Journal of Information & Knowledge Management, Vol. 9, No. 2 (2010) 105–118

DOI: 10.1142/S0219649210002565

World Scientific
www.worldscientific.com

Understanding Information and Knowledge Flows as Network Processes in an Oil Company

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Abstract. We focus on information and knowledge flows as social network processes in organisational contexts. Seeking and giving work-related *information* is distinguished from seeking and providing *problem-solving help* as knowledge flows. Hypotheses from the literature suggest that (perceived) accessibility, knowledge about the work-related skills of others, and knowledge about the functions that others perform in an organisation all predict knowledge and information flow relations. We also include membership in geographically dispersed work units as a feature of the formal organisational structure. As an additional predictive relation, non-work related socialisation is used to capture the informal structure. While all potentially predictive relations are significant and positively related to information and knowledge flows, once membership in work units and socialisation are included, the latter two relations are the dominant predictors. Perceived accessibility, at most, is a weak and inconsistent predictor of knowledge flows. Knowledge of work-related skills and the functions that others perform in an organisation also appear to have little relevance for seeking and providing knowledge. That work group membership and socialisation are the most potent predictors of knowledge and information flow relations suggests that these components of the formal and informal organisational structures operate in complementary ways. However, we note that this organisation may have a clear technical foundation that helps promote the effectiveness of both formal and informal organisational structures for promoting knowledge flows. This may be especially true for the studied managerial unit. In general, establishing the conditions under which the formal and informal organisational structures positively complement each other merits further attention. Some practical implications are outlined.

Keywords: Knowledge flows; network processes; oil company; work-related skills; social networks.

1. Introduction

In today's dynamic, global and knowledge-intensive business environment, the quality of relationships in an organisation is seen as a substantial determinant of value creation. Indeed, knowledge flows along existing pathways in organisations. To know how to improve the flow of knowledge, requires an understanding of these pathways (Cohen and Prusak, 2001). These 'pathways' for knowledge flow are best understood as networks in organisations. More specifically, communication is a process that encourages the sharing of knowledge among individuals and groups. Use of network ties stimulates innovation as an interactive process which may replace efficiency and quality as the main source of competitive advantage for firms (Swan *et al.*, 1999).

This study reports on potential predictors of knowledge flows among scientists and engineers in an oil company. We focus on a management team involving drilling operations where both routine and novel problems are encountered. When solutions are sought to technical problems, Cross *et al.* (2001, p. 100) quote a colleague reporting "that engineers and scientists were roughly five times more likely to turn to a person for information than to an impersonal source such as a database or a file cabinet." Communication is required to gain access to relevant and timely knowledge to tackle problems successfully. In general, this knowledge is sought over networks of relationships inside organisations. Our focus here is on network processes facilitating knowledge flow.

This paper is organised as follows. First, we present a literature review focused on networks within organisations. Second, we state hypotheses based on this review. Third, we provide a description of the study site and list the methods used. Fourth, we present our analyses and results. We finish with a discussion of our results, present

some implications from these results and suggest potentially fruitful avenues for further research.

2. Literature Review

Social network analytic methods provide means of visualising existing and potential interactions in organisational settings. Emmerik *et al.* (2006, p. 55) consider intra-organisational networking as creating "an increased exposure to other people within the organisation, the building and nurturing of personal and professional relationships to create a system of information, contact and support, and altogether this is thought to be crucial for career and personal success."

Garcia-Lorenzo (2006, p. 173) describes a social network as "the basic social form that permits interactions of exchange, concerted action and joint production." For him, social networks enable the creation of relational spaces where knowledge can be created, shared, and exchanged. More simply, Chui (2009, p. 64) regards a network as "a set of actors linked by a set of social relationships, whereby relationship contents vary in scope and depth." Marouf (2007) observes that social networks in organisations differ in their inherent nature and complexity. Some ties are friendship bonds while others are work or advice links. They also differ in terms of what flows through them. Members of a social network can transfer information or knowledge, or both, through face-to-face interaction or via electronic media. The obvious question is simple: What social relations facilitate knowledge flows in organisations? To address this question, we draw upon the following literatures: social networks in organisations; social network analysis; organisational social networks; formal and informal organisational networks and knowledge flows in networks.

2.1. *Social networks in organisations*

When adopting an intra-organisational network perspective, attention is focused on relationships among social actors *and* the patterns and implications of these relationships for organisational productivity and performance (Morton *et al.*, 2004). A networked organisation has a web of network relationships with many interactions occurring between individuals and groups. This social context forms the foundation for knowledge creation and distribution. In knowledge-based theories of the firm, organisations are viewed as social communities specialising in efficient knowledge creation and sharing (Kogut and Zander, 1992). Mapping informal organisational networks provides understandings beyond those shown in formal organisational charts. Informal connections reveal the importance of people's networks for overall organisational performance because a large amount of organisational work transpires through multiple social relationships. Morton *et al.* (2004) suggest that organisations are better understood by including their informal relationships. Furthermore, by adopting a network perspective, managers can increase an organisation's effectiveness and create opportunities for innovation (Cross and Parker, 2004). In addition to noting the importance of informal networks in organisations (Ehin, 2009), they need to be consistent with the organisation's design.

Cross and Parker (2004) outline a variety of reasons why people turn to particular persons in an organisation. These include people who: (i) provide information, resources and directions to get work done; (ii) provide feedback helpful for career development; (iii) occupy influential positions and are able to give career or political support; (iv) help in making sense of rumors, gossip or events; (v) help in coping with troubling situations at work (and even with personal problems); and (vi) help others know and understand that the work they are doing matters and has meaning.

2.2. *Social network analysis and organisational social networks*

Network analysis can provide insight into how work and knowledge flows occur within an organisation. This helps determine the extent to which expertise is integrated (or not) into an organisation's operation. Moreover, it can identify whether organisational expertise is used in ways that help an organisation serve its markets, develop or extend its products and services, or devise new processes. With mapped network connectivity, managers have a foundation for taking action to facilitate appropriate collaborations.

Social network analysts mobilise many techniques to measure and analyse how interaction and communication occurs between individuals and groups. This includes identifying members of informal networks and mapping flows of interactions and communications between them. A key current trend in knowledge management is the focus on the importance of relationships in facilitating knowledge sharing. Social network analysis (SNA) in business contexts has evolved from a collection of quantitative research methods (Kilduff and Tsai, 2003) to a set of diagnostic tools and a potential catalyst for organisational change (Cross and Parker, 2004). It has emerged also as a strategic tool for knowledge management with three applications identified by Cross *et al.* (2003): (a) assessing individual and organisational social capital; (b) ensuring effective knowledge creation and sharing; and (c)

analysing the extent to which an organisation's informal structure supports strategic objectives.

It is not surprising that organisational network analysis (ONA) has become a widely used method for diagnosing social relationships inside firms and across organisational boundaries. ONA leverages decades of work in SNA. For business purposes, many tools of SNA have been adapted and refined to understand the role of relationships in organisations (Anklam *et al.*, 2005). Making previously invisible or unrecognised patterns of interactions visible creates opportunities for working with individuals and groups to facilitate effective collaboration (Cross *et al.*, 2002). It is a powerful technique for diagnosing organisational problems constraining knowledge sharing and information flow (Morton *et al.*, 2004). SNA can be uniquely effective in promoting effective collaboration within strategically important groups; supporting critical relations crossing functional, hierarchical, or geographic boundaries and ensuring integration within groups following strategic restructuring initiatives (Cross *et al.*, 2002). Understanding how knowledge flows (or not) across various boundaries within an organisation can yield critical insight into where management should target efforts to promote collaboration which leads to a strategic payoff for the organisation (Cross *et al.*, 2001).

ONA reveals basic forms and functions of organisational networks to provide insight into how knowledge moves in organisations. This helps managers improve an organisation's performance. Intervening to fix flaws within a network can help connect and involve peripheral members. Using communication tools, investing money and promoting face-to-face meetings are also effective interventions (Cohen and Prusak, 2001). Organisational network diagrams, together with analyses of them, can re-focus executive attention on how organisational design decisions and leadership behaviours affect the relationships and knowledge flow at the heart of where work is done. This includes assessing patterns of relationships within groups and revealing actionable points in the overall structure (Cross *et al.*, 2002). Michael (1997) provides an example of how knowing intra-organisational communication networks can create positive outcomes. A new management team at a wood processing plant constructed a new wage package that was rejected by its labor force and which led to a strike. After consulted experts mapped out the communication structure in the factory, it was clear that information about the positive features of the new wage package did not reach most employees. Once this information was provided directly to key centrally located individuals — whose ties also bridged different age groups and ethnicities — it spread quickly and led to the acceptance of the new package and a vote to end the strike. Management previously had been consulting representatives who were older and peripheral in the plant's communication network.

Examining the structure of organisational networks is far from new. Additional examples include Cheuk (2007) showing how the British Council used SNA as a practical tool to support its knowledge management program when faced with the challenges presented by a globally dispersed workforce. This network analysis was used to promote knowledge sharing among a newly formed 30-person global leadership group. Anklam *et al.* (2005) provide an example of building a networked organisation at a consulting firm. Their findings illustrated how ONA — when accompanied by management practices that encourage, support, and require connectivity — allowed employees to leverage the expertise of organisational peers regardless of their location.

Technological innovation, a critical factor in the long-term economic growth of any country, functions successfully only within a social environment providing relevant knowledge and information inputs into innovative processes (Smith, 2005). Efficient transfer and communication of knowledge and information is dependent on the amount and quality of interaction among scientists and technologists in an organisation. ONA was used to map the knowledge network structure and communication practices of a group of scientists engaged in crystallographic research. A nucleus of prominent, well-connected and interrelated crystallographers constituted the core network of scientists and provided the main impetus to keep the group's network activity active. This core group of crystallographers was approached far more frequently for information and advice than any of their colleagues. They also frequently initiated interpersonal and formal information communication.

2.3. *Formal and informal networks*

As noted earlier, two broad types of organisational networks exist: formal and informal. Formal networks are officially designed and recognised networks within an organisation. They have an identifiable membership, explicit structure and receive official recognition by employers. Organisations have functionally defined groups designed to accomplish organisational tasks, and formal networks include the officially prescribed relations among them. In contrast, informal social networks are constructed by individuals on a day-to-day basis. Such networks are personal and voluntary. Often, these informal networks are neither formally governed nor officially recognised.

Informal networks often promote socialisation among colleagues who share common interests and participate in

activities they enjoy (Emmerik *et al.*, 2006). Most people working within a formal organisation recognise the existence of its informal structure. Units do not function as well without the many informal working relationships that exist within large organisations. Much of the real work of companies happens outside — and sometimes despite — the formal organisational structure. In order to attain success, attempts to change an organisation's design require attention to the informal organisation structure because these relational networks are often formed to accomplish tasks faster. Such informal networks can speed through formal reporting procedures to jump-start stalled initiatives and meet deadlines (Krackhardt and Hanson, 1993). Maps of these social links can help managers harness the real power in their companies and revamp their formal organisations to let the informal networks thrive. Consistent with Ehin's (2009) argument, we need to know when the formal and informal networks can complement each other productively.

2.4. *Knowledge sharing through networks*

While knowledge is perceived as a relatively stable entity moving through actors in networks, validated *new* knowledge also has to move to promote innovation. Knowledge, both public and tacit, is possessed by people in organisations. Their social networks form channels through which knowledge is transferred. Social interaction facilitates knowledge exchange (Chui, 2009). Individuals share information and knowledge for many reasons, including improving themselves, being recognised as relevant experts, getting respect and recognition from others and sharing with others who share knowledge with them.

Mitchell (2005) noted that regular meetings with employees to discuss work-related experiences provide a means for sharing and generating a knowledge collaboration strategy through encouraging informal social interaction between employees such as in the corridor or chats over lunch. As an example, he pointed to Xerox Corporation having benefited from informal social interactions when they discovered that providing a quick breakfast can be equivalent to hours of training. Smith and McKeen (2002) argue that knowledge is shared socially much of the time and report that people are far more likely to approach their friends and colleagues when facing work related problems rather than other information sources. In short, informal social settings often facilitate knowledge sharing.

2.5. *Dimensions of intra-organisational relationships*

Cross *et al.* (2001) assessed characteristics of relationships used by 40 managers for learning and knowledge sharing. They mapped the information flow and identified four different relational dimensions important for effective sharing and learning: knowledge (knowing what others know); access (having access to other parties' thoughts in a timely manner); engagement (actively thinking with the seeker and engaging in problem solving); and safety (ability to admit a lack of knowledge or to divulge in a conversation). Borgatti and Cross (2003) examined these ideas in two research sites. Their results strongly supported the utility of these relational dimensions. After identifying strategically important groups, the essential next step is to collect information that facilitates mapping these relationships (Cross and Parker, 2004). The relationships they, as well as others, found helpful are: (i) relationships revealing collaboration in a network; (ii) relationships that identify the information-sharing potential of a network; (iii) relationships that highlight rigidity in a network; and (iv) relationships showing well-being and supportiveness within an organisational network. Studying collaboration requires identifying the ways people obtain *from others* the knowledge they need to complete their work in knowledge-intensive settings. This includes information about communication activity to get or provide advice, and reports of their frequency. Joint *problem solving* goes beyond seeking, or providing, information and is especially important when pursuing innovation.

People must have some understanding about the relevant potential available in a work context in order to obtain or provide knowledge. Information potential includes an awareness of the knowledge possessed by others and an assessment of the accessibility of potential information sources. Both seeking and giving information requires some safety before information is exchanged. There is a need to ensure that one person's ignorance is not exposed and that useful information is not used selfishly. Anklam *et al.* (2005), studying a consulting firm, focused on both awareness and information flow networks. Their findings revealed the importance of people knowing what each other knows. Furthermore, they found that learning occurs during knowledge sharing. Learning is unlikely when people are unaware of the skills of those around them. In addition, their study showed that missing personal relationships are barriers to learning.

Cross *et al.* (2001) studied information flow among 20 top executives within an exploration and production division of a large petroleum organisation. They were also interested how groups create and share knowledge. Their analysis revealed a striking contrast between the group's formal and informal structure. Important points emerged for this study of sharing information and leveraging collective expertise. Their analyses identified mid-level managers who were critical for information flow and

revealed the extent to which the entire network was disproportionately reliant on one employee. In addition, SNA identified peripheral people who represented untapped expertise and were underutilised resources. In short, the literature suggests that network structures matter. The real issue is one of understanding how they matter and knowing which network processes are appropriate for different types of organisations.

Seeking such a general understanding, Borgatti and Cross (2003) adopted a relational view of information-seeking in networks. They tested basic hypotheses, some of which we examine here. The first posits a simple link between knowing the expertise of others and seeking help from them: The extent to which actors in organisations seek information from other actors is positively related to their knowledge of the expertise of others. Of course, knowing the expertise of others depends on the evaluation of others from who help could be sought. Borgatti and Cross (2003) found support for the hypothesis that seeking help is positively related to having a positive assessment of the competence or knowledge possessed by others. We assume this is the case for the current study. Furthermore, seeking information from others is positively related to the perceived accessibility of others from whom information is sought.

Doreian and Conti (2009) present evidence that the context within which networks form has direct relevance for the forms taken by networks. The physical layout of the well-known Bank Wiring Room (Roethlisberger and Dickson, 1939), to varying degrees, was shown to account for the social relationships formed in that work area. We pursue this idea by considering work group membership as a structural constraint on both the relationships formed in organisations and knowledge flows.

3. Hypotheses

Our basic predicted variables and their predictors are all relational arrays of social ties. The predicted relationships concern knowledge seeking. However, we separate knowledge *seeking* from *providing* knowledge while recognising that they are closely related. Following Borgatti and Cross (2003), we view knowledge of the expertise of others as a contributor to seeking information. However, we distinguish knowing what others do in the organisation (their function) from knowing about their (technical) skills. This leads to four sub-hypotheses:

— Hypothesis 1a: Knowing the work-related functions of others is positively related to seeking relevant knowledge from them;
— Hypothesis 1b: Knowing the work-related skills of others is positively related to seeking relevant knowledge from them;
— Hypothesis 1c: Knowing the work-related functions of others is positively related to providing relevant knowledge to them; and
— Hypothesis 1d: Knowing the work-related skills of others is positively related to providing relevant knowledge to them.

In addition to considering assessments of how accessible others are for obtaining knowledge, we also consider assessments of the perceived responsiveness of others. Seeking help requires positive assessments of both access and responsiveness and leads to two more hypotheses:

— Hypothesis 2a: Seeking relevant knowledge from others is positively related to viewing them as being accessible; and
— Hypothesis 2b: Seeking relevant knowledge from others is positively related to viewing them as being responsive.

While the formal and informal organisation structures differ, both have to be considered in attempts to understand knowledge seeking. If individuals belong to different functional units, this membership facilitates knowledge seeking within these units. This leads to:

— Hypothesis 3: Seeking and providing knowledge from others is conditioned by the formal organisational structure (operationalised as work unit membership).

Given this operationalisation of the formal structure, it is reasonable to expect a positive relation between work unit membership and knowledge flows.[1]

We know that some workers in organisations socialise outside of narrow work arrangements (e.g., Thurman, 1979) and it seems reasonable that socialising also helps generate knowledge of others that includes, but is not restricted to, knowledge of their skills. To the extent that some degree of trust is required to seek help from others, socialisation with others outside of work can promote that trust. In turn,

— Hypothesis 4a: Socialising with others is positively related to knowledge seeking;
— Hypothesis 4b: Socialising with others is positively related to providing knowledge.

4. Study Site and Research Methods

4.1. *Study site*

The site for this study is a government-owned oil and gas operating company, labelled here as TOC ('The Oil

[1] It is possible that there are some work environments that are toxic enough to impede knowledge flows.

Company') to protect confidentiality. Actual names of work units have been altered and neutral labels have been used for individuals. None of these name changes affects the essence of the relationships discovered and reported below.

In the 1930s, TOC was established by the Anglo-Persian Oil Company. The company's activities at that time included exploration, on-shore and off-shore surveys, drilling of test wells, and developing productive fields. In the mid-1970s, the government took complete control of TOC. The current TOC mission is to explore, develop, and produce marketable hydrocarbon resources while safeguarding its people and the environment. The company has implemented knowledge management to further help the company's efficiency and effectiveness. TOC is a very large organisation with seven major departments that are further divided into many sub-departments and subgroups. Studying the entire company was not feasible given the amount of resources available for this study. Knowledgeable informants provided our starting point for identifying an appropriate organisational unit. The first author (of this paper) met with the head of the IT group of TOC and a senior information specialist to identify a key division for the current study.

The 'Drilling Operations Group' (DOG) was selected for several reasons. First, TOC saw the need for cost reduction in its drilling business. Second, the DOG had the potential for cost savings through implementing knowledge management (KM) solutions. Finally, because the DOG's costs are attributed to its highly organised and complex primary responsibilities (for safety, efficient drilling, work over and completion of rig operations), it was seen as a feasible TOC organisational location for a KM project to yield valid and potentially useful results. The company's KM Project attempts to build a foundation to ensure solutions linked to its long-term business goals of developing a knowledge-based culture where information generates success and implements efficiency. Their KM Project was divided into two phases: (1) implementing KM as a business readiness assessment study and (2) conducting a pilot project. TOC bought an IT system with the intent of studying its impact in the DOG. If this is successful, their intent is to implement these changes throughout the company.

The SNA study is, in part, the pilot project that was designed to map extant ties within the DOG. The networks reported here describe relations affecting information and knowledge sharing as the basis for assessing the impact of the IT initiative. As such, it was intended to lay the foundations for showing how SNA can help TOC achieve economical efficiency and effectiveness by developing communication that is targeted, integrated, and readily assessed to create a more successful organisation.

The Drilling Operations Group consists of a central administrative group (10 managers) and several field drilling teams. We label the drilling teams as Drilling Teams A (with four members), B (with four members) and C (with three members). The manager of Drilling Operations is in the central administrative group and all field teams are composed of core professionals at the managerial level. Every field team is responsible of different specific geographic operations. There is also a group within DOG responsible for commercial affairs related to drilling operations (with seven members). The DOG has 28 employees distributed across five different locations.[2]

4.2. *Operationalised network relations*

The network data were collected by a web-based survey.[3] For each relational question asked, the respondents were provided with a list of all DOG staff names. The questions regarding information and knowledge flows follow.[4]

(1) Please indicate the frequency with which you typically **SEEK work-related information** from each person below [Seeks work information];
(2) Please indicate the frequency with which **you GIVE work-related information** to each person in the list below [Gives work information];
(3) Please indicate to whom do **YOU TYPICALLY TURN TO for help in thinking through a new or challenging problem at work?** [Seek problem solving help];
(4) Please indicate the frequency in which each person **TURNS TO YOU for help in thinking through a new or challenging problem at work?** [Provides problem solving help].

For these questions, there were five substantive responses: Never (0); Seldom (1); Sometimes (2); Often (3) and Very Often (4).

For the other social relations, the questions asked were:

(1) I am aware of the work-related knowledge and skills this person has. [Knows the skills of others];

[2] The central administrative group is located near TOC's headquarters. The drilling teams are located out by dispersed company-owned oil fields. Finally the commercial affairs group is located in yet another area.

[3] A draft questionnaire was administered to seven employees of TOC in a division not included in this study. However, the participants were very similar to the subjects of the study. Those answering the pilot instrument on the Web were requested to provide information about the time they spent in answering and any problem they had in understanding questions. Their useful feedback was applied in finalising the instrument.

[4] For each question, the terms in square parentheses are the variable names used in presenting the empirical results and response categories are those used in the analyses.

(2) I'm aware of what functions this person is in charge of within his organisation. [Knows the function of others]
(3) When I need **information or advice**, this person is generally **accessible** to me. [Accessibility of others]
(4) When **I need information or advice**, this person is generally **accessible** to me **within a sufficient amount of time**. [Responsiveness of others]
(5) Please indicate how often do you **socialise with each person below over coffee breaks, lunches, etc.** [Socialises with others].

These questions have the same five substantive responses as the other relations.

4.3. *Data analytic methods*

The basic units of analysis are dyadic pairs of engineers.[5] The four predicted variables form two pairs. Each pair can be used to partially corroborate the responses for *seeking* and *providing* work-related information. If one engineer, p_i, reports seeking information from another, p_j, and p_j reports providing work information to p_i, then the response of p_j confirms the response of p_i for the (p_i, p_j) dyad for the *presence* of the tie. When such a tie was confirmed, we used the value of the tie[6] as reported by p_i. The difference between the specific reports and the confirmed reports is shown in Fig. 1 for seeking work information. The top panel shows the reported seeking work-related information ties while the lower panel shows the confirmed ties for this relationship. Of course, the confirmed relations are sparser than the unconfirmed relations. Note also that the confirmed relation is not symmetric.

The rows and columns of the arrays in Fig. 1 correspond to (abstractly labelled) engineers. The small squares in the arrays represent valued ties. Black squares represent the strongest ties and the shading goes to light grey for the weakest ties. White squares represent absence of ties. In the top panel, white squares represent reports of ties not existing. In the bottom panel, the additional white squares represent ties that were reported but not confirmed. The same arguments hold for providing and seeking help in problem solving. Figure 2 shows the reported and confirmed ties for providing help. The five work groups, in the order used in Figs. 1 and 2, are the central administrative group, a commercial affairs group and three drilling teams labelled A, B and C. Lines extending slightly beyond the overall bounding box mark the boundary between these units.

[5]Throughout, we use the word 'engineer' to cover 'engineer or scientist'.

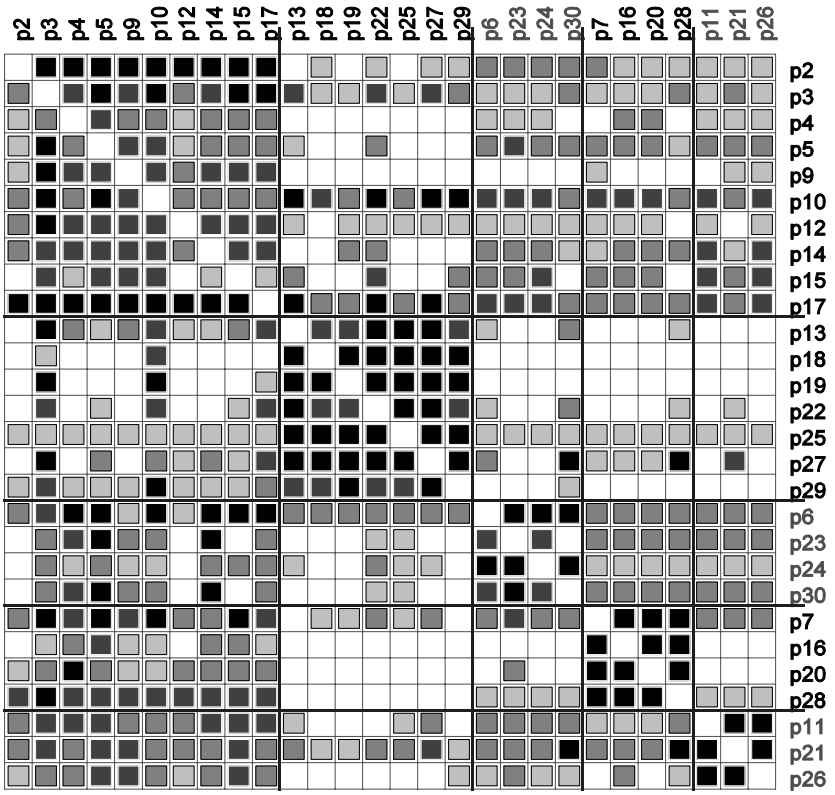
[6]An alternative is to average the reports of p_i and p_j regarding the tie from p_i to p_j (Borgatti and Cross, 2003).

Quadratic assignment (QAP) correlation and regression (Dekker *et al.*, 2007) are the primary data analytic tools used to link the distributions of knowledge seeking and providing knowledge to other social relations (while controlling for rival potential predictors). By definition, the data points for dyadic ties in a network are interdependent. If this network autocorrelation is ignored, then each data point is treated as if it is independent of all of the other data points. As a result, inference may be compromised seriously and lead to reports of falsely 'significant' estimated coefficients. QAP regression with its built-in permutation tests provides inferences that are robust in the presence of network autocorrelation (Krackhardt, 1988).

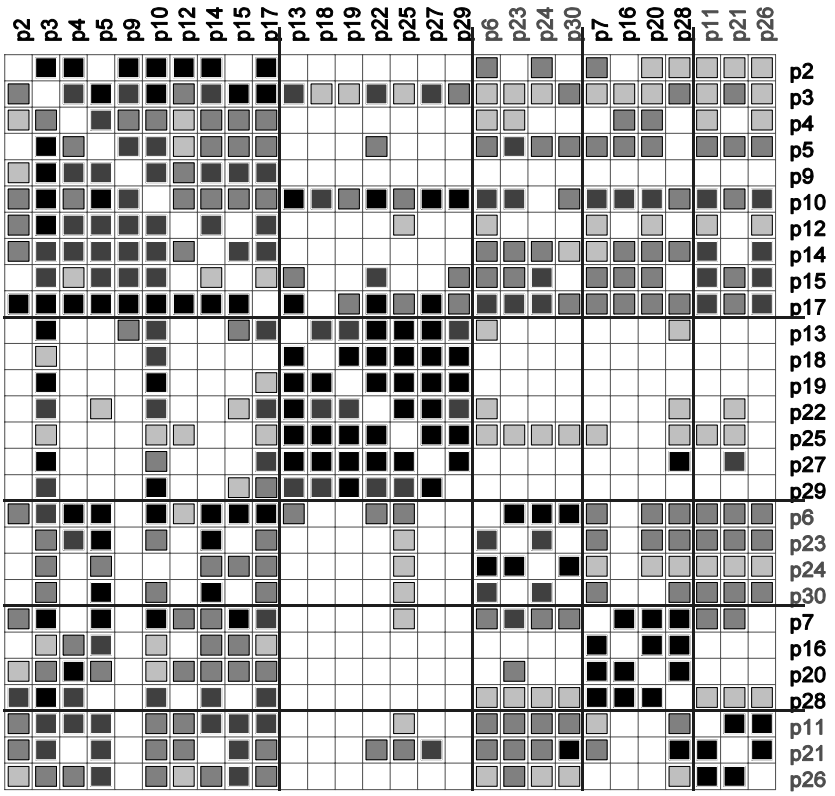
5. Analysis and Results

The depicted relations in Figs. 1 and 2 are more concentrated within the work units. The commercial affairs unit is less connected to the other units. Additionally, even though there are ties between the other four work units, one of the drilling teams (B) is less connected to the other drilling teams. Inspection of these figures suggests that work unit membership is related positively to seeking and providing work-related information, consistent with Hypothesis 3. Figures 1 and 2 make it clear that there is a considerable amount of seeking and providing knowledge in this unit of TOC and that there are patterns in these behaviours. The hypotheses stated in Sec. 3 are claims that provide accounts for these patterns. We now assess them.

The QAP correlations for all relational variables are reported in Table 1. The upper left triangle contains the correlations between the predicted variables for seeking and providing work-related information and knowledge. The p-values for these correlations are all less than 0.001. Seeking and providing work information are very highly correlated ($r = 0.96$) while seeking and providing help in problem solving are highly correlated ($r = 0.77$). The bottom left array shows correlations between all of the predictor relations and the four knowledge/information behaviour relations. Again, p-values are all less than 0.001. The predictor labelled 'socialises with others' was constructed to have only the confirmed claims of socialising. (This was done in exactly the same way as for the claims of seeking and providing knowledge to others.) All of the hypotheses stated in Sec. 3 are supported. However, these hypotheses are rather minimal because they posit only the existence of simple positive relations. It is both necessary and important to consider the *relative contributions* of the predictor relations for knowledge transmission that goes beyond the apparent existence of

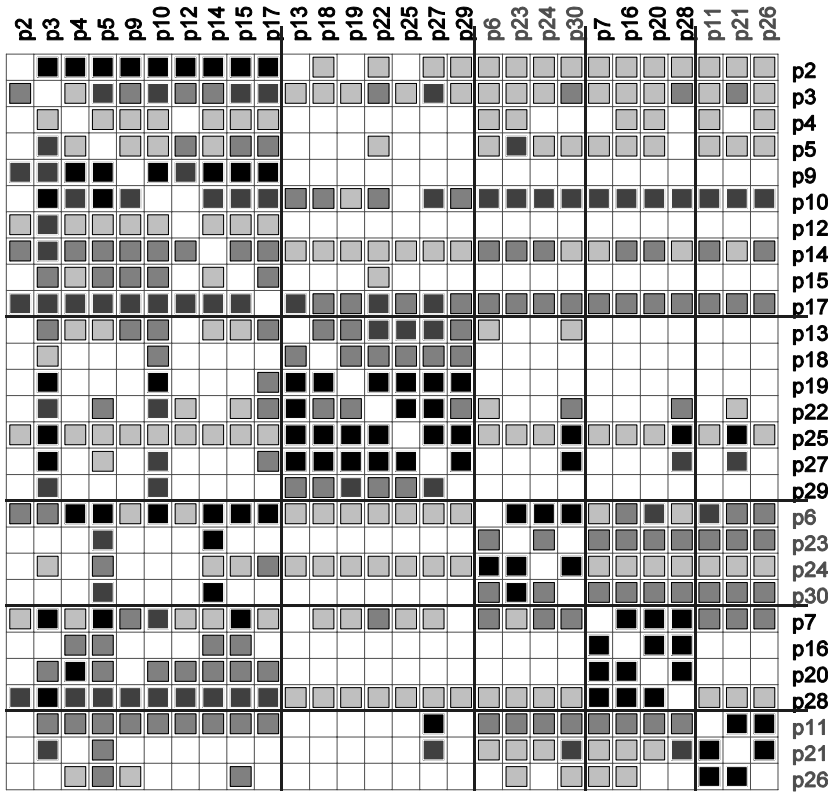


(A) Reported Ties

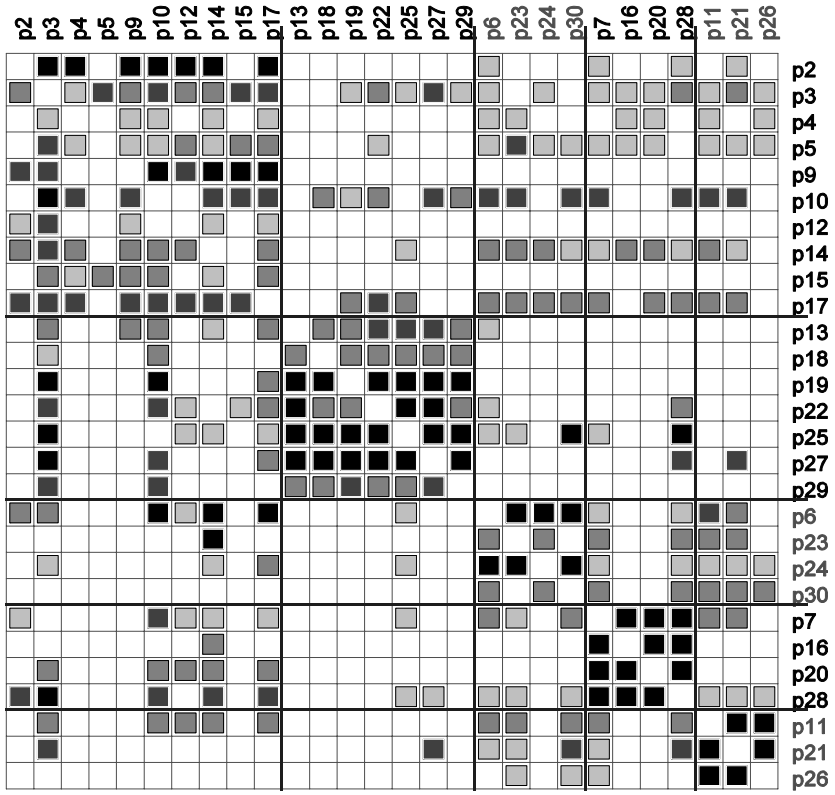


(B) Confirmed Ties

Fig. 1. Reported and confirmed ties for seeking work related information.
Note: The work units, in order, are the central administrative group, a commercial affairs group and drilling teams labelled A, B and C.



(A) Reported Ties



(B) Confirmed Ties

Fig. 2. Reported and confirmed ties for providing help in problem solving.
Note: The work units, in order, are the central administrative group, a commercial affairs group and drilling teams labelled A, B and C.

Table 1. Correlations between all relational variables.

Relations	Predicted relations				Predictor relations					
	1	2	3	4	5	6	7	8	9	10
1 Seeks work information	1.000									
2 Gives work information	0.955	1.000								
3 Seeks problem solving help	0.808	0.814	1.000							
4 Provides problem solving help	0.750	0.758	0.766	1.000						
5 Accessibility of others (perceived)	0.478	0.486	0.443	0.414	1.000					
6 Responsiveness of others (perceived)	0.387	0.388	0.389	0.381	0.664	1.000				
7 Knows the skills of others	0.459	0.451	0.394	0.391	0.536	0.466	1.000			
8 Knows the functions of others	0.438	0.442	0.402	0.396	0.548	0.494	0.508	1.000		
9 Work group membership	0.576	0.604	0.556	0.586	0.382	0.323	0.345	0.429	1.000	
10 Socialises with specific others	0.541	0.545	0.570	0.557	0.453	0.576	0.525	0.453	0.512	1.000

Table 2. Organisational unit membership as a predictor of all other relations.

Predicted relation	Variance explained by work group membership	p-value
(A) Predicting the other substantive predictors		
Accessibility of others (perceived)	14.6%	< 0.001
Responsive (perceived)	10.4%	< 0.001
Know function of	11.9%	< 0.001
Know skills of	18.4%	< 0.001
Socialise	20.8%	< 0.001
(B) Predicting knowledge seeking behaviour		
Seeks work information	33.2%	< 0.001
Gives work information	36.5%	< 0.001
Seeks problem solving help	30.9%	< 0.001
Provides problem solving help	34.3%	< 0.001

separate bivariate relations. The high correlation between accessibility and responsiveness precludes using both of them as predictors. Given the simpler definition of accessibility, we have used this predictor rather than responsiveness.

In examining the relative contributions of predictors, we give primacy to the relation capturing work group membership because it is part of the organisational design. Employees are assigned to work units and this allocation is fundamental. While the literature is clear about informal networks developing within organisations, these networks are conditioned by the formal organisation structure. Table 2 reports the results of the variance explained by work group membership for all of the other relations. Panel A focuses on the predictor variables while Panel B provides the corresponding results for the four behavioural knowledge relations by work group membership. Work group membership accounts for almost 21 percent of the socialising ties, slightly more than 18 percent of the relationship knowing the skills of others, almost 12 percent of knowing the functions others have in the organisation, about 15 percent of perceived accessibility and about 10 percent of responsiveness. While all of these relationships are significant ($p < 0.001$), much of these social relationships are not accounted for by the formal structure of the organisation, consistent with the informal structure and formal structure differing. However, these results show they are not independent of each other. Work group membership accounts for much more of the variance for all four of the seeking and providing of work information and help in solving problem relations. For all these variables, this aspect of the formal structure accounts between 30 and 36 percent of their variance.

Table 3 reports results of the QAP regressions for seeking and providing work information. Both the unstandardised and standardised coefficients are reported along with the p-values obtained from a permutation test with 2,000 permutations. Together, the five predictors account for 47 percent of the variation of seeking work information and 49 percent of the variation in providing work information. The p-values are 0.001 (or less) for both work group membership and socialising with others as predictors of seeking and providing work information.

Table 3. Predictors for seeking and providing work information.

Predictor relation	Unstandardised coefficient	Standardised coefficient	p-value
(A) Predicting *seeking work information*			
Intercept	0.397	—	—
Accessibility of others (perceived)	0.225	0.134	0.018
Knows the skills of others	0.143	0.115	0.030
Knows the functions of others	0.164	0.098	0.025
Work group membership	1.169	0.322	< 0.001
Socialises with others	0.241	0.233	< 0.001
		$N = 756$	$R^2 = 0.47$
(B) Predicting *giving work information*			
Intercept	0.371	—	—
Accessibility of others (perceived)	0.246	0.146	0.011
Knows the skills of others	0.105	0.084	0.079
Knows the functions of others	0.170	0.102	0.032
Work group membership	1.320	0.364	< 0.001
Socialises with others	0.226	0.219	0.001
		$N = 756$	$R^2 = 0.49$

From the standardised coefficients,[7] it is clear that these two are the most potent predictors with regard to the flow of work information. Perceived accessibility comes next as a predictor for both relationships (p-values are 0.018 for seeking information and 0.011 for providing information). Knowing the functions of others is significant for seeking work information ($p = 0.025$) and for providing this kind of information ($p = 0.032$). Knowing the skills of others is a significant predictor for seeking work information ($p = 0.030$) but not for providing work information. Knowing about the skills and functions of others in this organisational unit is far less important than work group membership, socialising and (perceived) accessibility. Hypotheses 2a and 3 find strong support while Hypotheses 1a and 1c receives some support. Hypothesis 1b has modest support while Hypothesis 1d is not supported. Both Hypotheses 4a and 4b are confirmed with these data.

The results in Table 4 are from the QAP regressions for predicting turning to others for help in solving problems and providing such help to others. As was the case with work information flow relations, both work group membership and socialisation are significant ($p < 0.001$) and are the most potent predictors for problem-solving relationships given their standardised coefficients. Hypotheses 3, 4a and 4b receive strong support. Hypotheses 1a, 1b and 1d receive no support once other relations (work group membership and socialising) are controlled for and Hypothesis 1c receives, at best, weak support. Hypothesis 2a has mixed support. The primary drivers of seeking and providing problem solving help are work group membership and socialising.

While the QAP regressions reveal which predictor relations are relevant for predicting the four (inter-related) knowledge behavioural relations, it clear that all of the variation in the knowledge seeking and providing relations is not accounted for by the five predictors used here. There are at least two options for attempting to better account for the knowledge transmission relations. One is to use additional predictors that contribute in ways beyond the variables used here. The second is to think about seeking and providing knowledge as parts of *endogenous* processes operating in mutually reinforcing ways beyond what is determined by the organisational formal and informal structures.

It is not possible to tease out the causal structure for these relations with cross-sectional data without making assumptions that cannot be justified. In particular, it is impossible to specify that seeking knowledge precedes providing knowledge — or the reverse — and then 'test' this with cross sectional data. However, we pursue this merely to provide some *suggestions* for future work. Given the very high correlation between seeking and providing work-related information (0.955), using one to predict the other will drive out all other predictors. So we pursue this issue only with seeking and providing help in problem solving. Table 5 presents the QAP results. When providing problem solving help is included as a predictor of seeking such help, and the reverse, in separate regressions,

[7]The standardised coefficients are compared only *within* a QAP regression. In general, comparing the magnitudes of these coefficients across QAP regressions is problematic given different variation of the relational variables.

Table 4. Predictors of turning to others and providing help to others in problem solving I.

Predictor relation	Unstandardised coefficient	Standardised coefficient	*p*-value
(A) Predicting *seek problem solving help* in problem solving			
Intercept	0.044	—	—
Accessibility of others (perceived)	0.185	0.119	0.032
Knows the skills of others	0.056	0.049	0.194
Knows the functions of others	0.119	0.077	0.074
Work group membership	1.028	0.305	< 0.001
Socialises with others	0.298	0.310	< 0.001
		$N = 756$	$R^2 = 0.45$
(B) Predicting *provides problem solving help* in problem solving			
Intercept	0.094	—	—
Accessibility of others (perceived)	0.111	0.073	0.102
Knows the skills of others	0.058	0.052	0.175
Knows the functions of others	0.130	0.086	0.043
Work group membership	1.186	0.361	< 0.001
Socialises with others	0.265	0.283	< 0.001
		$N = 756$	$R^2 = 0.45$

Table 5. Predictors of turning to others and providing help to others in problem solving II.

Predictor relation	Unstandardised coefficient	Standardised coefficient	*p*-value
(A) Predicting *seek problem solving help* in problem solving with providing help as a predictor			
Intercept	−0.012	—	—
Accessibility of others (perceived)	0.119	0.076	0.055
Knows the skills of others	0.022	0.019	0.341
Knows the functions of others	0.042	0.027	0.240
Work group membership	0.322	0.096	0.001
Socialises with others	0.140	0.146	< 0.001
Provides problem solving help	0.595	0.579	< 0.001
		$N = 756$	$R^2 = 0.63$
(B) Predicting *provides problem solving help* in problem solving			
Intercept	0.070	—	—
Accessibility of others (perceived)	0.008	0.005	0.468
Knows the skills of others	0.027	0.024	0.295
Knows the functions of others	0.064	0.042	0.119
Work group membership	0.612	0.187	0.001
Socialises with others	0.099	0.106	0.005
Seek problem solving help	0.558	0.573	< 0.001
		$N = 756$	$R^2 = 0.64$

each is the most potent predictor of the other. Given the zero order correlations this is not a great surprise. However, for both reported equations in Table 5, accessibility, knowing the function of others and knowing the skills of others are no longer significant predictors. Work group membership and socialising remain significant but are less potent predictors. The results *suggest* that seeking help and providing help in problem solving do form an endogenous mutually reinforcing process beyond the formal structure and some features of the informal structure. A more complex model could be specified with the two help variables in a reciprocal relationship. However, estimating such a model is not yet possible with QAP regression methods. More importantly, even if this data analytic method was available, temporal data are required to truly assess hypotheses concerning the social mechanisms involved in seeking and providing knowledge.

6. Discussion and Implications

The organisational unit we studied has five components. First, the commercial affairs group, had fewer information

flow ties with the remaining units. Also, one of the drilling teams had fewer connections to the other drilling teams. Of course, these fewer ties may or may not be problematic for the organisation. To the extent that these are problems, this is one place where the impact of the KM initiative can be assessed.

We imposed a basic partition on the variables considered here. The core predicted variables concern information flows (seeking and providing work information) as well as knowledge flows (seeking and providing help in problem solving for non-routine issues). They are highly correlated, especially the first two. A second category of variables contains relations thought to have an impact on the core predicted relationships. These include (perceptions of) the accessibility of other organisational members, knowledge of the relevant skills and functions of these other work group members, as well as evidence of socialising during breaks in work routines. There has been discussion in the literature about how the formal structure of an organisation is different from the informal relational structures that are developed. Here we focused on work unit membership and argued that it cannot be ignored when discussing the other social relationships. This organisational feature has predictive value for all of the variables in the second category of relationships, explaining between 10 percent (for responsiveness) to 21 percent (for socialising) of the variance of these relations. More importantly, it explains between 31 percent and 36 percent of the knowledge and information flow relations.

The high correlation between seeking and providing *work-related information* implies that that their primary predictors will be the same. Indeed, the most important predictors for both, in order, are work unit membership, socialising and perceptions of accessibility. When attention is focused on seeking and providing *problem solving help*, the primary predictors are reduced to only two: work unit membership and socialising. The other relational predictors are insignificant or modest. However, these potentially predictive links leave a lot of the variation between social relations as unexplained. Because more was going with regard to knowledge flows, we conducted a thought experiment involving potential causal orders to explore this in a preliminary fashion.

As noted above, the cross-sectional data used here implies that imputing causality is difficult, if not impossible. However, the ordering of [work unit membership → other social relations] is easy to justify because the work units exist as a part of the organisational structure with employees recruited into them. The extremely high correlation between seeking and providing work-related information precludes any attempt to assign one priority of the other. But there are differences in the seeking and providing problem solving help and we reported a pair of results involving each as the predictor of the other. Of course, each is a strong predictor of the other. The only other significant predictors are work unit membership and socialising. The other social relations have no predictive value in these QAP regressions. This suggests that 'higher level' information and knowledge movement are processes that are tightly coupled to each other. Furthermore, apart from work unit membership, the other relations inside the organisation have no predictive value. Of interest is the result that socialisation retains some of its predictive value for higher level information flow even though it is a part of the informal organisational structure. Rather than focus on the distinction between the informal and informal structures of organisations and seeing them merely as 'different,' it is more useful to examine how both have impacts on knowledge and information flows in organisations. Our results suggest that, at a minimum, the informal structure supplements the formal structure in facilitating knowledge flows.

Distinguishing more prosaic work information flows from higher order problem-solving knowledge flows is worthy of pursuit when temporal data are available. The dominant and complementary impacts of work unit membership (a formal organisation characteristic) and socialising (an informal organisation characteristic) on information and knowledge flows suggests that TOC has some of the organisational features that Ehin (2009) views as necessary for a well-run organisation. It may be that the complementarities detected in the operation of the DOG are more likely in organisations having a dominant technology mobilised under different environmental conditions. This may be especially true for the kind of drilling operations group studied here, given the many problems that can be encountered. To understand the general conditions for the presence of such complementary impacts on information and knowledge flows in organisations, it seems important to study these knowledge flows in a diverse set of organisations. This holds for both for specific parts of organisations as well as for organisations as a whole.

Some additional practical implications of this study include: (i) it is not enough to describe formal and informal structures as being different without getting an understanding of how they interact to facilitate knowledge and information flows; (ii) when evaluating KM initiatives, it is necessary to have a clear understanding of knowledge flows prior to implementing change; (iii) the TOC is one organisation that has managed to have knowledge flows that overcome geographical distances separating units of a particular managerial group and this

may have value for other units and organisations; and (iv) real progress in understanding information and knowledge processes requires temporal data.

References

Anklam, P, R Cross and V Gulas (2005). Expanding the field of vision. *Learning Organization*, 12(6), 539−551.

Borgatti, P and R Cross (2003). A relational view of information seeking and learning in social networks. *Management Science*, 49(4), 432−445.

Cheuk, B (2007). Using social networking analysis to facilitate knowledge sharing in the British Council. *Business Information Review*, 24(3), 170−176.

Chui, Y (2009). How network competence and network location influence innovation performance. *Journal of Business & Industrial Marketing*, 24(1), 46−55.

Cohen, D and L Prusak (2001). *In Good Company: How Social Capital Makes Organizations Work*. Cambridge, MA: Harvard Business School Press.

Cross, R and A Parker (2004). *The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations*. Boston, MA: Harvard Business School Press.

Cross, R, A Parker and L Sasson (2003). Introduction. In *Networks in the Knowledge Economy*, R Cross, A Parker and L Sasson (eds.). New York: Oxford University Press.

Cross, B, A Parker, L Prusak and S Borgatti (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organizational Dynamics*, 30(2), 100−120.

Cross, B, S Borgatti and A Parker (2002). Making invisible work visible: Using social network analysis to support human networks. *California Management Review*, 44(2), 25−46.

Dekker, D, D Krackhardt and TAB Snijders (2007). Sensitivity of MRQAP tests to collinearity and autocorrelation conditions. *Psychometrika*, 72, 563−581.

Doreian, P and N Conti (2009). Social infrastructure and social structure, Capturing Context Conference, Columbia University, New York, June 12−13, 2009.

Ehin, C (2009). *The Organizational Sweet Spot: Engaging the Innovative Dynamics of Your Social Networks*. New York: Springer.

Emmerik, H *et al.* (2006). Networking your way through the organization: Gender differences in the relationship between network participation and career satisfaction. *Women in Management Review*, 21(1), 54−66.

Garcia-Lorenzo, L (2006). Networking in organizations: Developing a social practice perspective for innovation and knowledge sharing in emerging work contexts. *World Futures*, 62, 171−192.

Kilduff, M and W Tsai (2003). *Social Networks and Organizations*. London: Sage Publication.

Kogut, B and U Zander (1992). Knowledge of the firm combinative capacities and the replication of technology. *Organization Science*, 3, 383−397.

Krackhardt, D (1988). Predicting with networks: Nonparametric multiple regression analysis of dyadic data. *Social Networks*, 10(4), 359−381.

Krackhardt, D and JR Hanson (1993). Informal networks: The company behind the chart. *Harvard Business Review*, 71(4), 104−111.

Marouf, L (2007). Social networks and knowledge sharing in organizations: A case study. *Journal of Knowledge Management*, 11(6), 110−125.

Michael, JH (1997). Labor dispute reconciliation in a forest products manufacturing facility. *Forest Products Journal*, 47, 41−45.

Mitchell, HJ (2005). Knowledge sharing — The value of story telling. *International Journal of Organizational Behavior*, 9(5), 632−641.

Morton, S *et al.* (2004). Managing the informal organization: A conceptual model. *International Journal of Productivity and Performance Management*, 53(3), 214−232.

Roethlisberger, FJ and WJ Dickson (1939). *Management and the Worker*. Cambridge, MA: Harvard University Press.

Smith, P (2005). Knowledge sharing and strategic capital: The importance and identification of opinion leaders. *Learning Organization*, 12(6), 563−574.

Smith, HA and JD McKeen (2002). Instilling a knowledge sharing culture. *Third European Conference on Organizational Knowledge, Learning, and Capabilities*, Athens, Greece. Retrieved on January 8th, 2009 from http://www.business.queensu.ca/centres/monieson_old/docs/working/working_03-11.pdf.

Swan, J *et al.* (1999). Knowledge management and innovation: Networks and networking. *Journal of Knowledge Management*, 3(4), 262−275.

Thurman, B (1979). In the office: Networks and coalitions. *Social Networks*, 2, 47−63.