network into production units.

DISCUSSIONS

In the context of participative research, the interpretation of such as sociograms and other network data by researchers alone is not the whole story. To conform to participative research principles, it was important for the researchers to engage with industrialists, and the UCInet software (Borgatti, Everett, & Freeman, 2002) . It proved to be an effective way of developing theories of organizational network effectiveness to scholars and practitioners concerned with understanding how organizations can purposefully create network structures to achieve desired outcomes(Brennecke et al., 2019). Information and communication technology and trust all have a significantly positive impact on information or knowledge sharing(Xia, Xiong, & Weng, 2020).

As an example, the network for stream 2 appeared particularly dense compared to other streams. This point was conveyed by using the software to present sociograms that highlighted this difference. The managers contextualised this thus: individuals in this stream had to get to know one another quickly as the nature of the stream meant that stream participants would spend much of their time on site once the programme passed beyond the initial stages. That is, there was a particular imperative to establish communication paths faster than in other streams. This difference also reflected that the nature of work allocation would be different within this stream to the other streams (i.e., there was likely to be more formal tenders for large value projects in this stream), although at the time of data

Table 12. Figure 7 key

Stream Attribute	
Colour	***Stream Name***
Red	1
Blue	2
Black	3
Grey	4
Dark Green	5
Pink	Multiple streams

(strength of tie=3 “a great deal” and stream and floor attribute)

Table 13. Figure 7 key

Floor Attribute		
Shape	***Floor #***	***Stream location***
Circle	2nd	1
Square	3rd	5 and a small no. of 1
Up Triangle	4th	2 and 4
Down Triangle	5th	3

gathering not much was known about how work would be allocated within any of the streams. For the programme that consisted of multiple projects, the evolution and plurality of goals over the life cycle create complexity not only because of the multiple simultaneously involved agents, each with their own specific goals. This complexity requires programme managers to manage their relationship portfolios strategically (Ahola, Ståhle, & Martinsuo, 2021).

Despite anonymisation, some individual managers were identifiable in the sociograms; however, the majority of nodes remained anonymous, as had been agreed previously. Immediate feedback from the meeting attendees was that the apparent cliques discernible around production units, rather than streams of work, concurred with managers' perceptions. The roles of key individuals were discussed, i.e., those who acted as brokers or conduits in passing communications to others. Managers were concerned about the risk that communication would be unduly affected should a broker suddenly leave an organisation.

Overall, the networks were dense; denser than would otherwise have been expected given the relative newness of the programme. The powerful position of the UC was evident in their staff being generally more central than contractors' staff. Prior relationships also played a part in placing individuals closer to the center of the networks. However, this factor was not clear cut as the following comments illustrate. In some streams the UC personnel appeared more highly integrated with some contractors compared to others despite prior relationships not being as strong. Individual managers reflected within the meeting upon this disparity as part of their role is to help facilitate the UC's objective of 'effective collaboration'. The two contractors with the more longstanding relationships with the UC had been awarded the greatest number of stream contracts, at three and four of the five streams, respectively. Surprisingly, the contractor (G) contributing to the four streams of work appeared the most distanced from the UC (at the greatest strength of tie) and other contractors in all of its streams. Historically the contractor had performed well in previous AMPs and therefore might be expected not to be as distanced as the results showed. However, at the point of the data gathering for the questionnaire survey, the programme was not fully operational in that such as the performance measurement system had not been finalised, so this was not a major influence at this stage. Interestingly the other experienced contractor (E), the one contributing to three streams and also historically a good performer, had a more integrated network profile within the streams, though still less than some of the 'newer' contractors. It may be that the lower volume of integrated relationships for those contractors with less prior experience enables them to dedicate more effort to establishing relationships.

The pattern of group centrality results for the contractors when grouped in production units raised some interesting issues. The contractors who were in both production units had higher scores than those contractors who were just in one production unit. This suggests that being in both units conveyed greater opportunities to extend their connections and embed themselves more centrally in the communication networks. However, it should also be noted that the contractors E and G who were in this advantageous position were the contractors with the highest involvement in the number of streams; a factor that also could add to their embeddedness. For those contractors who were in only one production unit, it seems that production unit II confers an advantage over unit I. A few possible reasons for this difference could be identified. It might be explained by the differing technical nature of the work content of the streams that are grouped into the production units. For example, work packages that involve working in isolated locations, such as reservoirs (which was in unit I), might work against building strong connections across the whole of UC's geographical region; particularly when compared with those contractors heavily involved with work that is closer to the regional hub (e.g., work connected to the regional piping network which was in unit II). On the other hand, differences between units may be linked to the personal styles of the individual unit managers; however, in the study, we were not in a position to discern any differences that there might be between the two unit managers. Of course, the differences could simply reflect the a priori characteristics of the individual contractors but the consistency in the results would tend to argue against this possibility.

An intended outcome of the co-location initiative was to engender collaboration. While a good degree of collaboration has been inferred by virtue of the dense network structure, this collaboration appears to be aligned with the mutual membership of streams and production units (e.g., see Figure 7). Basing the criterion for close physical proximity of individuals in the office block on membership of stream and production unit can be seen to be a logical approach at first glance. This type of arrangement will no doubt facilitate such as information exchange within the individual streams and encourage efficiency and effectiveness in achieving technical work goals. However, the downside to this arrangement is that the size of the groups affiliated to the different streams and the consequent allocation of streams to different floors generates inter-stream separation that militates against idea-sharing across streams. The fuzziness in the physical location of partners, unfortunately, renders it difficult to draw conclusions about the impact of location on communication networks.

It is worthwhile observing here that in addition to the study topic being about collaborative networks, the effectiveness of the study's participative research methodology also depended on a collaborative network. Such an approach will help organizations, and the individuals within them, to identify appropriate internal and inter-organizational network development strategies (Morton et al., 2006). This network involved the researchers, the research sponsors (senior managers of UC and a consultancy partner), senior managers of the contractors and various staff drawn from the partners. At times fostering the necessary collaboration required some considerable efforts, particularly on the part of the researchers and the consultancy firm's representative. The latter individual performed a key role in liaising between the researchers and the various managers who were involved in the study.

CONCLUSION

The core idea is that belonging to a group gives an informational advantage: individuals who are part of a group use their interactions to gather information about past transactions which they employ in future bilateral negotiations. The study was successful in exploring how organizational affiliation, seniority, technical streams of work and geographical proximity impacted on the communications network structure of collaborating partners in a utility's asset management programme. The client (UC) was clearly more at the center of the communications network than the contractors. Senior managers, in both the client and contractors, tended to be toward the center of communication networks. There was some weak evidence for the impact of tenure and prior relationships on the network configuration. The evidence was stronger for the impact on communication networks of the way that work was arranged. In the programme, projects were grouped on the basis of technical content into work streams and then these streams were grouped into a higher-level structure of production units. The impact of these groups on communication networks was evident in the study results. The interpretation of the impact of geographical location of individuals on communication networks was not that straightforward. Since individuals were co-located on the basis of their membership of production units, the two variables location and technical work content were difficult to tease apart. The study also illustrated how the use by researchers of a visually interactive software tool in a research study engendered managerial buy-in; and ensured the results have practical utility in that they have informed managerial decision-making within the programme.

The reflections in this paper stem from the results of a cross-sectional SNA study carried out during the early phase of the asset management programme. The roster-based questionnaire survey has its limitations, such as the need for a high response rate which was met in this study. To facilitate such a high response rate requires protocols such as a limited number of focused questions.

Theoretical Contributions

This study provides contribution in several aspects. First, a key contribution of the study is the novel setting of the research. Programmes vary in different organizational settings, yet context complexity has not attracted sufficient attention in the literature on programme management. Pellegrinelli and

Partington (2006) illustrate programme managers are aware of the contextual factors and then consider them in reshaping the programme. This paper recognizes the importance of classifying programme complexity and interprets each complexity's role in facilitating or impeding IOR practice in the water programme.

Second, our research reveals inter-organizational relationships (IOR) and collaboration within programme context. We contend that IORs refer to establishing and maintaining relationships between the UC and its contractors in the programme to achieve its long-term. For the programme consisting of multiple projects, the evolution and plurality of goals over the life cycle create complexity, which requires programme managers to manage their relationship portfolios strategically (Ahola, Ståhle, & Martinsuo, 2021). Thus, our research contributes to the literature on the complexity of a firm's IORs and how they can positively impact a programme.

Third, social network theory is one of the underpinning theoretical foundations for studying patterns of communication among members (Tichy, Tushman, and Fombrun, 1979) in the project group. In this research, social network analysis is adopted as an analytical tool to reveal the structure of a communication network and the interaction via information flow in the sociogram. Our empirical research findings contribute to the social network theory for taking broader views of relational and structural properties of networks (Granovetter, 1985) and how communication in inter-organizational networks breeds trust. This influences the type of collaboration and quality of communication. Our research highlights the stream-level analysis as a foundation for centrality analysis and group centrality analysis. It is a novel way to understand how individuals embed themselves in the network and how they link between network positions and programme cycles. Powell et al. (2005) apply analysis of network degree distributions and network visualizations to estimate dyadic relationships and demonstrate affiliation shapes network evolution.

Practical Contributions

The questions in this case focused on aspects such as general communication, information exchange and idea-sharing to construct the networks. For programme managers, our research shows that programme management is more complex than project management. The programme's projects are arranged in five main streams of work, and it exists to relieve the tension between strategic direction, project delivery and operational effectiveness among projects. Thus, programme managers should consider multiple organisations that collaborate and communicate, thereby forming various networks through the interaction of the individuals and organizations.

Second, multiple sociograms are set out to investigate the social networks of individuals and their positions to understand the interaction between UC and contractor partners. The network is also the result of past longitudinal and current collaborations, and the network acts as a repository of information, ideas and knowledge. It sheds light on how construction companies and their utility clients can use the core network of individuals and organizations to enhance overall project performance through long-term programme relationships. In this way, innovations and learning developed in one programme can also be used in other programmes.

Future Research

Taking these contributions into account, an intriguing issue is how network structure and collaboration will develop as the programme cycle and other events unfold such as the performance management system. The ongoing relationship between the researchers, research sponsors and other stakeholders has led to a longitudinal approach being agreed upon. Further surveys will look to track future developments in the network. In addition, we conclude that future research needs to pay more attention to the contextual complexity and its impact on the communication network in other programmes. It may also be of great importance to study various organizational arrangements that support or hinder different value processes in program (Miterev, Jerbrant, & Feldmann, 2020).

ACKNOWLEDGMENT

The authors would like to thank the UC and consultancy partner and supplier participants for their time throughout this research.

FUNDING

Project is funded by the Philosophy and Social Science Planning Program of Shanghai (Project no.: 2021BGL016).

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