Testing impact of knowledge characteristics and relationship ties on project performance

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Abstract

Purpose – *The aim of this paper is to empirically test and find the correlation between knowledge characteristics and relationship ties on project performance.*

Design/methodology/approach – *Data were collected via personal interviews based on a structured survey of project managers in a knowledge-intensive firm. The data were analyzed using a multiple regression model.*

Findings – *The results show that project performance was positively related to the frequency and closeness of source, and difficulty of the ''knowledge element'' described in the survey. Interestingly, against the prevalent view, the source and the level of tacitness of the knowledge element were not found to be significant.*

Research limitations/implications – *Data are limited to specific corporate setting and variables are not exhaustive, despite the fact that this study includes the most theoretically interesting variables. One implication is that strong ties to a knowledge element source are important for project success, but distinctions between internal and external sources, and degree of codification, are not.*

Practical implications – *This study also implies that, in this day and age of knowledge management and chief knowledge officers, most of the important knowledge may already have been codified inside the firm, thus alleviating the past focus on transfer of tacit knowledge. This fact also implies that firms that are left behind in terms of managing their knowledge inside the firm stand to lose a lot more since the other firms are managing their own knowledge base better.*

Originality/value – *This paper incorporates and empirically tests most of the variables considered important to theoreticians and practitioners in the realm of knowledge management and network theory. The latter theory is important in the field of knowledge management because it offers the link and medium in which knowledge travels and transfers.*

Keywords *Knowledge management, Knowledge sharing, Networking, Tacit knowledge*

Paper type *Research paper*

Introduction

In recent years, effective management of knowledge has become a critical task in building competitive advantage (Teece, 1996; Eisenhardt and Santos, 2001). This steady shift in interest from physical resources to an abstract resource called ''knowledge'' reflects the significant disparities in performance across teams and divisions within a single firm when the necessary knowledge is not shared effectively within the firm. Firms that capture useful knowledge about their practices, and are able to share it across the organization, can sharpen their competitive edge. For example BP, a $262 billion oil giant, cut down drilling costs by $47 million per oil well in 1998 by identifying and sharing seemingly insignificant innovations that workers practiced in different parts of the world (Prusak, 1999).

The knowledge-based view draws its roots from the resource-based view, organizational learning, and dynamic capabilities. These literatures explain what knowledge is and why knowledge is critical to competitive advantage. Social network theory gives us insight into how knowledge moves between individuals of the firm, because knowledge by itself does

not move. Other research draws on transaction cost economics to explore the relationship between a firm's organization and management of knowledge. However, as Argyres and Silverman (2004) note, and exemplify, most research focus on knowledge in an inter-firm setting, almost to the exclusion of intra-firm setting. More infrequent and rare is research encompassing both inter- and intra-firm settings to ensure a balanced look at knowledge and how it behaves in these different environments. The purpose of this paper is to precisely address this hole in the research field and to find how knowledge behaves in both intra- and inter-firm settings.

The resource-based view of the firm explains firm performance differences that the structure-conduct-performance paradigm of industrial organization (IO) (Bain, 1959; Porter, 1980) does not consider. Wernerfelt (1984), Dierickx and Cool (1989), and Prahalad and Hamel (1990) built a resource-based theory based on the idea of competitive advantage rooted inside a firm rather than from external attributes of its industry. Some sources and nature of competitive advantage of the firm have since been suggested, such as: valuable, rare, inimitable, and non-substitutable resources (Wernerfelt, 1984; Barney, 1991); the management's abilities to marshal these assets (Grant, 1991); and related sets of operational routines and technological skills (Prahalad and Hamel, 1990; Stalk *et al.*, 1992). Added to the idea of competitive advantage of the firm is the idea that in an increasingly fast-moving environment, very few competitive advantage can be sustained over time unless the firm has organizational and managerial processes – termed ''dynamic capabilities'' – to integrate, build, and reconfigure internal and external competencies (Teece *et al.*, 1997; Eisenhardt and Brown, 1998).

Thus given the increasingly dynamic nature of the environment itself, resources static in nature – such as fixed assets or outdated skills – can no longer be deemed a sustainable competitive advantage of the firm. Based on this understanding of organizations and environments, Grant (1996) proposed that tacit knowledge is the source of sustained competitive advantage. He argues that the source of competitive advantage in dynamic environments is not knowledge that is codified and proprietary to the organization, because the value of such knowledge erodes quickly due to obsolescence and imitation. Rather, sustained competitive advantage is determined by non-proprietary knowledge in the form of tacit individual knowledge. According to Grant (1996), tacit knowledge can form the basis of competitive advantage because it can be both unique and relatively immobile. Yet, because that knowledge is possessed by individuals and not the organization, a critical element of sustained competitive advantage is the ability to integrate the specialized and tacit knowledge of individuals.

The concept and types of knowledge, originally borrowed from sociology, has since been expanded to answer the question of why firms exist. Conner and Prahalad (1996) identify knowledge carried and shared by individuals within the firm to be both the *raison d'être* for that firm against alternative forms of organization such as markets, and also to be the source of such firm's performance difference with other firms. Kogut and Zander (1996) also expand on this belief that the firm is a better facilitator of knowledge sharing than a market, hence its predominance in the world.

Despite the preponderance of the tacitness of knowledge as a sustained competitive advantage of the firm (Nelson and Winter, 1982), recent views from mostly European schools of thought suggest that codified knowledge is a more solid source of firm competitiveness (Sanchez and Heene, 1997). The characteristic of difficulty in transmitting tacit knowledge

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has led scholars to assert that tacit knowledge in particular is a source of competitive advantage because it is more difficult for other firms to copy or replicate (Teece and Pisano, 1994; Teece *et al.*, 1997). But on the other hand, the same nature of tacit knowledge that makes it difficult for other firms to copy also makes it difficult to connect internally. Thus Sanchez and Heene (1997) posit that it is not tacit knowledge, easily lost through employee turnover and job switching, but it is the explicit knowledge that has been codified, which builds the foundation for firm competitiveness.

Sanchez and Heene (1997) argue that Polyani's (1962) use of the term ''know'' in the famous example of the skater who ''knows'' more than she can tell about how she skates. They suggest that ''whatever the skater cannot tell (albeit with some mental effort), she really does *not* 'know,' at least not within the concept of knowledge proposed by Sanchez, Heene and Thomas (1996)''. Sanchez *et al.* (1996) seem to imply that tacit knowledge cannot be relied on to improve firm performance, and only explicit knowledge can be used to compete with others. To them, knowledge is ''the set of beliefs held by an individual about causal relationship among phenomena'' (Sanchez *et al.*, 1996, p. 9). They argue that strategically relevant knowledge is never certain, but rather only exists in the form of beliefs, in the sense that knowledge is not absolute or deterministic, but consists of probabilistic assessments of causal relationships between phenomena. They agree with Polyani in the aspect that knowledge originates with and exists within individual humans, but expand their definition of knowledge by conceding that ''organizations may also have knowledge that may exist in various forms understood by more than one individual within an organization'' (Sanchez *et al.*, 1996, p. 5). This sharing of knowledge by more than one individual form the basis of that organization's competence, which Sanchez *et al.* (1996, p. 8) define as:

> [. . .] an ability to sustain the coordinated deployment of assets and capabilities in a way that promises to help a firm to achieve its goals.

Thus the degree of codifiability is yet to be empirically tested in its contribution to firm competitiveness.

Another dimension of knowledge, its difficulty, is another salient way of categorizing knowledge. Difficulty is considered one of the aspects having the most influence in the transfer of knowledge (Rogers, 1962; Winter, 1987). Knowledge by itself in isolation cannot move. It requires a medium, and the medium is usually individuals or products created by individuals, such as books or software. This requirement of a medium necessitates individual interaction, meaning ties between people or network of ties.

This is where the organizational learning literature comes in to explain the knowledge-based view. Learning can be defined as the process by which new information or knowledge is incorporated into the behavior of agents, changing their patterns of behavior. Brown and Duguid (1991) proposed a unified view of working, learning, and innovation which links individual and organizational levels of knowledge. The authors start by pointing out that codification of work procedures can be quite different from actual working practices, even contradictory. They argue that learning theory should be distanced from codified, transferable, and objective notions of knowledge, and focus instead on knowledge in context. In their view, meaningful knowledge is deeply related to daily work, and the acquisition of new knowledge (i.e. learning) is socially constructed from working practices. This social construction of knowledge occurs within informal communities, where knowledge is freely shared through collaborative mechanisms such as communications and joint work.

Nelson and Winter (1982) were among the first to integrate organizational knowledge and routines with the notion of dynamic competitive environments. In their approach to evolutionary economics, the firm is understood to be a repository of knowledge, which is represented by routines that guide organizational action. The authors see individuals as responding to information difficulty and uncertainty through their own skills and routine organizational activity, in line with the behavioral tradition (Simon, 1965; Cyert and March, 1963).

Cohen and Levinthal (1990) related organizational learning and innovation to the evolving knowledge base of the firm. The authors define absorptive capacity as the ability to

"Project performance is strongly associated with high frequency and high closeness of the relationship tie, and the difficulty of the knowledge element."

recognize the value of external information, assimilate it, and apply it to commercial ends. According to the authors, absorptive capacity is largely a function of the level of the firms' prior knowledge (which emphasizes the cumulative nature of knowledge), and is history or path-dependent (which emphasizes the importance of earlier decisions). Important determinants of absorptive capacity are the internal channels of communication, the distribution of knowledge in the environment and in the firm, and the pattern of R&D investment decisions.

To describe the internal channels of communication that Cohen and Levinthal (1990) identify as an important determinant of absorptive capacity, theories in network literature are helpful. Initially Granovetter (1973) advanced the idea that weak ties – infrequent and distant relationships – facilitate searching for new information because their contacts are less likely to provide redundant knowledge. He posited and found evidence to support the proposition that weak ties serve as a source of new information, or explicit knowledge. However, he later revisited the idea of tie strength and noted that ''strong ties have greater motivation to be of assistance and typically more easily available'' than weak ties (Granovetter, 1982, p. 113). Krackhardt (1992) extended this work to suggest that the benefit of strong ties is that they provide a base of trust that is crucial when an actor or individual confronts uncertainty. Thus strong ties facilitate innovation by providing exchanges that reduce suspicion.

The strength of ties is usually defined by a few characteristics. Among the prominent are: frequent interaction (frequency) and intimacy (closeness) (Granovetter, 1982) between the parties to the relationship (Krackhardt, 1992). Strong ties are thought to provide less diverse or novel information because individuals are much more likely to form strong ties with socially similar individuals, who tend to possess the same information and to hold similar opinions (Granovetter, 1973; Rogers, 1962). However, they do provide other benefits that may facilitate adaptation. First, strong ties are more likely to promote in-depth two-way communication and to facilitate the exchange of detailed information (Granovetter, 1982; Krackhardt, 1992; Uzzi, 1996). Thus although strong ties may not maximize the awareness of environmental changes and potential adaptive responses, they are likely to be more valuable than weak ties in helping to decipher the implications of external threats and to evaluate potential responses to these threats. Further, the trust and mutual identification that are likely to exist when ties are strong make it more likely that both information will be shared and actually acted on.

This study is based on structured survey interviews with top managers of project teams of a firm. Project teams have long been the focus of research, especially in product development (Myers and Marquis, 1969; Rothwell, 1972; Imai *et al.*, 1985). Product development is one practical case of applying knowledge to create new knowledge or innovation. In many firms, project team members are the people who actually do the work of product development (Brown and Eisenhardt, 1995). These are the people who transform vague ideas, concepts, and product specifications into the design of new products. Thus it is not surprising that project team is central to many models of product development (Brown and Eisenhardt, 1995).

The unit of analysis in this study is a knowledge element, defined as the smallest unit of discrete and independent piece of knowledge necessary to carry out an operation. The following hypotheses are derived from the theoretical discussion and tested:

H1. The closer the source of knowledge is to the individual of the project team, the higher the knowledge element's importance to its project performance (source of knowledge).

H2. The higher the tacitness component of the knowledge element, the higher the knowledge element's importance to its project performance (tacitness of knowledge).

H3. The higher the difficulty component of the knowledge element, the higher the knowledge element's importance to its project performance (difficulty of knowledge).

H4. The higher the frequency of contact to the source of knowledge during the course of the project, the higher the knowledge element's importance to project performance (frequency of ties).

H5. The closer the contact of knowledge source is to the individual at the beginning of the project, the higher the knowledge importance to project performance (closeness of ties).

This study focuses on how knowledge is integrated from different sources – internal and external – to generate new knowledge and thus contribute to project performance of a firm. This is unique from other studies in its integrative nature. Most research in knowledge theory research centers on one aspect of knowledge sourcing, knowledge integration, internal knowledge transfer, or external knowledge transfer (Eisenhardt and Santos, 2001) or either inter-firm setting or limitedly, intra-firm setting (Argyres and Silverman, 2004).

Studies on knowledge sourcing suggest that external linkages are important for a variety of innovation-related outcomes. These external linkages include incentives that motivate scientists to stay connected with the larger scientific community (Henderson, 1994), formal network relationships (Powell *et al.*, 1996; Brown and Eisenhardt, 1997; McEvily and Zaheer, 1999), exploratory products (Brown and Eisenhardt, 1997, Jett, 1999), gatekeepers (Allen, 1977; Katz and Tushman, 1981), and informal networks (Henderson and Cockburn, 1994; Liebeskind *et al.*, 1996; Tripsas, 1997; Rosenkopf and Nerkar, 2001; Cummings, 2004). Few studies suggest that similar knowledge sourcing processes occur within firms and can also lead to more innovation (Henderson and Cockburn, 1996; Hansen, 1998). Yet this research stream leaves unexamined several fundamental issues pertinent to strategy studies. Only a few studies examine firm performance, and those that do rely on a variety of close proxies, including survival (Tripsas, 1997), growth (Powell *et al.*, 1996), market segment dominance (Brown and Eisenhardt, 1998), and profit (Bierly and Chakravarti, 1996). As a result, these need no demonstration of any specific conception of performance (Eisenhardt and Santos, 2001). Further unlike this study, these studies do not examine micro-processes within the firm failing to give us a clear picture of how knowledge actually creates value within the firm. For this we have to look at another area of empirical research: knowledge integration.

Studies with a focus on knowledge integration emphasize the micro-processes of interaction, mostly within organizations, that enable the integration of knowledge. This stream of research is especially relevant to knowledge theory because of the assertion that knowledge integration (especially integration of the tacit knowledge that is held by individuals) is a primary source of superiority of firms over markets and a major way in which competitive advantage is achieved (e.g., Grant, 1996). However, most studies in this field are ethnographic (e.g., Hargadon and Sutton, 1997; Bechky, 1999; Helper *et al.*, 1999) or experimental (Okhuysen and Eisenhardt, 2002) in nature, thus failing to address firm performance, unlike this study.

Most studies on internal knowledge transfer tend to focus on the knowledge characteristics that affect the efficacy of internal knowledge transfer. These characteristics include tacitness (Zander and Kogut, 1995; Lord and Ranft, 1998), causal ambiguity (Szulanski, 1996), and complexity (Hansen, 1998), which impede knowledge transfer, and strategic value (Brown and Eisenhardt, 1998; Gupta and Govindarajan, 2000), which enhances knowledge transfer. Some of these internal focused studies also included relationships. These studies also

indicate that the relationship between the sender and recipient is crucial for knowledge transfer. When the sender and recipient have difficulty establishing interpersonal interactions (Szulanski, 1996) such as when they are distant, knowledge transfer is impaired. In contrast, when integrative mechanisms such as teams, informal social networks, norms for collaboration, and formal meetings exist (e.g., Hargadon, 1998; Gupta and Govindarajan, 2000; Eisenhardt and Galunic, 2000), knowledge transfer is facilitated. Some studies looked at research units (Birkinshaw *et al.*, 2002; Hansen *et al.*, 2005), informal relationships (Levin and Cross, 2004) and globally dispersed R&D organizations (Kim *et al.*, 2003) with some social science approach of looking at researchers within the firm (Reagans and Zuckerman, 2001). In summary, these studies are very useful for understanding internal knowledge transfer.

Lastly, studies on external knowledge transfer indicate that knowledge transfer is affected by knowledge characteristics and by the relationship between the sender and recipient. As such these studies replicate the studies of internal knowledge transfer in terms of its method, variable contented, and results except in some alliance relationships (Mowery *et al.*, 1996; Powell *et al.*, 1996). The studies, unlike this one, do not try to answer whether external knowledge transfer is either easier or qualitatively different from internal knowledge transfer. Some consider this a theoretically critical question because a primary assumption of knowledge theory is that knowledge transfer is facilitated within firms as compared with markets (Kogut and Zander, 1996; Grant, 1996). While some notable effort has undergone to link knowledge management and R&D management for example (Park and Kim, 2005), much is needed at intra- and inter-firm settings like this article does.

This study of knowledge management is uniquely positioned at the knowledge element level to find its impact on project performance. Knowledge element is defined as a discrete and independent piece of knowledge. During the interview, respondents are given the definition and examples of the knowledge element. The examples of a knowledge element are: information (previously available findings, such as data sets, literature, and published reports); analytical methods; any insights; any measurement methods; any project management knowledge; client knowledge; any client management knowledge; and others.

Most studies use a chunk of knowledge piece such as an innovation defined simply as ''new knowledge or expertise'' (Tsai, 2001, p. 1000). Most studies tend to use a conceptual concept of ''knowledge'' that is not quantified or even defined (e.g., Hansen, 1999; Kogut and Zander, 1993).

To explore the extent of knowledge importance to a project, the author considers the following three attributes of knowledge:

1. the characteristics of knowledge (tacitness and difficulty);
2. the source of the knowledge (internal or external to the firm); and
3. the strength of the connection to the source (strength of tie, or frequency or closeness of ties).

The knowledge elements are a unit of analysis and may have different characteristics such as difficulty or degree of tacitness, which are some of dependent variables. This study, by focusing on knowledge in its most basic discrete form, will unravel some of the organizational-level issues involved with knowledge management.

"Tacitness and source of the knowledge element were not found to be significant."

Method

The data for this study were collected by personal interviews based on a structured survey. Project managers of a knowledge-intensive firm were interviewed to answer questions regarding knowledge characteristics, ties, and project performance. Prior to the interviews, pre-tests were conducted using a small but similar sample. This pre-test phase allowed the survey to be revised and interview technique to be refined. The survey embedded several advances recommended by previous interview researchers (e.g., Cronbach, 1984; Diesing, 1971; Sundberg, 1977; Nunnally, 1978; Corcoran and Fischer, 1987).

Data collection and research site

This study is based on structured survey interviews with top managers of project teams of a firm. The project managers were selected as respondents because they are the ones who are ''in the thick of things'' (Hansen, 1999).

The author tested the predictions in a large, multidepartmental and multinational consulting company (hereafter called ''the firm'' or ''the company''). The company, which has annual billing of more than $5 million, is involved in developing, planning, and selling a range of consulting analyses. It has been profitable for a number of years and has continued to grow. The company is structured into a number of fairly autonomous departments that are responsible for business. These departments are organized according to product-market segments or industries, such as medicine, education, and heavy industries. Within each department are project teams, formed for each new project by a designated project manager. The project manager has the option of selecting team members based on the needs of the project which may span over years of data collection and multinational collaboration. Table I gives a brief description of the projects involved.

Model

A simple ordinary linear regression (OLS) was used to analyze the data collected from the personal interviews. Often it is the simplest model that offers most insight and understanding of a phenomenon. The model is as follows.

The contribution of a knowledge element *i* of project *j* to the project performance is assumed to be given by:

$$R_{ij} = \beta_0 + \beta_1 \text{Locself}_{ij} + \beta_2 \text{Freq}_{ij} + \beta_3 \text{Close}_{ij} + \beta_4 \text{Tacit}_{ij} + \beta_5 \text{Diff}_{ij} + \delta_1 \text{Duration}_j + \delta_2 \text{Size}_j + \varepsilon_{ij} \text{ for all } i \text{ and } j,$$

where $E(\varepsilon_{ij}) = 0$ and $\text{cov}(\varepsilon_{ij}, \varepsilon_{kl}) = 0$ whenever $i \neq k$ or $j \neq l$.

The LocSelf variable refers to the source of knowledge. The respondents were asked to identify the source of knowledge amongst the following alternatives: 1 = from outside of the firm, 2 = distantly located department, 3 = from unrelated department, 4 = from related department, 5 = from the team, 6 = from a team member, 7 = personal knowledge. Thus the higher the beta coefficient, the more internal is the source of the knowledge element. In addition, regressions are done with the LocSelf variable split into three parts: personal knowledge (a dummy variable called LocDumSelf); knowledge from outside the firm (a dummy variable named LocDumExt); and inside the firm (a variable called LocInFirm of four-interval scale from 2 = distantly located department to 6 = from a team member).

The Freq variable refers to the frequency of contact with the source of knowledge. The respondents are asked to choose the frequency of knowledge among the following alternatives: 1 = less than once a month, 2 = twice a month, 3 = thrice a month, 4 = once a week, 5 = twice a week, 6 = thrice a week, 7 = essentially every working day. Thus the higher the beta coefficient, the higher the frequency of contact with the source of the knowledge element.

The Close variable refers to the closeness of contact with the source of knowledge. The respondents are asked to indicate the closeness of knowledge from a continuous scale

Table I Models with third transformation (restricted set of four top elements)

	Model 19		*Model 20*		*Model 21*		*Model 22*		*Model 23*		*Model 24*	
Variable	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*
Constant	1.09	0.44**	1.03	0.52*	0.98	0.44**	0.94	0.51*	1.00	0.42**	0.93	0.50*
LocSelf	−0.03	0.07	−0.03	0.07								
Freq	0.02	0.05	0.02	0.05	0.01	0.05	0.01	0.05	0.03	0.05	0.03	0.05
Close	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.04	0.05
Tacit	0.13	0.06**	0.13	0.06	0.14	0.06**	0.15	0.06**	0.12	0.06**	0.12	0.06**
Diff	0.19	0.06***	0.20	0.06***	0.19	0.06***	0.19	0.06***	0.19	0.06***	0.19	0.06***
Duration			−0.00	0.01			−0.00	0.01			−0.00	0.01
Size			0.02	0.06			0.02	0.06			0.02	0.06
LocDumSelf					0.18	0.23	0.20	0.24				
LocDumExt					−0.45	0.45	−0.47	0.46				
LocInsFirm									0.03	0.07	0.03	0.07
Adj *R*-square	0.11		0.09		0.11		0.10		0.11		0.09	

Notes: * $p < .010$; ** $p < 0.05$; *** $p < 0.01$; values are unstandardized regression coefficients

where 1 = not at all close, 4 = moderately close, 7 = very close. Thus the higher the beta coefficient, the closer was the source of the knowledge element to the respondent.

The Tacit variable refers to the tacitness of the knowledge element. The respondents are asked to indicate the tacitness from a continuous scale where 1 = mainly reports manuals documents self-explanatory software etc., 4 = half know-how and half reports or documents, 7 = mainly personal practical know-how, trick-of-trade. Thus the higher the beta coefficient, the more tacit the knowledge element.

The Diff variable refers to the difficult of the knowledge element. The respondents are asked to indicate the difficulty using a continuous scale where 1 = not at all difficult or difficult, 4 = moderately difficult or difficult, 7 = very difficult or difficult. Thus the higher the beta coefficient, the more difficult the knowledge element.

Dependent variable. The dependent variable R_{ij} captures the importance of the knowledge element's contribution to its project's performance. After identifying knowledge elements for a project, respondents were then asked to rank-order the knowledge elements in their importance to the project's success. The rankings are then converted to a fraction for the following reasons. The number of knowledge element varies from project to project. This may distort the relative importance of knowledge elements in projects with less number of knowledge elements to those with more knowledge elements. This transformation corresponds to [(number of knowledge element in the project − ranking + 1)/number of knowledge element in the project] or where kth ranked element of n elements is $(n - k + 1)/n$. This number, which is a fraction greater than 0 and equal to or less than 1, is referred to as the Rank variable. This also ensures that the ordering of the dependent variable is compatible with that of the other variables in the model. For example, a knowledge element most critical in a project would always be assigned the value 1 and the least important knowledge element would always be assigned the value of (1/number of knowledge element in the project).

In addition to this original transformation, three other transformations are conducted to ensure robustness of the dependent variable. The first transformation is where kth of n elements is $2^{n-k}/2^n - 1$, whose characteristics among others, is that a ranking would carry twice as more weight than the previous ranking. The second transformation is a clustering of knowledge elements into three parts: the top third, the middle third, and the bottom third of knowledge elements in a project. The third transformation included only the top four knowledge elements.

Control variables

Next, ordinary linear regression was performed with the control variables included. There are two control variables and they are called Duration and Size.

The Duration control refers to the duration of the project in months. The Size control refers to the number of people involved in the team.

Summary statistics

Table II presents the summary statistics. The 228 knowledge element observations were collected from 27 projects of the firm. The average number of knowledge elements from a project is 9.7, distributed between three elements and 15 elements.

Results

In the regression model including the control variables, Freq, Close, and Diff variables are shown to be significant, with beta coefficients of 0.037, 0.022, and 0.061 respectively. Adjusted R-square is 0.24 (see Table III).

Therefore the hypotheses regarding frequency, closeness, and difficulty of knowledge elements are supported by the data, but the hypotheses regarding the source of the knowledge element and the tacitness of knowledge element cannot be supported.

Table II Description and correlations of key variables

Variable	*Mean*	*SD*	*Max.*	*Min.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Rank	0.57	0.29	1.00	0.07							
2. LocSelf	5.62	1.57	7	1	−0.01						
3. Freq	3.33	1.89	7	1	0.36	0.11					
4. Close	4.19	2.02	7	1	0.15	0.09	0.12				
5. Tacit	4.75	1.90	7	1	−0.09	0.13	−0.10	0.08			
6. Diff	3.88	1.65	7	1	0.41	0.07	0.29	−0.06	0.01		
7. Duration	33.62	18.64	60	4	−0.01	0.06	−0.08	−0.21	0.03	0.08	
8. Size	5.45	2.18	10	2	−0.02	0.06	−0.01	−0.05	0.11	0.04	0.42

Increasing the frequency of contact is associated with increased importance of the knowledge gained from that contact. The regression results also imply that difficulty of knowledge is associated with the importance of that knowledge to project performance.

This study shows that project performance is strongly associated with high frequency, high closeness, and high difficulty of the knowledge element. However, the actual source of knowledge and the tacitness of knowledge element were found to be irrelevant in explaining project performance. The results show strong support for strong relationships and project performance.

Along with the original model, the various location variables are tested in two different models, the first model with LocDumSelf and LocDumExt, and the second model with LocInFirm. Results show a similar pattern of significance and coefficients to the original model. The Freq, Close, and Diff variables stay significant and the Tacit variable along with LocDumSelf, LocDumExt, and LocInFirm stay insignificant like the LocSelf variable in the original model. Even the *R*-square stays in the same range. The similarity of pattern in significance and coefficients among the models seems to ensure the robustness of the original model.

However, some interesting patterns emerge when different forms of transformations are used for the dependent variable. The additional first and second transformations led to a similar pattern of significance amongst variables but lower *R*-square than the original model. However, the third transformation led to an interesting result. In the model using the third transformation of the Restricted Sample Model (the transformation which include only the top four knowledge elements), the Tacit variable shows significance, whereas the Close and Freq variables do not show significance. The Diff variable stays significant in this model (see Tables I, IV and V).

Discussion and conclusion

In this article, the author reviewed various theories of knowledge and social network theory and identified several characteristics of knowledge and relationship ties considered important in building competitive advantage of a firm. Each of the characteristics was then operationalized and surveyed during face-to-face interviews based on structured interviews. The results showed that project performance is strongly associated with high frequency and high closeness of the relationship tie, and the difficulty of knowledge element; however, tacitness and source of the knowledge element were not found to be significant. These lead to insightful implications, shifting the focus to relationship ties and the type of interactions from the type of knowledge, typified by tacitness of knowledge.

This study suggests that tacitness of knowledge does not have any relationship to project performance previously theorized by many in the field, but rather uphold the views of Sanchez and Heene (1997). Tacitness has been a strong idea in the past literature. Many in the field concede that tacitness is difficult to measure, difficult to describe, and therefore difficult to transfer, even inside an organization. Thus the importance of tacitness in competitive advantage, according to the mainstream view of knowledge, has been tantamount to competitive advantage itself.

Table III OLS regression models of the performance for knowledge characteristics

	Model 1		*Model 2*		*Model 3*		*Model 4*		*Model 5*		*Model 6*	
Variable	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*
Constant	0.24	0.08**	0.23	0.09*	0.18	0.07*	0.18	0.09	0.16	0.07	0.17	0.09
LocSelf	0.01	0.01	0.01	0.01								
Freq	0.04	0.01**	0.04	0.00**	0.04	0.01**	0.04	0.00**	0.04	0.00**	0.04	0.00**
Close	0.02	0.01**	0.02	0.00*	0.02	0.01*	0.02	0.00*	0.02	0.00*	0.02	0.00*
Tacit	0.01	0.01	−0.01	0.00	−0.01	0.01*	−0.01	0.00	0.01	0.00	0.01	0.00
Diff	0.06	0.01**	0.06	0.01**	0.06	0.01	0.06	0.01**	0.06	0.01**	0.06	0.01**
Duration			0.00	0.00			0.00	0.00			0.00	0.00
Size			0.00	0.00			−0.00	0.00			0.00	0.00
LocDumSelf					0.03	0.04	−0.03	0.04				
LocDumExt					0.02	0.07	0.03	0.07				
LocInsFirm									0.01	0.01	0.01	0.01
Adj *R*-square	0.24		0.24		0.24		0.23		0.24		0.24	

Notes: * $p < 0.10$; ** $p < 0.01$; values are unstandardized regression coefficients

Table IV Models with first transformation (*k*th of *n* elements is $2^{n-k}/2^n-1$)

	Model 7		*Model 8*		*Model 9*		*Model 10*		*Model 11*		*Model 12*	
Variable	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*
Constant	−0.02	0.05	−0.01	0.06	−0.02	0.04	−0.01	0.05	−0.04	0.05	−0.03	0.05
LocSelf	−0.00	0.00	−0.00	0.01								
Freq	0.01	0.00**	0.01	0.01**	0.01	0.01**	0.01	0.01*	0.01	0.01**	0.01	0.01**
Close	0.01	0.00**	0.01	0.01**	0.01	0.01*	0.01	0.01**	0.01	0.01*	0.01	0.01*
Tacit	−0.01	0.00*	−0.01	0.01	−0.01	0.01	−0.01	0.01	−0.01	0.01	−0.01	0.01
Diff	0.03	0.00***	0.03	0.01***	0.03	0.01***	0.03	0.01***	0.03	0.01***	0.03	0.01***
Duration			0.00	0.00			0.00	0.00			0.00	0.00
Size			−0.00	0.01			−0.00	0.01			−0.00	0.01
LocDumSelf					−0.01	0.02	−0.01	0.02				
LocDumExt					−0.03	0.05	−0.03	0.04				
LocInsFirm									0.01	0.01	0.01	0.01
Adj *R*-square	0.13		0.13		0.13		0.12		0.13		0.13	

Notes: * $p < .010$; ** $p < 0.05$; *** $p < 0.01$; values are unstandardized regression coefficients

Table V Models with second transformation (three clusters)

	Model 13		*Model 14*		*Model 15*		*Model 16*		*Model 17*		*Model 18*	
Variable	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*	*n*	*Standard error*
Constant	1.08	0.25**	1.02	0.27**	0.85	0.21**	0.78	0.25**	0.91	0.21**	0.86	0.25**
LocSelf	−0.04	0.03	−0.04	0.03								
Freq	0.08	0.03**	0.08	0.03**	0.08	0.03**	0.08	0.03**	0.08	0.03**	0.08	0.03**
Close	0.06	0.02**	0.07	0.03**	0.07	0.02**	0.07	0.03**	0.06	0.02*	0.06	0.03*
Tacit	−0.03	0.03	−0.03	0.03	−0.03	0.03	−0.03	0.03	−0.03	0.03	−0.04	0.03
Diff	0.17	0.03**	0.17	0.03**	0.18	0.03**	0.18	0.03**	0.17	0.03**	0.17	0.03**
Duration			0.00	0.00			0.00	0.00			0.00	0.00
Size			0.01	0.02			0.01	0.02			0.01	0.02
LocDumSelf					0.02	0.11	0.01	0.11				
LocDumExt					0.28	0.21	0.29	0.22				
LocInsFirm									−0.00	0.03	−0.00	0.03
Adj *R*-square	0.21		0.20		0.21				0.21		0.20	

Notes: * $p < 0.05$; ** $p < 0.01$; values are unstandardized regression coefficients

However, the results of tacitness not showing significant contribution to project performance is consistent with what Sanchez and Heene (1997) have been theorizing. Rather, the results of this study reinforce the idea that the interaction pattern does matter. This reflect the recently highlighted spotlight on ''networking'' by firms, especially among firms that traditionally have been focusing on science and technology and less – if any at all – on human interactions.

Indeed, engineering firms and even schools are now redirecting their energy on management issues to help understand organizational issues as well as interpersonal relationships. In this study, project performance is strongly associated with high frequency and high closeness of the relationship tie. It is interesting to note that the variable of closeness measures psychological distance rather than physical distance or work distance, as one could presume. Even before this new interest in management issues were highlighted, firms have been keen on sending their science workforce to academic and professional conferences to update their knowledge base and even publish their own findings in academic or industry journals. This study shows that these efforts are and have been worthwhile.

Tacitness may play a relatively smaller role in this context, but the conclusion may not be representative. In these days of knowledge management and chief knowledge officers, important knowledge may already have been codified inside the firm, thus alleviating the importance for tacit knowledge transfer. It may also well be that for a well-established firm, the crucial stage is in locating the knowledge. Once the knowledge is located, a well-established firm with enough resources, financial or human, can easily procure the knowledge, either by learning or purchasing it.

It is also interesting to note that there may be industries where tacit knowledge is less important than other industries. For example, a consulting firm may be different from a biotech firm in terms of the importance of tacitness. Consulting firms have been much more oriented towards explicit codification due to the extreme mobility of manpower. These are some vast areas left to be explored by future research.

The reader should also be mindful of the fact that this particular firm where the study takes place is a consulting firm whose primary product is reports. This firm by nature, tradition, and evaluation produces a large number of internal and external reports for internal sharing as well as for clients. While the firm does not have a formal computerized knowledge management system, it has a long history of informal and formal sharing work, data, and methods through an efficient library system. In addition, employees of this firm have a relatively long tenure at the firm, meaning that work of colleagues is well and widely known. Many of both types of reports will find their way to professional journals, where they will be ultimately shared by the entire community. All of this suggests that tacit knowledge plays a less of a role in this firm than in other firms even in the consulting industry.

This implication may sound counter-intuitive initially in view of the mainstream knowledge theory, but the research on search costs may shed some light on this matter. Search costs – the time and money spent locating the best product at the best price – are a familiar and often unwelcome aspect of everyday life. Think of the teeth-gritting experience of driving from dealership to dealership in search of the perfect car. Even with the advent of e-commerce with vast amounts of information readily available, which seemed to predict slashed prices and razor-thin margins, recent studies suggest that the internet's impact on pricing has been less dramatic – especially online – than some may have expected (Kwak, 2001).

This study suggests several implications for management practice. Foremost, it is important to identify and locate knowledge. Because the effects of knowledge flow on project performance appear to be so consistently positive, CEOs and managers must be sure that important firm knowledge is stored and shared in the firm (Kogut and Zander, 1995).

After the mid-1990s, many firms implemented knowledge management systems trying to codify their firm-specific and industry-general knowledge. In their effort to codify their knowledge, most firms fall into the trap of capturing only codifiable knowledge, which may

> **"Instead of an intricate and user-friendly knowledge management system, firms should also invest in more informal employee gatherings such as lunches or outdoor activities."**

be lower in the priority or importance. What they are doing may only exacerbate their competitiveness in the face of imitation and copying by their competitors. By focusing on a formal knowledge management systems, these firms may be missing out on important knowledge accrued by first-hand experience. Instead of an intricate and user-friendly knowledge management system, firms should also invest in more informal employee gathering such as lunches or outdoor activities. Strong ties within and outside of work environment may well bring the high-investment effects of computer system. Overall, CEOs and managers should remember that important knowledge is still carried by the individuals of the firm and try to bring together these individuals to efficiently share their historical knowledge and experience.

Clearly, there are limitations to conclusions that can be drawn from this study. First, and perhaps most importantly, this study identified relationships, not causes. It is possible that something else was going on at the same time as knowledge sharing that led to some or all of the changes noted. For example, there may have been changes in the employee population from which we drew our samples, owing to layoffs and resignations. Respondents for the data collection may have used different psychological frames of reference in conducting the interviews. However, given that the project performance was measured by one person – the top manager responsible for the project – and given that interviews were conducted on a pre-planned survey protocol that underwent several stages of preliminary tests and pre-tests, the confidence in attributing these results to the independent variables is bolstered.

The method of conducting interviews – personal interviews – ensured that all the questions in the survey were completed by the respondents. Also, low response rate is a persistent problem in many survey type studies. Because this study was sanctioned by the head of the firm most managers of one department were included in the study, which made the response rate high, but due to the size of the department, the absolute sample size is still not large. Similarly, the self-reported perceptions of knowledge characteristics, tie strength, and ranking of knowledge elements, could have been cited as a limitation in survey type studies in lieu of objective departmental data.

However, most ''objective'' data such as reports are based on these self-reported publications or reports and are not proofs of absolute objectivity. Moreover, these self-reported perceptions and evaluations on project success offer more information in terms of first-hand experience by the persons in charge of each project. Most objective measures, such as time length, and budget offer very little information because these tend to be intrinsic to the nature of the project and not objective measures of performance. For example, a project involving military weaponry may be big in terms of budget and payment size but not necessarily successful if the project was conducted in an inefficient manner or resulted in wrong conclusions. This is why many aspects of the method in this study – which may be considered a limitation in other survey studies – may end up being strengths.

Since this study is limited to a single firm, this finding can be considered unique to this firm, limited by the ability to measure tacitness. However, because this study was conducted in only one company, conceptual replications in other organizations will be required before concrete conclusions can be drawn. This study used only one firm by design to help eliminate across-firm differences and biases – especially in evaluating project performance. However, the natural extension of this study is to resume the analysis with a broader sample

size, not only across the departments of a firm, but also to include projects from other firms in the same industry as well as other industries. It would be interesting to see if these results carry over to other similar firms in knowledge-intensive industries.

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