

A Psychological Contract Perspective on Social Embeddedness and Knowledge Exchange

by

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## ABSTRACT

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This study examines the role psychological contracts play in the link between workplace relationships and knowledge exchange in organizations. It introduces the construct of *psychological contract of knowledge sharing* – the specific way each team member interprets his/her obligations to share knowledge with other team members. I develop a model of psychological contract of knowledge sharing, bringing together theory from social exchange, social networks and knowledge management. The model is then empirically tested in a field study of work teams in a large, multinational R&D firm. Results of structural equation modeling suggest two important antecedent conditions to psychological contracts of knowledge sharing: *instrumental* and *relational* embeddedness. The findings indicate that psychological contract obligations are positively associated with *knowledge contribution* and *knowledge acquisition* among team members. Building on similar phenomena in previous research, I investigate the mechanism of psychological contracts in the relationship between embeddedness and knowledge exchange by examining the mediating role of psychological contract obligations. This study's implications for research and practice are discussed with respect to emerging issues in contemporary psychological contract theory.

## INTRODUCTION

The goal of this study is to develop and test a theoretical model of psychological contracts of knowledge sharing, investigating psychological contracts as mediators between workplace relationships and knowledge exchange. A *psychological contract of knowledge sharing* is the obligations an individual has to share knowledge with others in the organization. Generally speaking, a psychological contract is the individual's belief about what he/she is entitled to receive and obligated to give in return (Rousseau, 1995). My thesis is that psychological contracts focused upon knowledge sharing activities play a fundamental role in contemporary work groups where access to knowledge plays a central role in group and organizational performance (cf. Guest, 2004; Piccoli & Ives, 2003). As knowledge sharing is shaped by a broad array of social exchanges (Chang & Rousseau, 2005; Molm & Cook, 1995), psychological contracts are a lens through which these social processes are interpreted (Chang, 2005).

Sharing expertise and innovative solutions is critical to competitive advantage for organizations. This sharing allows firms to adapt and reinvent themselves in rapidly changing work environments (Ancona & Caldwell, 1992; Argote, 1999; Nahapiet & Ghoshal, 1998). However, knowledge sharing is difficult. It requires significant exchanges from individuals who carry knowledge as a powerful resource that they, rather than the organization, control (Davenport & Prusak, 1998). Individuals engaged in knowledge sharing behaviors have to sacrifice their time and effort to communicate knowledge to another. They can fear loss of control and exclusivity. Sharing may make their expertise less special and valued. Thus, organizations have to motivate individuals to share knowledge with their co-workers. Frequent interactions between individuals help

firms to create and institutionalize knowledge beyond that held by any one individual (Nonaka & Takeuchi, 1995).

As knowledge sharing is essential to organizational flexibility, teams characterized by geographic dispersion and electronic interdependence (i.e., distributed teams) are formed to integrate the expertise of individuals who are not necessarily located near one another (Gibson & Gibbs, 2006; Hinds & Mortensen, 2005). Distributed teams often face difficulties in sharing knowledge successfully (Cramton, 2001). For example, knowledge sharing usually takes place through communication technologies that mask social cues, body language and other interpersonal aspects of traditional face-to-face teams (Daft & Lengel, 1986; DeSanctis & Poole, 1994; Siegel et al., 1986). Working from different geographical locations, team members have fewer opportunities for informal contact, an important factor in creating mutual understanding (Cramton, 2001). The availability of communication technologies is no guarantee that knowledge sharing will actually take place (Orlikowski, 2002). Moreover, norms of interpersonal support are difficult to enforce, especially at a distance. Knowledge seekers have less control over who will respond to their questions. Knowledge contributors lack assurance that those they are helping will return the favor. To address these challenges, past research has examined how interpersonal relationships can enhance knowledge sharing behaviors among individuals.

Previous studies on social networks examine social ties as conduits for the flow of interpersonal resources (Nahapiet & Ghoshal, 1998). The interconnectedness of individuals in social networks can be examined in terms of social embeddedness (Granovetter, 1985). *Social embeddedness* refers to the extent to which interactions are

shaped by norms of social exchange (Uzzi, 1997). Embeddedness in strong social ties results in increased reciprocity and obligations (Granovetter, 1985; Uzzi, 1997) that may facilitate knowledge sharing (Wasko & Faraj, 2005). Several recent studies have linked social ties to knowledge sharing (e.g., Hansen, 1999; Borgatti & Cross, 2003). However, most of them focus on empirical observations regarding network ties (e.g., strength of tie, number of ties) and do not provide a theoretical explanation for the effects. Although interconnectedness can be examined from other perspectives (e.g., structural mechanisms), social embeddedness delineates relationships shaped by exchange norms, and reflects the interconnectedness of these relationships. Hence, embeddedness is more appropriate in the investigation of workplace relationships and social ties.

Understanding the beliefs and obligations of individuals may help to open the "black box" between social ties and willingness of team members to share. It can provide insights into the motivation underlying knowledge sharing processes. Psychological contracts of knowledge sharing provide a mechanism for knowledge exchange by creating obligations in anticipation of future benefits. Although the importance of psychological contracts on knowledge sharing in distributed teams has been suggested by others (e.g., Guest, 2004; Piccoli & Ives, 2003), primary research in this area is still lacking.

Personal obligations to share knowledge constitute an individual's psychological contract of knowledge sharing. Previous studies have examined various forms of these obligations (Molm & Cook, 1995). These include negotiated agreements (e.g., "I will share my results with you if you will share yours with me") and reciprocal commitments (e.g., "I will share my results with you because we have a relationship of unconditionally

helping each other”). Individuals may feel obligated to share knowledge because of beliefs regarding the nature of their relationship with others. For instance, individuals can develop reciprocal commitments to share knowledge with close friends and others whom they trust (Nahapiet & Ghoshal, 1998), or negotiate for help from others who ‘owe’ them favors (Flynn, 2005). At present, however, empirical work linking social ties to knowledge sharing by investigating psychological contracts is still in its infancy.

In a previous study, Chang and Rousseau (2005) examined social exchanges and knowledge sharing behavior. They found that strong social ties led to greater knowledge exchange as a result of reciprocal exchanges (i.e., where expectations of future returns were implicit between both parties). In contrast, weak social ties promote greater knowledge exchange as a result of negotiated exchanges (i.e., parties explicitly specify what they will do for each other). A follow-up study by Chang, Rousseau and Lai (2007) further differentiated the social relationships involved in knowledge exchange. Using advice and trust ties to differentiate forms of social ties, Chang and colleagues argued that these social ties in themselves motivated knowledge exchange via the knowledge sharing obligations the ties created between co-workers. Findings confirmed that advice (i.e., instrumental) and trust (i.e., relational) components of social ties influenced individual obligations to share. These obligations in turn mediated the relationships between social ties and knowledge exchange, i.e., they explained why social ties led to knowledge exchange.

Based on theoretical foundations and empirical work on psychological contracts, the present research extends the two aforementioned studies. It addresses an important explanation for individuals’ willingness to share knowledge - the set of knowledge

sharing obligations that individuals are party to. The critical question is: Does the social network of team members lead to different forms of knowledge sharing obligations? Do these different obligations regulate and motivate knowledge exchange in different ways? Specifically, at this novel intersection of the psychological contracts and knowledge sharing literatures, three research questions are pertinent:

- (1) What forms of psychological contract obligations impact knowledge exchange among individuals in teams?
- (2) Are psychological contracts of knowledge sharing influenced by social embeddedness of individuals in teams? If so, how?
- (3) Do psychological contracts of knowledge sharing provide an intervening mechanism (i.e., mediating) to account for the effects of social embeddedness on knowledge exchange?

## **THEORETICAL BACKGROUND**

### **Psychological Contract Theory**

Psychological contract theory provides an analytic framework for investigating and managing the employment relationship (Rousseau, 1995; Coyle-Shapiro & Kessler, 2000; Guest, 2004). Psychological contracts function as forms of schemas, i.e., cognitive structures that organize information (Morrison & Robinson, 1997; Rousseau, 1995). In the present case, psychological contracts refer to cognitive models regarding whether, when, and how to seek and provide knowledge among co-workers. They incorporate implicit understandings and beliefs in obligations that go beyond explicit economic and legal aspects (MacNeil, 1985; Morrison & Robinson, 1997). A psychological contract

perspective offers an inclusive view of knowledge sharing obligations by examining work relationships between all parties involved in the knowledge exchange.

Workplace relationships are often pluralistic, i.e., exchange partners can include team members, superiors, subordinates, formal departments such as the human resources, or the organization as a whole. Thus, psychological contracts can exist between many parties, including co-workers (Chang, Rousseau & Lai, 2007; Galvin, McKinney & Chudoba, 2005), employer-employee (Rousseau & Tijoriwala, 1999), buyer-seller (Pavlou & Gefen, 2005) and customer-supplier (Koh, Ang, & Straub, 2004). The focus in the present study is the psychological contracts among individual co-workers. Co-workers play a pivotal role in the assessment of knowledge exchange because they act as social referents to individuals. Similar to the contract between an employer and employee, knowledge exchange involves a psychological contract comprising a set of obligations between co-workers. This contract is important in determining whether or not knowledge sharing occurs between co-workers. I assert that it is these obligations that drive individual knowledge exchange behaviors with co-workers.

The literature on psychological contracts offers a useful starting point for the investigation of knowledge exchange. First, it does so because breach of a psychological contract, such as violation of an agreement to exchange knowledge, has been empirically linked to lower levels of knowledge sharing (Omar, 2004). Employees who experienced a contract violation shared less knowledge with others than did those who perceived no violation. Second, in the context of distributed teams, the fulfillment of psychological contracts has been used to explain trust behaviors (Piccoli & Ives, 2003) and team formation (Galvin, McKinney & Chudoba, 2005). Third, psychological contracts provide



a basis for identifying an array of knowledge sharing obligations that arise in social settings. The obligations can vary from simple discrete categories (e.g., sharing of a piece of information with the promise of rewards upon project completion) to complex categories (e.g., knowledge exchange relations consisting of interrelated obligations). These categories can run the gamut of obligations from those arising in limited social situations to those in highly embedded ones. Developing a classification scheme for psychological contracts of knowledge sharing can aid understanding of the linkage between embeddedness and knowledge sharing.

### **Classifications of Psychological Contracts of Knowledge Sharing**

Since knowledge sharing is a form of social exchange, I infer that individuals establish and continue the exchange of expertise and resources in anticipation of some mutual benefit. To examine individual obligations to share, I propose a framework that characterizes the typical obligations associated with knowledge sharing. In this research, a 2 x 2 matrix with two psychological contract dimensions is used to identify specific obligations and classify them into general categories useful for understanding knowledge exchange. This framework builds upon prior organizational studies for determining relevant sources and recipients of knowledge. Its categories of knowledge-sharing psychological contracts form the basis for developing this study's research model and hypotheses.

Using a social exchange perspective, this study examines the obligations from an actor to a target. Knowledge sharing obligations can be conceptualized in terms of (1) *forms of social exchange* (explicit vs. implicit) and (2) *knowledge recipient* (team vs.

organization). The two dimensions yield a four-fold classification of knowledge sharing obligations. Building on existing assessments of employee obligations (e.g., Rousseau, 1995; De Vos, Buyens & Schalk, 2003), I discern the following categories of knowledge sharing obligations: (1) reciprocal local, (2) reciprocal global, (3) negotiated local, and (4) negotiated global. These obligations are distinguished from one another by three features: (a) nature of reciprocity (whether expectations for returns are explicitly stated or loosely defined), (b) type of reciprocity (whether returns are directly made by the recipient of the knowledge exchange, or indirectly by someone else), and (c) motive (whether a team member exchanges knowledge out of self interest or group interest). Table 1 presents a brief description of each content area with respect to the forms of social exchange and knowledge recipients. These obligations are explained in the next section.

--- insert Table 1 about here ---

### **Forms of Knowledge Sharing Obligations**

Knowledge sharing obligations arise via social exchange (Chang & Rousseau, 2005; Chang, 2005), that is, voluntary actions of individuals motivated by the returns anticipated from others (Blau, 1964; Homans, 1961). Studies on knowledge exchange underscore the importance of distinguishing between obligations to individuals in the immediate team (referred to as the *local* target in this study) and obligations to individuals external to the team (referred to as the *global* target in this study). This distinction is not new since research has demonstrated that members seek from and contribute to sources of knowledge both internal and external to the team (e.g., Ancona

and Caldwell, 1992). Although knowledge exchange within the team builds shared understanding and aligns collective actions (Senge, 1990), knowledge exchange with external individuals acquires and develops knowledge that is novel to the team (Hansen, 1999; Sutton and Hargadon, 1996).

Knowledge sharing obligations can take two basic forms of social exchange (Flynn, 2005): explicit and implicit. These two forms differ in terms of the nature and timing of reciprocation. The explicit form of social exchange, a *negotiated exchange*, occurs when the nature and timing of reciprocation are openly discussed. In such a case, the benefits of giving and receiving knowledge resources are often immediate (Molm & Cook, 1995). Negotiated exchanges are defined by the voluntary actions of individuals motivated by the specific anticipated returns from these actions (Cardona et al., 2004). The terms of negotiated exchanges are direct and simultaneously stated. Negotiated exchanges have been examined in the context of economic transactions (e.g., Bazerman et al., 2000) as well as social exchanges (Flynn, 2003) wherever risks and uncertainty are minimized due to explicit bargaining. Both parties focus on tangible benefits anticipated from the exchange (e.g., access to new information, career advancement), rather than the socio-emotional rewards (e.g., friendship and positive affect).

*Negotiated local* obligations are built on explicit bargained-for exchanges between two members of the same team. For instance, in the knowledge sharing context, two team members may explicitly agree to exchange information (“I’ll give you the solutions next week if you give me your solutions for this week”). In this example, there are low costs of exchange to the contributor since the expectation of direct reciprocation is clear. *Negotiated global* obligations are built on negotiated exchanges among two or

more people not part of the same team. These obligations include sharing knowledge with one person while anticipating reciprocity by a third party, not necessarily the recipient (Molm & Cook, 1995). Team members may engage in social exchange with unfamiliar or unaffiliated others. In this case, the contributor can anticipate subsequent exchanges, though not necessarily from any specific person.

The implicit form of social exchange, or *reciprocal exchange*, occurs when the nature and timing of reciprocity are not explicit, and the benefits of giving and receiving knowledge resources are not immediate (Emerson, 1976). Group norms to regulate exchange, in particular, the norms of reciprocity, reinforce tendencies towards balance inherent in social interactions (Blau, 1964). This balance ensures that the terms of each exchange are reciprocated in some fashion without bargaining for payback. Instead, exchange is sustained via norms of reciprocity. Social rewards (e.g., improved reputation), rather than the tangible benefits via particular transactions, are valued.

*Reciprocal local* obligations are built on reciprocal exchanges between two parties who are members of the same team. For instance, two team members may develop the habit of acquiring knowledge from each other via favor exchange over time (Flynn 2005). Frequent reciprocal exchanges have been found to increase knowledge sharing (Chang & Rousseau, 2005). When members feel obligated to share knowledge as they perceive it will help another team member, they will offer to do so (e.g., providing a piece of critical information) without knowing when, whether, or to what extent the other members will reciprocate (Bordia et al., 2004). Benefits can be high as the increased frequency of exchange may foster stronger bonds of attachment and greater direct reciprocation over time.

*Reciprocal global* obligations are built on reciprocal exchanges among two or more people who are outside of the team. A person may provide a benefit to an external person who may reciprocate indirectly by benefiting another member in the community. In this case, the nature and timing of reciprocity is not explicit. Reciprocal obligations have been investigated primarily in terms of generalized forms of social exchange and found them to be associated with the obligations and norms of sharing (e.g., Wasko & Faraj, 2005). The notion of generalized reciprocity suggests that individuals help others as a result of a broad norm of reciprocity, where obtaining future returns from others is only one exchange benefit. Receiving payback can be less important than being a supportive member of the community.

### **Social Embeddedness as a Function of Instrumental and Relational Ties**

Social embeddedness consists of instrumental and relational components that regulate the behaviors of team members (Lazer & Katz, 2007). *Instrumental embeddedness* refers to the degree to which social exchanges take place through advice relationships using exchange protocols associated with task-oriented goals. It represents the work role of an individual, and captures task relationships such as advice seeking (Katz et al., 2004). In particular, individuals have greater accountability and more obligations when they shared more instrumental ties with team members. When many go to an individual for work-related advice, that individual is said to be prominent, central or high on instrumental embeddedness.

*Relational embeddedness* refers to extent to which an individual has affective ties to other members within the team. It represents the quality of social ties within the

network (Granovetter, 1985; Nahapiet & Ghoshal, 1998). Unlike instrumental embeddedness, which focuses on self- interested or goal-oriented relationships among team members, relational embeddedness reflects the affective nature of ties, including a sense of trust and belongingness (Jones et al., 1997; Wasko & Faraj, 2005).

Consequently, relational ties increase the level of trust between the parties, i.e., the “intention to accept vulnerability based upon positive expectations of the behavior of another” (Mayer et al., 1995; Rousseau et al., 1998). Since knowledge exchange is subject to risk and uncertainty, it is not generally amenable to enforcement by economic contract (Omar, 2004). As a result, knowledge sharing parties must rely upon their trust ties with the other party throughout the exchange (Carlile & Reberntsch, 2003).

The integration of these two bases (instrumental and relational embeddedness) for knowledge exchange is warranted because of their connection with social exchange theory and anticipated future rewards. Although each perspective is important, instrumental and relational embeddedness, by themselves, provide only incomplete explanation of the origins of knowledge sharing obligations. Examining both bases helps to illuminate elements that have not received sufficient emphasis in each perspective.

## **RESEARCH MODEL AND HYPOTHESES**

### **Instrumental Embeddedness and Psychological Contracts**

I develop testable hypotheses based upon the framework specified above. From a social exchange perspective, we would expect a co-worker whose advice is sought after by many other co-workers to adopt a more task-oriented view of knowledge exchange relationships with others. Strong instrumental advice ties between individuals generate

social obligations to help members within the team (Umphress et al., 2003; Cardona et al., 2004). In a previous study, individuals with high expertise, i.e., many people come to them for advice, have reported greater obligations to provide useful knowledge (Constant et al., 1996). Conversely, individuals are less likely to share when they believe their own expertise is inadequate (Wasko & Faraj, 2005).

Earlier work on advice ties has focused on knowledge sharing obligations by examining local social exchanges (Brandes et al., 2004). A team member may develop negotiated local obligations as such obligations reduce risk and uncertainty in an exchange relation with a specific partner (Klein, 1993). Individuals who give advice often develop negotiated obligations to reduce the level of unreciprocated contribution involved in the exchange (Flynn, 2003). For example, a team member in a central advisory role is more likely to create explicit obligations to ensure the benefits of each transaction and to monitor the repayment of the exchanged resources. Thus, I predict that the more individuals are instrumentally embedded in their teams, the greater negotiated obligations they have to their team members (local target).

**H1a: *Instrumental embeddedness* of a member will be positively associated with negotiated local obligations of knowledge sharing.**

Although communication technologies can be helpful to support knowledge exchange among distributed team members, issues of uncertainty and risk are difficult to address in knowledge exchange with other people in the organization (global target). Individuals who frequently provide advice to team members can hold more explicit expectations of exchanges with others outside the team. They perceive an obligation to share as they want to remain an instrumental person in the organizational network

(Brandes et al., 2004). However, obligations to the global target are often negotiated to minimize risk (e.g., non-reciprocation or delayed payback) (Flynn, 2005). Previous studies have found that individuals with strong ties to local members also develop obligations to other organizational members as they expect the organization to recognize and reward their efforts (Eisenberger et al., 2001). Thus, I predict:

**H1b: *Instrumental embeddedness* of a member will be positively associated with negotiated global obligations of knowledge sharing.**

### **Relational Embeddedness and Psychological Contracts**

Research evidence has highlighted the value of affective relationships between individuals in promoting knowledge exchange (e.g., Ardichvilli et al., 2003; Piccoli & Ives, 2003; Constant et al., 1994; Cross & Cummings, 2004). Trust increases knowledge exchange (e.g., O'Reilly & Roberts, 1974; Smith & Barclay, 1997) and facilitates the exchange of valued resources through norms that encourage cooperation (Krackhardt, 1999). Becker et al. (1996) found that trust in a local group of individuals (e.g., between team members) was more important in influencing performance than trust in a global group (e.g., between non team members in an organization).

Extending this evidence to the knowledge sharing domain, strong relational ties between team members will be important in predicting one's obligations to local co-workers (Chang, 2005). Individuals who have greater trust ties with others are less likely to demand immediate repayment (Culnan & Armstrong, 1999). They trust their team members to reciprocate in future, even if the value and timing of the reciprocation are unclear (Jarvenpaa & Staples, 2001). Reciprocity exerts its influence via "feelings of



obligations to return another's favor, and these feelings occur automatically regardless of whether the favor is requested" (Paese & Gilin, 2000). Thus, I predict that an individual's relational embeddedness is positively related to reciprocal obligations to local members.

***H2a: Relational embeddedness of a member will be positively associated with reciprocal local obligations of knowledge sharing.***

Conversely, reciprocal global obligation involves a norm of unilateral giving without direct reciprocation (Bearman, 1997). Prior work on global social exchange has focused on generalized exchanges (e.g., Flynn, 2005). Individuals who trust many others tend to provide more help, even to people outside the team (Leana & Van Buren, 1999). In electronic social networks, people with strong trust ties tend to contribute knowledge due to the perceived obligation to repay the benefits they had received (Wasko & Faraj, 2005). The social exchange theory postulates that if support is received from others then they must be compensated, and that the greater the support received the greater the subsequent compensation (Gouldner, 1960). This need to reciprocate is like a moral obligation (Greenberg, 1980). It may be extended to a larger community, such as other groups of individuals in the organization. Thus, I predict:

***H2b: Relational embeddedness of a member will be positively associated with reciprocal global obligations of knowledge sharing.***

### **Psychological Contracts and Knowledge Exchange**

Knowledge exchange is defined here as the contribution and acquisition of task information and know-how regarding a procedure or product (Wathne, Roos and von Krogh, 1996). It consists of activities carried out between team members to obtain and

process information that will enable them to learn and improve their work (Cummings, 2004), e.g., sharing feedback and discussing problems (Cross & Cummings, 2004). Although individuals incur tangible costs (e.g. time and effort to share information), perceived obligations (i.e. psychological contracts) help them interpret actions and respond accordingly (Paese & Gilin, 2000).

Both negotiated local and negotiated global obligations involve social exchanges with expectations of future extrinsic benefits to the contributor (Molm et al., 1999). Hence, negotiated knowledge sharing can occur because it benefits each party in doing their job (Culnan & Armstrong, 1999). Moreover, team members with negotiated obligations experience less risk of unreciprocated contributions (Chang & Rousseau, 2005). Thus, I hypothesize:

**H3a: Negotiated local obligations of knowledge sharing will be positively associated with *knowledge exchange*.**

**H3b: Negotiated global obligations of knowledge sharing will be positively associated with *knowledge exchange*.**

In previous studies on psychological contracts, researchers have found that employees reciprocate what they receive from the organization (e.g., salary, support) with their contributions (e.g., commitment and job performance), depending on how well they perceive the organization was meeting its contractual obligations to them (Robinson & Morrison, 1995). Among co-workers, greater reciprocal obligations increase knowledge sharing between the contributor and the recipients (Bordia et al., 2004). When an individual feels that a co-worker has failed to meet the obligations, this feeling of violation of psychological contract may lead the employee to withhold individual

knowledge and not engage in knowledge exchange. Thus, I suggest that employees not only differentiate between different kinds of obligations, but also share knowledge to different extent when reciprocating different sources of support. Reciprocal obligations of individuals to both the local and global targets drive actual knowledge exchange because they form intent, create personal goals, and generate commitments that can be enforced based on norms of reciprocity (Settoon et al., 1996).

**H3c: Reciprocal local obligations of knowledge sharing will be positively associated with *knowledge exchange*.**

**H3d: Reciprocal global obligations of knowledge sharing will be positively associated with *knowledge exchange*.**

In summary, the research model of psychological contracts of knowledge sharing, social embeddedness, and knowledge exchange is depicted in Figure 1.

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## METHODOLOGY

### Sample

An R&D unit in a large global high-technology firm served as the research site for this study. This firm developed integrated software solutions (e.g., commercial printing, imaging and scanning software) for other divisions of the firm and external clients. The site involved software development teams with a total of 252 individuals. The R&D unit comprised of 36 time-limited cross-functional project teams in different geographical regions, including San Diego, Vancouver, Bristol, Haifa, and Bangalore (see Appendix A). The teams were made up of software developers, technical leaders, supervisors and

project managers. The majority of team members were software engineers and computer scientists, holding university degrees. Knowledge sharing was critical for project success because the teams were created to generate integrated solutions based on an array of individual expertise. The study was approved by senior management, and the firm was willing to participate in this research to obtain feedback on how well their teams were working. Permission was sought from the Institutional Review Boards (IRB) to conduct this research.

## **Procedures**

First, in semi-structured interviews, key managers provided information on their team's goals, tasks and names of members, the activities that members carried out with people within and outside the team, how the team organized its work, and the challenges it faced. The general questions provided factual descriptions and examples of knowledge sharing behavior. These included sharing best practices, transferring know-how of product tools, and exchanging organizational resources.

Next, a web-based survey was developed incorporating information from these interviews. It was piloted tested on twenty-three employees from the R&D organization who were not included in the actual survey. Minor changes were made to the wording of some obligations so that they were applicable to all employees. The final list of knowledge sharing obligations included 20 items, with five in each of the four cells presented in Table 1.

The formal study was then conducted using the web-based survey administered to the remaining R&D organization members. A follow-up web-based survey containing the

same items was administered one month *after* the first survey. I also collected additional archival information such as messages on electronic forums and documents in online repositories that were contributed and retrieved by the respondents for the entire month after the administration of the first survey. Given the importance of contextualization, the knowledge sharing obligations reflect the types of activities characteristic of the organization being studied (Rousseau & Tijoriwala, 1999; Ho & Lesvesque, 2005). I developed survey items using the modified empathetic strategy (Alderfer & Brown, 1972), i.e., in a language that was meaningful to the respondents. Appendix B lists the questionnaire items used to measure each construct. Respondents were assured that individual responses would be held in strict confidence. Feedback of results to the management was provided in summarized form.

## **Measures**

To assure that the instrument was valid both in this setting and on a broader scale, I used a combination of the results of the interviews and pre-existing standardized scales to derive the measures used in this study. The online questionnaire combined structured and open-ended questions to measure respondents' perceptions on knowledge exchange, obligations and social networks. The survey items included measures at the network level (instrumental network, relational network, knowledge contribution, and knowledge acquisition), at the individual level (knowledge sharing obligations, demographic information) and at the team level (team performance and other alternative measures). Appendix B contains a summary of the survey items and the measures for each construct in the research model.

*Network variables.* Each participant was presented with a list of members from their own team in the web-based survey, and asked to indicate their work relationships with each person. I used two items as measures of *instrumental* and *relational* networks respectively. For each of these networks, I constructed individual-level measures of *instrumental* and *relational embeddedness*.

*Instrumental embeddedness* was operationalized as the ratio of actual individual advice ties to others within the team to total possible ties. Participants indicated the extent to which they went to each team member for advice or help concerning the project on a 5-point Likert scale (1=not at all, 5=to a great extent). I computed the in-degree score for each individual, i.e., advice relations that other team members reported with that individual. Instrumental embeddedness reflects the ratio of in-degree score to total possible ties. A high score indicated that an individual was instrumentally embedded in the overall network. Out-degree scores, i.e., relations that an individual reported with other team members were also computed for additional comparisons with the in-degree scores.

*Relational embeddedness* was operationalized as the ratio of actual individual relational ties others within the team to total possible ties. Participants indicated the extent to which they trusted each member with matters that were important to them on a 5-point Likert scale (1=not at all, 5=to a great extent). I computed the out-degree score for each individual. Relational embeddedness reflects the ratio of out-degree score to total possible ties. A high score indicated that an individual was relationally embedded in the overall network. Similarly, in-degree scores were also computed for additional comparative analyses.

*Psychological contracts of knowledge sharing.* Four aspects of knowledge sharing obligations were adapted from the interviews and from previous studies (Chang & Rousseau, 2005). *Reciprocal local obligations* describe the extent to which members make implicit commitments or obligations to share knowledge with their team members (e.g., “I feel obligated to contribute information beneficial to the team because I believe my team members will contribute in the same manner”). *Reciprocal global obligations* describe the extent to which members make implicit commitments or obligations to share knowledge with people outside their team (e.g., “I feel obligated to contribute information beneficial to people outside my team because I believe they will contribute in the same manner”). *Negotiated local obligations* describe the extent to which members make explicit commitments or obligations to share knowledge with their team members (e.g., “I feel obligated to contribute information to my team because we have explicitly agreed upon sharing the information that I need in return”). *Negotiated global obligations* describe the extent to which members make explicit commitments or obligations to share knowledge with people outside their team (e.g., “I feel obligated to contribute information to people outside my team because they have explicitly agreed upon sharing information I need in return”).

*Knowledge exchange.* Measures created by Borgatti and Cross (2003) and Cross and Cummings (2004) were adapted to assess knowledge contribution and knowledge acquisition. Since knowledge can be intangible and hard to observe or measure (Ancona & Caldwell, 1992), an individual’s perception of whether he/she has acquired knowledge from or contributed knowledge to others is a relevant indicator of knowledge exchange. For *knowledge contribution*, I asked the respondents to rate the extent to which they

contributed knowledge to each member that enabled him/her to perform tasks and develop new insights (1=not at all; 5=to a great extent). For *knowledge acquisition*, I asked the respondents to rate the extent to which they acquired knowledge from each member that enabled them to perform tasks and develop new insights (1=not at all; 5=to a great extent).

Additional measures of knowledge exchange were collected for corroboration of findings. First, I examined the volume of messages retrieved and contributed by each respondent in the organizational electronic forums (i.e., a centralized computer system where each employee can post work-related messages and retrieve messages contributed by other employees). I recorded the total number of archived messages within a month from the day of administering the first survey that was posted and retrieved by each respondent respectively. These messages contained work solutions such as software programming codes and pointers to resources useful for software development. Second, I examined the number of documents that each employee retrieved and contributed via the online repositories (i.e., a shared computer folder that each employee has access to). I computed from the organization's archived log files the total number of documents that were posted and retrieved by each employee, respectively, for the whole month following the administration of the first survey. These documents contained task-related information and work flow processes of the teams.

*Control variables.* To control for possible alternative explanations of observed effects, seven control variables were taken into account: gender, age, organizational tenure, prior work experience, employment status, task interdependence and geographical distance. Demographic characteristics such as gender and age were controlled because



previous research has shown that males and females differ in communication patterns that could generate a different mechanism by which psychological contracts would affect perceptions and behavior of individuals. Gender was included as a dummy variable (“0” = female; “1” = male). Age was operationalized in terms of years.

Organizational tenure and prior work experience were controlled because individuals with similar beliefs might be attracted and selected into the organization and tend to remain in the organization longer than those with different beliefs. Organizational tenure was operationalized as the actual number of years with this organization. Prior work experience was operationalized as the actual number of years worked prior to joining the organization. Employment status (e.g., part-time vs. full-time) can impact perceived obligations and was controlled. This control variable was dichotomized as “0” where team members were part-time and “1” where team members were full time.

I also controlled for the possibility that task interdependence and geographical distance might affect the relationship between social ties and perceptions of obligations. Knowledge exchange might occur as a result of work interdependence as individuals rely on other team members for knowledge based on formal work structures. Task interdependence was measured by adapting scales from Campion et al. (1993). Similarly, individuals who were located in close proximity might exchange knowledge more frequently than those who are separated by geographical and time zones. Geographical distance between an individual and other people was measured using the distance index (Cross & Cummings, 2004).

## Analyses

In the exploratory data analyses, network correlations were used to examine dyadic relationships between each social network. As network data observations are not independent, the Quadratic Assignment Procedure (QAP) (Baker & Hubert, 1981; Krackhardt, 1988) was used to run the correlations and multiple regressions. QAP analyses have been shown to remain unbiased as compared with ordinary least squares (e.g., Krackhardt, 1988).

To analyze hypotheses partial least squares (PLS) (Barclay et al., 1995), a structural equation modeling (SEM) technique was used. It helps to assess the reliability and validity of the measures of theoretical constructs, and to determine the relationships between these constructs. PLS method was used because the multi-item reflective indicators could be included in the research model to analyze the endogenous constructs (Chin, 1998). In addition, the direct and mediating effects of the variables could be examined together. The minimum sample size criterion was satisfied, i.e. 10 times the number of paths going into the endogenous constructs with the most paths (Chin, 1998).

The SEM process using PLS consists of two parts: analyzing the *measurement* model, and analyzing the *structural* model. The measurement model assesses reliability and validity of the measures in the research model, and the structural model examines path coefficients and hypothesized relationships between the variables. I used the software PLS-Graph to estimate and interpret the measurement and structural parameters. In testing the theoretical model, I fitted several nested models to the data, each model incorporating different assumptions regarding model parameters. Comparisons with

alternative models were conducted to show whether a hypothesized model is the best representation of the data, an important part of assessing the model fit.

## **RESULTS**

### **Preliminary Analyses**

At the network level, descriptive statistics and correlations of each network variable (instrumental ties, relational ties, knowledge contribution, knowledge acquisition) were examined. Table 2 reports the means, standard deviations, range of values for the binary tie (0=no tie between each dyad; 1=a tie existed, with the tie being dichotomized at the level of “to some extent” and “to a great extent”), as well as correlations of the network-level variables.

--- insert Table 2 about here ---

The descriptive statistics and correlations of the individual-level and control variables are reported in Table 3. To ensure that the instrumental and relational embeddedness measures are reliable and valid, I conducted a principal components analysis with varimax rotation using the social embeddedness indices for instrumental and relational network measures. Two factors, explaining 88% of the variance in the network measures, had eigenvalues greater than 1.0. The instrumental and relational items indicated high loadings on each factor, therefore demonstrating convergent and discriminant validity (see Table 4).

--- insert Table 3 about here ---

## **Measurement Model**

In analyzing the measurement model, a table of internal consistency values for each construct in the research model is generated using a formula by Fornell and Larcker (1981). A value of 0.7 would indicate that the construct is reliable. In addition, the square root of the average variance for each construct is verified to determine if it is larger than any of the intercorrelations between the latent variables (Barclay et al., 1995). To ensure that discriminant validity exists, the loadings of each individual item are examined. The results of the measurement model (Factor Loadings, Internal Consistency, Cronbach Alpha and Average Variance Extracted) are presented in Table 4.

--- insert Table 4 about here ---

## **Structural Model**

After evaluating the adequacy of the measurement model, the structural model is analyzed using two methods: Analyzing the strength of the hypothesized relationships between the constructs, and assessing the predictive power of the model for each group by looking at the R-square values on the endogenous variables. It is then possible to calculate the path coefficients from the PLS analyses and the related hypotheses, and t-values for each path obtained through bootstrapping. The t-values would indicate the significance of the direct or mediating effect as described in the hypotheses. The path coefficients and t-values for the hypothesized relation are presented in Table 5.

--- insert Table 5 about here ---

## Comparisons with Alternative Models

The hypothesized model has good statistical fit ( $\chi^2 = 190.33$ ,  $p < .01$ , root mean square error of approximation RMSEA = .05, adjusted goodness-of-fit index AGFI = .91, normed fit index NFI = .93 and comparative fit index CFI = .94). Next, it was compared with a series of nested models using the change in chi-square test. In the first comparison, the alternative model specified only the direct paths from the control variables to the knowledge exchange variables. The results showed that the hypothesized model provided a significantly better fit than did the control-variables-only model ( $\Delta\chi^2 = -479.25$ ,  $p < .01$ ). In the second comparison, the hypothesized model was compared with the partially mediated model, which specified paths in the hypothesized model as well as the direct paths from the social embeddedness constructs (instrumental and relational) to the knowledge exchange constructs. The change in chi-square test showed that this alternative model was significantly better than the hypothesized model ( $\Delta\chi^2 = 27.34$ ,  $p < .01$ ). I also compared the hypothesized model with the non-mediated model. In the non-mediated model, the paths from psychological contract obligations (reciprocal and negotiated) to knowledge exchange were constrained to zero, but the paths from social embeddedness to knowledge exchange were freely estimated. As the non-mediated model was nested within the partially mediated model, it was compared to the partially mediated model. This alternative model was not significantly better than the partially mediated model ( $\Delta\chi^2 = -142.67$ ,  $p < .01$ ).

The nested model comparisons indicated that the model including the hypothesized effects and direct effects from social embeddedness to knowledge exchange (partially mediated model) was the best fitting and most parsimonious model

( $\chi^2 = 168.63$ ,  $p < .01$ ,  $RMSEA = .05$ ,  $AGFI = .92$ ,  $NFI = .91$  and  $CFI = .95$ ). Thus, I retained this model as the best-fitting model and interpret it in order to examine the hypothesized relationships.

### **Hypothesized Model**

Examining the standardized parameter estimates indicated that 11 of the 12 hypothesized relationships were significant and in the predicted directions when the control variables were accounted for (see Table 5). First, Hypotheses 1a and 1b positively relate instrumental embeddedness to negotiated local and negotiated global obligations respectively. A statistically significant parameter estimate (“b”) was found for the path between instrumental embeddedness and negotiated local obligation ( $b = .27$ ,  $p < .01$ ). The estimated path between instrumental embeddedness and negotiated global obligation was not significant. Thus, support was indicated for Hypothesis 1a but not for Hypothesis 1b.

Hypotheses 2a and 2b positively associate relational embeddedness and reciprocal local and reciprocal global obligations respectively. A statistically significant parameter estimate was found for the path from relational embeddedness to reciprocal local obligation ( $b = .33$ ,  $p < .01$ ), and for the path from relational embeddedness to reciprocal global obligation ( $b = .26$ ,  $p < .01$ ). The results indicated support for both hypotheses associating relational embeddedness and reciprocal obligations.

Hypotheses 3a and 3b positively relate negotiated local and global obligations to knowledge exchange. Respondents who indicated greater negotiated local obligations had greater knowledge contribution ( $b = .28$ ,  $p < .01$ ) and knowledge acquisition ( $b = .25$ ,  $p < .01$ ). Respondents who indicated greater negotiated global obligations had greater knowledge

contribution ( $b=.30, p<.01$ ) and knowledge acquisition ( $b=.26, p<.01$ ). Thus, the results indicated support for Hypotheses 3a and 3b. Hypotheses 3c and 3d positively relate reciprocal local and global obligations to knowledge exchange. Respondents who indicated greater reciprocal local obligations had greater knowledge contribution ( $b=.24, p<.01$ ) and knowledge acquisition ( $b=.16, p<.05$ ). Respondents who indicated greater reciprocal global obligations had greater knowledge contribution ( $b=.28, p<.01$ ) and knowledge acquisition ( $b=.29, p<.01$ ). All the parameter estimates were statistically significant. Thus, the results indicated support for Hypotheses 3c and 3d.

Although not hypothesized, there were four other significant path estimates pertaining to social embeddedness and knowledge exchange in the partially mediated model. Significant positive parameter estimates were found for the path from instrumental embeddedness to knowledge contribution ( $b=.23, p<.01$ ), and for the path from relational embeddedness to knowledge acquisition ( $b=.15, p<.05$ ). A significant, positive parameter estimate was found for the path from instrumental embeddedness to reciprocal global obligation. Respondents with greater instrumental embeddedness reported greater reciprocal global obligation ( $b=.25, p<.01$ ). A significant, negative parameter estimate was found for the path from relational embeddedness and negotiated local obligation. Respondents with greater relational embeddedness reported lower negotiated local obligations ( $b=-.21, p<.01$ ).

Supplementary analyses were conducted where additional team and task variables were added in the correlation and regression analyses. Consistent with previous findings in the literature, instrumental embeddedness was predicted by task interdependence ( $b=.14, p<.05$ ) and team diversity ( $b=.16, p<.05$ ). However, psychological contract

obligations (negotiated and reciprocal obligations) and knowledge exchange outcomes (knowledge contribution and acquisition) were not significantly predicted by task interdependence and team diversity. Other team variables (team size, team efficacy) and task routineness were not significantly related with relational embeddedness, psychological contract obligations and knowledge exchange. This suggests that social embeddedness has a more central influence on obligations and knowledge exchange than overall team and task structures. The social embeddedness and control variables together explained 48% of the variance in knowledge contribution and 40% of the variance in knowledge acquisition. The explained variance in the knowledge exchange outcomes was greater in the alternative hypothesized model (partially mediated model) than in the control-variables-only model, with the latter explaining 28% of knowledge contribution and 16% of knowledge acquisition.

## **DISCUSSION**

This study posited that psychological contracts of knowledge sharing are central to understanding knowledge exchange. These psychological contracts provide an important frame of reference in guiding exchange behaviors (Chang, Rousseau & Lai, 2007). The current findings identify the nature and role of psychological contracts in knowledge exchange relationships that are often taken for granted. Specifically, the results suggest that employees engage in knowledge exchange because of their obligations to share, and these obligations exist in negotiated and reciprocal forms. They demonstrate the importance of specific psychological contract obligations in driving knowledge exchange based on norms of reciprocity and instrumental negotiation.



By examining knowledge exchange from the perspective of psychological contracts, the current research provides further evidence that knowledge exchange can be a voluntary or discretionary behavior that is not formally rewarded. Psychological contract obligations were found to be positively associated with two forms of knowledge exchange: contribution and acquisition. The results reported in this study were surprisingly strong when further analyses were conducted. First, when psychological contracts were examined with reports of knowledge exchange one month *after* the first survey, obligations were positively associated with both contribution ( $b=.24, p<.01$ ) and acquisition ( $b=.21, p<.01$ ). Thus, the effects of psychological contracts may be enduring. Second, the respondents reported their knowledge contribution in the same survey that they reported organizational tenure, work experience and pay/promotions. Despite the fact that these factors are central motivators of knowledge contribution, they did not explain as much variance in contribution as did psychological contracts.

The results were further reinforced when psychological contract obligations were examined with actual amount of contribution to knowledge repositories. Respondents with greater *negotiated* global obligation posted a greater volume of messages containing work solutions on organizational electronic forums ( $b=.26, p<.01$ ) and contributed more documents in online repositories ( $b=.22, p<.01$ ). Similarly, respondents with greater *reciprocal* global obligation also posted a greater volume of messages on organizational electronic forums ( $b=.28, p<.01$ ) and contributed more documents in online repositories ( $b=.27, p<.01$ ). On the other hand, both negotiated and reciprocal *local* obligations were not significantly related to volume of messages and contribution of documents in online repositories. These findings contradict prior research that suggests knowledge exchange

is reduced in electronically-mediated work environments due to lack of common ground (Nahapiet & Ghoshal, 1998; Cramton, 2001). Knowledge contribution, both perceived and in actual amount, increases when obligations to share with the *global* target increases, even when individuals do not explicitly negotiate for reciprocation. One possible explanation is that direct reciprocity is expected for personal exchanges between individuals (local target), whereas generalized reciprocity, i.e., reciprocation in other forms by another party other than the recipient of the exchange (Wasko & Faraj, 2005), is the key to sustaining knowledge exchange in distributed teams.

The current study also identifies the underlying sources of psychological contract obligations. Contrary to previous empirical evidence, the results demonstrate that psychological contract obligations are affected by one's social embeddedness, and are largely independent of personal attributes and team factors. The findings show that two measures of social embeddedness, instrumental and relational, positively relate to each form of psychological contract obligations. Existing theories maintain that what matters in distributed teams is the impact of distance, face-to-face interactions, and use of communication technologies (Sproull & Kiesler, 1991; Cramton, 2001; Cross & Cummings, 2004). While having some explanatory power, along with other individual and team factors such as familiarity and identity (Henry et al., 1999; Espinosa et al., 2002), this study found that distance and technology effects can be overshadowed by the impact of the social relationships where knowledge exchange is concerned.

Another surprising result is the positive relationship between instrumental embeddedness and reciprocal global obligation, and the negative relationship between relational embeddedness and negotiated local obligation. These findings further support

my theoretical contention that a member's psychological contract obligations may serve as an anchor point from which to interpret social ties and knowledge sharing behaviors. Individuals with strong advice relationships to others, i.e., high instrumental embeddedness, may perceive their knowledge sharing obligations to their team members as explicit agreements that will make their contributions salient. Yet, to others outside their team, they may perceive their obligations as forms of reciprocal arrangements that will help to portray their contributions as extra-role or helping behaviors. In contrast, individuals with strong trust ties to others, i.e., high relational embeddedness, are more likely to avoid negotiation and conflicts. Therefore, their contributions to others, both team members and other organizational members, are based on norms of reciprocity.

The findings confirm and extend prior studies that have found negative relationships between psychological contract breach and employee behaviors, including citizenship behavior (Robinson & Morrison, 1995) and perceived obligations to the employer (Robinson, Kraatz & Rousseau, 1994). This study, however, has several significant unique contributions. It involved a more comprehensive examination of the relationship between psychological contracts and employee contributions in the domain of knowledge management by considering different facets of knowledge exchange. It also statistically controlled for alternative explanatory variables, thus providing stronger evidence than prior studies that psychological contract obligations influence employee contributions to the organization.

Finally, the current study extends psychological contracts to relationships between co-workers, which have a significant theoretical and practical relevance as individuals seldom interact with only their project managers and supervisors. Co-workers play

multiple roles in developing psychological contracts of knowledge sharing. They can influence patterns of knowledge exchange through the extent to which they develop social ties with their peers (Chang et al., 2005). They are key enablers of knowledge exchange since the obligations of an individual can lead to anticipation of future exchanges from peers and influence the extent of help provided to them for problem solving. In this regard, knowledge exchange is construed as citizenship behavior (e.g., Williams and Anderson, 1991) that should be recognized and investigated in future studies. These findings have implications both for the psychological contract and knowledge exchange literatures.

### **Theoretical Implications**

The above results on the mediating role of psychological contracts have several important theoretical implications. The social networks literature has repeatedly stated two assumptions: (1) that obligation to share is the critical ingredient in the relationship between social networks and knowledge exchange, and (2) that the impact of social networks comes from something more than just the expectations of rewards and benefits. This study empirically supports these previously untested assumptions, and this is important for two reasons. First, it demonstrates, for the first time, why social ties have the effect on knowledge exchange, because it identifies the crucial mediating variables, i.e. different forms of obligations. Second, it validates prior studies on the effects of social ties. Until now, it was impossible to determine whether prior work on the effects of social networks in distributed teams were demonstrating anything new beyond what is already known about the effects of reciprocity. Even though it has been argued in the

contract literature that the effects of psychological contract obligations were something more than just the effects of reciprocity, there were no empirical data to support these claims. The results of this study show that social ties generate reciprocal obligations, but that reciprocal obligations alone cannot account for these effects of different social ties. The results also suggest that although the constructs of instrumental and relational ties are related to psychological contract obligations, they are in fact distinct. To date, the relationship between these constructs has been unclear, and the literatures on them have remained separate. This study integrates established literature on psychological contract theory with emerging literature on social networks when relating workplace relationships to knowledge exchange. These literatures do not compete with each other, but rather, they complement one another.

The current study contributes to psychological contract research by investigating two important forms of obligations, negotiated and reciprocal, as social exchange mechanisms. If we had examined only direct relationships between social ties and knowledge exchange, we would have concluded that strong ties facilitate knowledge exchange without explaining for *why* they influence the exchange process. The findings reveal an additional way in which social ties affect knowledge exchange: by influencing employees' perceptions and obligations to share. For instance, trust may beget trust not only by influencing trusting behavior of individuals but also by influencing each person's obligations to share with others. By showing that psychological contract obligations, constructs previously conceptualized as independent of the context of knowledge sharing, occur under influences of social embeddedness, the results provide strong corroborations for social exchange effects found in previous studies (Omar, 2004; Bordia et al., 2004;

Wasko & Faraj, 2005; Cullinane & Dundon, 2006; Wayne et al., 1997; Sparrowe et al., 2001). More importantly, they enhance theory development in psychological contract by demonstrating why social ties are important informal constituents in the development of mutual obligations – the level of agreement between two individuals regarding their obligations to each other (Dabos & Rousseau, 2004). Mutual obligations are valuable both for meeting the expectations of others and performing what others expect. Once formed between two individuals, they facilitate spontaneous knowledge exchange and regulate the repayment of exchange favors.

Another implication of this study is the importance of the findings to social networks research. Existing studies have typically focused on social structures and organizational outcomes such as influence (Burkhardt & Brass, 1990), promotions (Burt, 1992) and turnover (Krackhardt & Porter, 1985). The effects of social ties have been theoretically explained as a form of access to information and resources embedded in such relationships (e.g., Burt, 1992). This study is unique in its inclusion of variables, including psychological contract obligations, which provide an important perspective in understanding knowledge sharing processes. Although commitments from employees to the organization can be signaled from human resource practices and through training activities (e.g., Guest, 2004), beliefs regarding the psychological contract and obligations to share are significantly shaped by a set of social relations.

Finally, research on distributed work can benefit from these findings. While face-to-face interactions during the course of a project are important, alternative means of communication should be employed to develop instrumental and relational components of social ties that facilitate the development of psychological contract obligations. As in

evidence-based management (Rousseau, 2006), identifying such ties and obligations reveal the cause-effect connections in distributed work practices, and help to translate them into practices that promote desired knowledge exchange.

### **Practical Implications**

Managers face the challenge of motivating employees to actively and willingly engage in knowledge sharing. The current findings provide further evidence that psychological contract theory provides not just a framework to understand knowledge exchange, but also practical directions on how to facilitate knowledge exchange. Specifically, the results showed that team members with greater obligations to share were more likely to exchange knowledge. Interestingly, different types of social ties were associated with different forms of obligations. Thus, organizations initiating a knowledge management strategy should first consider what kind of knowledge exchange they are trying to promote.

The strategy to promote knowledge exchange directed at the *local* target, e.g., personalized knowledge between team members, will differ from the strategy to promote knowledge exchange directed at the *global* target, e.g., codification of knowledge in repositories to benefit other organizational members. Managers who want to increase knowledge sharing directed at the *local* target can provide opportunities to develop trust relationships that promote feelings of reciprocal obligations between co-workers, or advice networks that promote instrumental negotiation. The findings suggest that trust relationships allow team members to establish a sense of reciprocity and obligations to share knowledge. Managers who want to increase knowledge sharing directed at the

*global* target can promote contributions to knowledge repositories or among organizational members by establishing strong task-oriented structures. These structures can increase situational cues that are often lacking in distributed work contexts, by clarifying individual expectations and organizational policies, and guiding behavior through making knowledge sharing less discretionary (Dirks & Ferrin, 2001).

The results that show the impact of instrumental advice relationships on negotiated local and global obligations offer a particularly interesting consideration for managers. Prior work implicating the role of contracts and contracting within organizations has centered on specifying optimal contracts to achieve a convergence between individual and organizational goals (e.g., Williamson, 1975). This study suggests, however, that managing employees' perceptions of co-workers and knowledge sharing obligations may be as important as creating a specific type of contract in the first place.

As more organizations are confronted with the demand for flexibility and agility in the workplace, relationships between members of distributed teams become emblematic of new forms of psychological contract. The results complement recent studies on contemporary teams, where employees are no longer driven by security, status and hierarchy, but rather by performance, self-fulfillment and participation (Wasko & Faraj, 2005; Ahuja & Carley, 1999). Thus this research has practical significance for the design of new work teams. It highlights the importance of maintaining perceptions of obligations and contract fulfillment.



## **Limitations**

The implications above must be considered in the light of the study's limitations as with most field research. For example, the theory advanced in this study included only two aspects of social embeddedness: instrumental and relational ties. Other unmeasured exogenous variables such as cognitive embeddedness (e.g., expertise and cognitive social structures) (Sproull & Faraj, 2000; Ehrlich & Chang, 2006) and organizing principles (e.g., leadership) (Galvin et al., 2005) might affect team members' knowledge sharing behaviors.

The psychological contract obligations included in the research model are general representation of knowledge sharing practices, and not an exhaustive set. Although rigorous steps have been taken to reduce constraints dealing with site specificity, it is possible that the obligations elicited in this study may vary from categorizations in other organizations (e.g., Bordia et al., 2004; Brandes et al., 2004; Omar, 2004). Future research may need to customize a set of knowledge sharing obligations to fit particular organizational contexts and also examine the extent to which such obligations maintain a social climate for knowledge sharing between individuals.

The focus is on knowledge exchange in teams. However, knowledge exchange can occur via boundary spanning involving members of other teams (e.g., Ancona & Caldwell, 1992; Hinds & Bailey, 2003). Thus, the observed effects are less applicable to extra-team knowledge sharing although interesting inferences can be drawn from the current results on psychological contract obligations to global social referents. Generalizing the findings to teams of different sizes and types can offer exciting opportunities for future research.

## CONCLUSION

### Summary of Findings

This research program builds on previous theoretical and empirical studies in psychological contracts and social exchange to provide insights into the nature of knowledge exchange in distributed work teams. Important relationships between social embeddedness, psychological contract obligations and knowledge exchange have been discovered. Specifically, instrumental and relational embeddedness were found to be associated with negotiated and reciprocal obligations. The more an individual is *instrumentally embedded*, the greater *negotiated* obligations they have towards their exchange partners. The more an individual is *relationally embedded*, the greater *reciprocal* obligations they have towards their exchange partners. The results also showed that these obligations, both to local and global targets, have positive relationships with knowledge contribution and knowledge acquisition. These findings provide new and unexpected insights into the role of psychological contracts on knowledge exchange. They integrate divergent research in the fields of social networks and social exchange to build an integrative framework for examining psychological contracts on knowledge exchange. These conceptual linkages help to answer existing questions for researchers interested in exchange dynamics to explain how people obtain valued resources, i.e., knowledge, through their social interactions with others.

### Future Research

This study opens multiple avenues for future research. An interesting area of further work is to compare social networks that are built on cognitive capital (Nahapiet &

Ghoshal, 1998; Constant et al., 1996). Previous studies provide some indication that cognitive capital, such as experience and expertise, is important when considering the type of knowledge shared (e.g., Wasko & Faraj, 2005). While this study focuses on motivations of knowledge exchange by examining negotiated and reciprocal obligations, a distinction of the types of motivations from the perspective of cognitive capital (e.g., shared mental models and self-rated expertise) may provide good indicators about why team members enjoy helping others, share more useful knowledge, and commit to contributing more knowledge.

An important question for future research is whether the psychological contract theory applies to different knowledge sharing practices and organizations over time. Can psychological contracts of knowledge sharing be construed as a joint occurrence where reciprocation matters to the contributor and recipient? As some teams come together for a short time and other teams are together over years, evaluation of individual obligations may be more significant in influencing temporary teams with short term goals, whereas evaluation of *joint* obligations between contributor and recipient may have greater impacts on teams with long term goals (Bordia et al., 2004; Rhoades & Eisenberger, 2002). Future work should explore other related antecedents to the psychological contract obligations, i.e., social exchange processes under which these obligations are developed, and their impacts on general knowledge sharing practices that evolve over time.

### **Concluding Remarks**

In conclusion, this study contributes by increasing the theoretical and empirical understanding of the antecedents and consequences of psychological contracts of

knowledge sharing. The importance of social embeddedness on knowledge exchange has been increasingly recognized in the organizational behavior literature. This study illustrates the role of psychological contracts in distributed work environments, and calls for contextualized views of psychological contract obligations. In addition, the theory and results posited in this study build on and expand beyond research on psychological contracts and knowledge exchange. Overall, this study underscores the role of psychological contracts in the evaluation of knowledge sharing processes, and highlights the importance of considering social ties when studying the phenomenon of psychological contracts of knowledge sharing.

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Figure 1. Research Model of Psychological Contracts of Knowledge Sharing

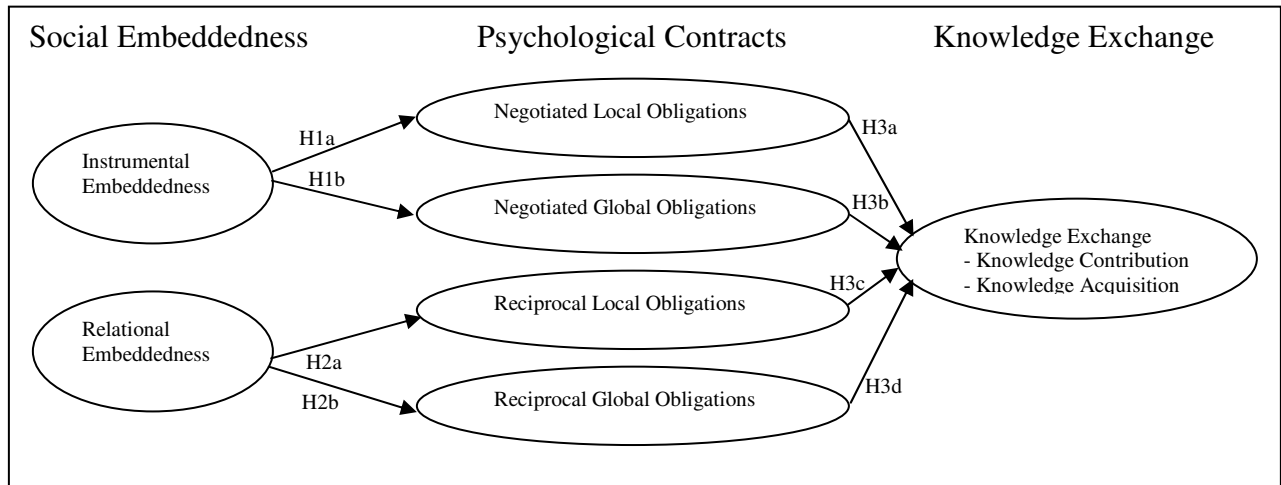


Table 1. Psychological Contracts of Knowledge Sharing

		Target of Knowledge Exchange	
		Team (Local)	Organization (Global)
Forms of Social Exchange	Implicit (Reciprocal)	<p><b><u>Reciprocal Local</u></b></p> <ul style="list-style-type: none"> <li>- Obligations to share knowledge with the team</li> <li>- Nature of reciprocity: <b>Loosely defined / implicit</b></li> <li>- Type of reciprocity: <b>Direct (repayment of exchange by a known recipient)</b></li> <li>- Motive: <b>Self interest &amp; group interest</b></li> </ul>	<p><b><u>Reciprocal Global</u></b></p> <ul style="list-style-type: none"> <li>- Obligations to share knowledge outside the team</li> <li>- Nature of reciprocity: <b>Loosely defined / implicit</b></li> <li>- Type of reciprocity: <b>Indirect (uncertainty about who will make the repayment)</b></li> <li>- Motive: <b>Solely group interest</b></li> </ul>
	Explicit (Negotiated)	<p><b><u>Negotiated Local</u></b></p> <ul style="list-style-type: none"> <li>- Obligations to share knowledge with the team</li> <li>- Nature of reciprocity: <b>Clearly defined / explicit</b></li> <li>- Type of reciprocity: <b>Direct (repayment of exchange by a known recipient)</b></li> <li>- Motive: <b>Solely self interest</b></li> </ul>	<p><b><u>Negotiated Global</u></b></p> <ul style="list-style-type: none"> <li>- Obligations to share knowledge outside the team</li> <li>- Nature of reciprocity: <b>Clearly defined / explicit</b></li> <li>- Type of reciprocity: <b>Indirect (uncertainty about who will make the repayment)</b></li> <li>- Motive: <b>Self interest &amp; group interest</b></li> </ul>

Table 2. Descriptive Statistics and QAP Correlations for Network-Level Variables

	Min-Max <sub>1</sub> (# Indegree Ties)	Mean Indegree (Std Dev) <sub>2</sub>	Min-Max <sub>1</sub> (# Outdegree Ties)	Mean Outdegree (Std Dev) <sub>2</sub>	Correlation Coefficients <sub>3</sub>			
					1	2	3	4
1. Instrumental Network	0-24	10.7829 (3.1224)	0-28	9.8597 (3.2268)	1.00			
2. Relational Network	0-27	12.0795 (2.9012)	0-25	11.4389 (3.1453)	.173	1.00		
3. Knowledge Contribution	0-26	15.1932 (3.8727)	0-22	14.8371 (3.9186)	.417*	.394*	1.00	
4. Knowledge Acquisition	0-23	13.2265 (3.4053)	0-27	16.1629 (3.5369)	.359*	.310*	.204	1.00

\* p < 0.05; \*\* p < 0.01

1. The Min-Max value indicates the minimum and maximum number of ties that a person in each network has (i.e., the range of the sum of binary ties across each row in the network matrix)

2. The Mean value indicates the average number of ties that a person has with another in each network

3. The results indicate the QAP correlation coefficients between each primary network assessed

Table 3. Descriptive Statistics and Correlation Matrix with Key Individual-Level Variables

	Mean	Std Dev	Correlation Coefficients																
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Control Variables																			
1. gender	0.21	0.23	1.0																
2. age	39.35	7.88	-.01	1.0															
3. organizational tenure	3.13	2.54	.10	.02	1.0														
4. work experience	8.17	2.91	.05	.08	.02	1.0													
5. employment status	0.31	0.36	.03	.01	.01	-.01	1.0												
6. task interdependence	3.62	1.27	.10	.02	.13	.08	.02	1.0											
7. geographical distance	2.59	1.03	.01	.08	.02	-.04	.09	.11	1.0										
Instrumental Embeddedness																			
8. In-degree	3.12	0.76	-.08	-.03	.02	-.08	.09	-.11	-.08	1.0									
9. Out-degree	2.98	0.69	-.02	.01	.04	.06	.10	-.01	.06	.09	1.0								
Relational Embeddedness																			
10. In-degree	3.54	0.91	.10	.03	.01	-.03	.04	.03	.07	.14	.12	1.0							
11. Out-degree	3.78	1.02	.13	.01	.04	.10	.02	-.09	-.09	.19	.13	.10	1.0						
Negotiated Obligations																			
12. Local	2.54	0.40	.02	.06	.01	.08	.08	.10	.12	.30**	.09	.05	-.33**	1.0					
13. Global	3.78	0.59	.13	.01	.05	.03	.05	.03	.06	.23*	.12	.10	-.13	.25*	1.0				
Reciprocal Obligations																			
14. Local	3.22	0.83	.11	-.02	.04	-.04	.01	-.02	.09	.15	-.06	.09	.29**	.05	.09	1.0			
15. Global	2.54	0.57	-.04	.08	.02	-.06	.06	-.10	.02	.30**	.11	-.12	.21*	.15	.14	.23*	1.0		
Knowledge Exchange																			
16. Knowledge Contribution	2.91	0.93	-.05	.10	.17*	.06	.10	.04	.11	.32**	.16	.13	.30**	.31**	.29**	.24*	.34**	1.0	
17. Knowledge Acquisition	3.48	0.78	.07	.06	.19*	-.07	.11	-.08	.07	.34**	.15	.10	.29**	.24*	.23*	.30**	.28**	.20*	1.0

\* p < 0.05; \*\* p < 0.01; N=221



Table 4. The Measurement Model –  
Factor Loadings, Internal Consistency, and Discriminant Validity

	Indicators	1	2	3	4	5	6	7	8	9	10	Internal Consistency	Cronbach Alpha	Average Variance Extracted
Instrumental Embeddedness														
1. In-degree	SE1	.99	.12	.11	.10	.03	.08	.11	.09	.12	.09	.90	.94	.87
2. Out-degree	SE2	.10	.89	.13	.04	.05	.09	.14	.13	.10	.08	.88	.89	.81
Relational Embeddedness														
3. In-degree	RE1	.13	.10	.92	.10	.11	.06	.13	.14	.08	.15	.90	.89	.82
4. Out-degree	RE2	.12	.06	.09	.98	.12	.09	.17	.15	.10	.12	.89	.90	.88
Negotiated Obligations														
5. Local	NL1	.02	.03	.10	.08	.92	.01	.23	.12	.07	.18	.81	.87	.90
	NL2	.09	.06	.09	.10	.90	.21	.18	.10	.11	.10			
	NL3	.10	.02	.11	.12	.87	.14	.11	.13	.04	.07			
	NL4	.03	.05	.08	.10	.85	.14	.12	.05	.09	.09			
	NL5	.10	.11	.04	.05	.80	.08	.32	.14	.14	.12			
6. Global	NG1	.02	.11	.07	.05	.11	.93	.09	.08	.20	.18	.87	.82	.92
	NG2	.04	.13	.05	.06	.09	.88	.12	.12	.17	.19			
	NG3	.09	.10	.06	.11	.14	.82	.07	.23	.13	.07			
	NG4	.12	.18	.02	.12	.30	.78	.23	.24	.14	.19			
	NG5	.04	.20	.14	.20	.21	.74	.12	.18	.08	.07			
Reciprocal Obligations														
7. Local	RL1	.01	.04	.13	.03	.10	.09	.91	.12	.06	.12	.90	.89	.87
	RL2	.04	.02	.10	.02	.11	.18	.86	.09	.05	.13			
	RL3	.12	.01	.09	.07	.06	.12	.80	.12	.11	.07			
	RL4	.02	.23	.14	.13	.12	.21	.78	.15	.12	.14			
	RL5	.15	.14	.09	.20	.18	.16	.72	.20	.07	.21			
8. Global	RG1	.13	.10	.04	.12	.16	.07	.21	.92	.19	.03	.91	.93	.91
	RG2	.09	.09	.02	.19	.13	.02	.15	.89	.12	.23			
	RG3	.10	.05	.08	.08	.07	.13	.11	.88	.09	.19			
	RG4	.14	.08	.09	.19	.09	.15	.18	.82	.19	.15			
	RG5	.21	.16	.15	.24	.12	.19	.20	.75	.08	.20			
9. Knowledge Contribution	KC	.05	.10	.07	.04	.08	.12	.20	.16	.98	.13	.90	.89	.86
10. Knowledge Acquisition	KA	.17	.11	.05	.09	.16	.17	.09	.13	.17	.99	.87	.83	.90

Table 5. Summary of Path Analyses and Hypotheses

Hypotheses and Corresponding Paths	Path Coefficient	t-value	Path Statistically Significant?
H1a: Instrumental Embeddedness to Negotiated Local Obligation (+)	.27	21.20**	Yes
H1b: Instrumental Embeddedness to Negotiated Global Obligation (+)	.07	6.15	No
H2a: Relational Embeddedness to Reciprocal Local Obligation (+)	.33	26.36**	Yes
H2b: Relational Embeddedness to Reciprocal Global Obligation (+)	.26	20.29**	Yes
H3a <sub>i</sub> : Negotiated Local Obligations to Knowledge Contribution (+)	.28	22.93**	Yes
H3a <sub>ii</sub> : Negotiated Local Obligations to Knowledge Acquisition (+)	.25	19.57**	Yes
H3b <sub>i</sub> : Negotiated Global Obligations to Knowledge Contribution (+)	.30	24.63**	Yes
H3b <sub>ii</sub> : Negotiated Global Obligations to Knowledge Acquisition (+)	.26	20.86**	Yes
H3c <sub>i</sub> : Reciprocal Local Obligations to Knowledge Contribution (+)	.24	18.91**	Yes
H3c <sub>ii</sub> : Reciprocal Local Obligations to Knowledge Acquisition (+)	.16	13.67*	Yes
H3d <sub>i</sub> : Reciprocal Global Obligations to Knowledge Contribution (+)	.28	22.66**	Yes
H3d <sub>ii</sub> : Reciprocal Global Obligations to Knowledge Acquisition (+)	.29	23.38**	Yes
Relationships that were not hypothesized			
Instrumental Embeddedness to Knowledge Contribution	.23	18.13**	Yes
Relational Embeddedness to Knowledge Acquisition	.15	12.96*	Yes
Instrumental Embeddedness to Reciprocal Local Obligation	-.09	8.95	No
Instrumental Embeddedness to Reciprocal Global Obligation	.25	19.24**	Yes
Relational Embeddedness to Negotiated Local Obligation	-.21	19.63**	Yes
Relational Embeddedness to Negotiated Global Obligation	-.06	10.11	No

**R<sup>2</sup> values for Negotiated Local = .908, Negotiated Global = .882, Reciprocal Local = .891, Reciprocal Global = .869, Knowledge Contribution = .953, and Knowledge Acquisition = .946**

### Appendix A. Description of Sample (Teams and Participants)

Team #	Team Name	Size	Location(s)	Geographical Distribution Index	Member Roles	Cross-Functional Diversity Index
1	Project Management	5	Bangalore, Bristol, Haifa, San Diego, Vancouver	5.33	Engineering, Marketing, Finance, Architecture, Human Resource	1.76
2	Backwards Compatibility	6	Bristol, Haifa	3.23	Development, Engineering, Architecture	1.01
3	Basic Imaging and Research	6	Bristol, Haifa	3.76	Development, Research	1.01
4	Compatibility & Adv Imaging	9	Bristol, Haifa, San Diego	4.43	Development, Research	1.22
5	Compression Techniques	6	Bristol	1.32	Development	0.50
6	Connectivity	8	Haifa, Vancouver	2.65	Development, Architecture	1.12
7	Corporate Testing	7	San Diego	1.82	Testing, Quality Assurance, Human Resource	1.53
8	Customer Feedback	8	Haifa	1.33	Customer Service, Quality Assurance, Sales	1.65
9	Digital Imaging	8	Haifa, San Diego, Vancouver	4.21	Development, Engineering, Research	1.22
10	DIPS Software	6	Haifa, San Diego, Vancouver	3.98	Development	0.50
11	DIPS Systems	6	San Diego, Vancouver	2.87	Architecture	0.50
12	Documentation	6	Bristol	1.12	Marketing, Sales, Customer Service,	1.01
13	Driver Development	8	San Diego, Vancouver	3.01	Development, Engineering	1.22
14	Enterprise Applications	6	Haifa, San Diego	2.66	Marketing, Development	1.01
15	Image Effects	7	Vancouver	1.59	Research, Development, Engineering	1.12
16	Image Enhancement	10	Bangalore, Bristol, Haifa	5.01	Research, Development, Engineering	1.32
17	Image Modeling	6	San Diego, Vancouver	2.75	Development, Engineering, Architecture	1.23
18	Inkjet Optimization	11	Bangalore, Bristol, San Diego	5.46	Research, Engineering	1.12

**Appendix A (cont.). Description of Sample (Teams and Participants)**

Team #	Team Name	Size	Location(s)	Geographical Distribution Index	Member Roles	Cross-Functional Diversity Index
19	Integration Testing	6	Bangalore	2.54	Testing, Quality Assurance, Customer Service	1.43
20	Laserjet Integration	8	Vancouver	2.80	Development, Architecture, Engineering	1.34
21	Operating Systems	9	Bangalore	2.19	Architecture Development, Engineering	1.29
22	Optical Research	7	Bangalore, Vancouver	3.62	Research, Development	1.05
23	Peripheral Connectivity	6	Haifa	1.87	Engineering, Architecture	1.01
24	Peripheral Integration	7	Bangalore, Bristol	2.20	Development, Architecture, Engineering	1.21
25	Planning	7	Bangalore	1.86	Marketing, Sales, Human Resources	1.40
26	Platform Architecture	7	San Diego, Vancouver	2.91	Architecture, Engineering	1.05
27	Printing Services	8	Bangalore, Haifa	3.12	Development, Engineering	1.01
28	Quality Assurance	6	Bristol	1.39	Quality Assurance, Testing	1.33
29	Requirements	7	San Diego, Vancouver	2.34	Architecture, Engineering	1.21
30	Retail Testing	8	Bristol, San Diego, Vancouver	4.98	Quality Assurance, Testing	1.22
31	Scanning Technologies	7	Bangalore	1.56	Research, Development, Engineering	1.35
32	Software Integration	7	Bangalore, San Diego, Vancouver	4.89	Development, Engineering	1.21
33	Usability Testing	10	Bristol, San Diego, Vancouver	5.21	Testing, Development	1.10
34	User Interface	7	Bangalore	2.01	Development	0.63
35	User Testing	6	Haifa	1.19	Testing, Customer Service	0.80
36	Workflow Revisions	6	Haifa	1.54	Marketing, Development, Sales, Human Resources	1.05

## Appendix B. Survey Instrument & Measures

### *Instrumental Embeddedness*

Measure: Extent to which a member shares overlapping ties with his/her team members to people outside the team

Survey Item: To what extent have you gone to each person for advice or help concerning the project? [5-point Likert scale (1=not at all, 5=to a great extent)]

### *Relational Embeddedness*

Measure: Ratio of actual relational ties that a member has to other members within the team and the total number of possible relational ties to them

Survey Item: From time to time, most people discuss important matters with those whom they trust. You can trust someone for a variety of reasons – because you are comfortable sharing sensitive information with them, or because you are confident they won't take advantage of you. To what extent have you discussed with each person matters that are important to you for the project? [5-point Likert scale (1=not at all, 5=to a great extent)]

### *Psychological Contracts of Knowledge Sharing*

#### *Reciprocal and Global Obligations*

(Source: Molm et al., 1999; Chang & Rousseau, 2005, 2007)

#### *Reciprocated Local*

##### Survey items

I feel obligated to contribute information that I deem beneficial to the team because I believe my team members will contribute in the same manner.

I am obligated to share my expertise without formal requests from my team members as I expect them to share their expertise with me.

I have obligations to provide regular progress reports to my team because I believe my team members will also do so in future.

My team members seldom state explicitly what they need for every piece of information they share as we have obligations to exchange information freely.

I feel obligated to discuss knowledge of products and tools with my team through face-to-face / ad-hoc communication since I expect them to share their knowledge with me.

[5-point Likert scale with anchors “strongly disagree” and “strongly agree”]

### *Reciprocated Global*

#### Survey items

I feel obligated to contribute information that I deem beneficial to people outside my team because I believe they will contribute in the same manner.

I am obligated to share my expertise without formal requests from people outside my team as I expect them to share their expertise with me.

I have obligations to disseminate my technical reports to people from other teams using organizational knowledge repositories because I believe they will also do so in future.

People outside my team seldom state explicitly what they need for every piece of information they share as everyone in the organization has obligations to exchange information freely.

I feel obligated to discuss knowledge of products and tools with people outside my team through face-to-face / ad-hoc communication since I expect them to help me in their areas of expertise.

[5-point Likert scale with anchors “strongly disagree” and “strongly agree”]

### *Negotiated Local*

#### Survey items

I feel obligated to contribute the information I have to my team because we have explicitly agreed upon sharing the information that I need in return.

Often when there is a formal request for my expertise from my team, I will specify my request for other information in return.

I am obligated to share best practices with my team members because we have jointly agreed to help one another.

My team members often negotiate what information they will share in exchange for information that they will receive in return.

I have obligations to share specific research resources with my team members as I have explicitly asked for their advice in exchange.

[5-point Likert scale with anchors “strongly disagree” and “strongly agree”]

### *Negotiated Global*

#### Survey items

I feel obligated to contribute the information I have to people outside my team because they have explicitly agreed upon sharing the information that I need in return.

Often when there is a formal request for my expertise from people outside my team, I will specify my request for other information in return.

I am obligated to share best practices with people outside my team because we have jointly agreed to help one another.

People outside my team often negotiate what information they will share in exchange for information that they will receive in return.

I have obligations to share specific research resources with people outside my team as I have explicitly asked for their advice in exchange.

[5-point Likert scale with anchors “strongly disagree” and “strongly agree”]

*Knowledge Exchange*

*Knowledge Contribution* (Source: Borgatti & Cross, 2003)

Measure: Ratio of total number of team members an individual contributed knowledge to and total possible number of team members.

Survey Item: During the last 3 months, please indicate the extent to which you have contributed knowledge to each person that enabled him/her to perform tasks and develop new insights for the project. [5-point Likert scale (1=not at all, 5=to a great extent)]

*Knowledge Acquisition* (Source: Cross & Cummings, 2004)

Measure: Ratio of total number of team members an individual acquired knowledge from and total possible number of team members.

Survey Item: During the last 3 months, please indicate the extent to which you have acquired knowledge from each person that enabled you to perform tasks and develop new insights for the project. [5-point Likert scale (1=not at all, 5=to a great extent)]

## **Appendix C. Overview of Quadratic Assignment Procedure (QAP)**

The Quadratic Assignment Procedure (QAP) is used to assess the dyadic-level effects. This procedure is a non-parametric, permutation-based test that is similar to the ordinary least squares (OLS) technique used in typical multiple regression analyses (Krackhardt, 1988). However, since the observations in social network data are not independent, the error terms within rows and columns in a sociomatrix are auto-correlated to each other (Wasserman & Faust, 1994). When estimates of standard error are biased, traditional significance test cannot be conducted (Krackhardt, 1987). This auto-correlation is resolved by using QAP to regress one dependent matrix onto independent matrices and to test the significance of the regression coefficients (Borgatti & Cross, 2003). QAP analyses have been shown to remain unbiased as compared with ordinary least squares (Krackhardt, 1988). Data are analyzed using the social network analysis program UCINET VI for Windows (Borgatti et al., 1999).

QAP correlation analyses are used to generate a bivariate correlation matrix. Two steps are involved in QAP. First, Pearson's correlation coefficient is computed for corresponding cells in the two matrices. Second, the rows and columns of the one matrix are randomly permuted and the correlation is recomputed. The algorithm recalculates the Pearson correlation between the two matrices. This step is repeated thousands of times, with each correlation from Step One being compared with Step Two to discover the number of times that the correlation based on random permutations is larger or equal to the correlation computed in Step One, i.e., the procedure counts the proportion of random permutations required to yield the regression coefficient found in step one



(Borgatti et al., 1999; Wasserman & Faust, 1994). These steps in QAP take into consideration the row and column interdependence in network data when testing the regression coefficients (Krackhardt, 1988). QAP is reasonably robust for any row and columns auto-correlation parameters and have been used in many recent studies (e.g., Cross & Cummings, 2004; Chang, Rousseau, & Lai, 2007; Ho & Lesvesque, 2005; Umphress et al., 2003).

QAP regression analyses are used to test the hypotheses (Huber & Schultz, 1976). In multiple regression QAP (MRQAP), each knowledge exchange matrix is regressed on the set of all social network matrices and control variables. The MRQAP algorithm is similar to the QAP correlation algorithm described above. First, a standard multiple regression is conducted across corresponding cells of the dependent, independent and control variable matrices (Borgatti et al., 1999). Second, the algorithm permutes all rows and columns of the dependent matrix randomly and recalculates the regression. This step is completed 1000 times to estimate the standard error. The results from Step Two are in the form of r-squared values and coefficients. Each result from Step Two is compared with the coefficient computed in Step 1. The algorithm then computes the number of random permutations from Step Two that yield results similar with those computed in Step One. A significant relationship is indicated if a low proportion ( $p < 0.05$ ) of similar results is found in Step Two when compared with Step One (Borgatti et al., 1999). As is standard in social network analyses, missing data are removed for the QAP correlations and regression analyses. The high response rate of 86% helps to reduce the problems of missing data in the analyses.