Association for Information Systems
AIS Electronic Library (AISeL)

PACIS 2004 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 2004

Transactive Memory and Trust Networks in Computer-Supported Teams

Klarissa Chang
Carnegie Mellon University

Transactive Memory and Trust Networks in Computer-Supported Teams

Klarissa Ting-Ting Chang
Carnegie Mellon University
changtt@cmu.edu

Abstract

The development of transactive memory facilitated by trust relationships and social exchanges is of emerging importance in distributed environments characterized by a lack of rich social presence. Situated at the nexus of research on computer-supported teams, this study examined the effects of trust networks and social presence on transactive memory. The results indicated that dense trust networks helped develop greater transactive memory than sparse networks. The degree of social presence was found to moderate the impacts of trust networks on transactive memory. Teams with dense trust networks also had greater reciprocal exchanges, whereas teams with sparse trust networks had greater negotiated exchanges. Implications for enhancing transactive memory from a social exchange perspective were discussed.

Keywords: transactive memory, trust networks, social exchange, social presence

1. Introduction

This paper applies the lens of trust and social presence from a social exchange perspective to the phenomenon of transactive memory in computer-supported teams. *Transactive memory* analyzes how members of a group share task knowledge with one another via a shared system for encoding, storing, and retrieving information (Wegner, 1987). The pool of knowledge may liberate organizations from the fear of losing critical intellectual assets when employees leave. As we move into an era where collaboration is central to organizational effectiveness, attention has been shifted to examine sets of social relations in teams rather than individual characteristics. Interpersonal behaviors can be viewed as *social exchanges*, and these exchanges typically involve reciprocal and negotiated forms. However, due to the lack of rich social cues in computer-supported teams, members might be reticent in sharing knowledge with one another.

The phenomenal increase in studies investigating *trust* indicates the belief that problems regarding motivation to share knowledge can be overcome by entrusting knowledge sharing activities to social relationships. Various types of trusting ties (e.g., Rousseau et al., 1998) may enhance various forms of social exchange. Trust is the "single most important precondition for knowledge sharing" (Rolland & Choudahary, 2000). It refers to the willingness of oneself to be vulnerable to actions of another based on the expectation that the other will perform a particular action important to oneself (Mayer et al., 1995). The social network perspective is increasingly adopted in recent studies, but little research has examined the role of trust networks. While trust relationships among dyads in teams can be built into a network of trusting ties affecting coordination of knowledge, it is not clear how trusting ties in such social networks underlie the development of transactive memory. Hence, this paper aims to address three main research questions: (1) What are the effects of trust networks on transactive memory in computer-supported teams? (2) How does the degree of social presence influence the impacts of trust

networks on transactive memory? (3) Does transactive memory improve as a result of the form of social exchange in different trust networks? I hypothesize several impacts of trust network density on transactive memory from a social exchange perspective, and these impacts are predicted to be contingent upon the social presence of computer-supported teams.

2. Theoretical Background

Conditions under which transactive memory may be effectively developed are drawn from several theoretical foundations for knowledge sharing in groups: distributed cognition, information processing, social networks, and social exchanges. These theoretical approaches have been developed largely independent of each other, but they specify the conditions under which transactive memory may be effectively developed.

2.1 Distributed Cognition and Transactive Memory

The concept of distributed cognition in the field of organizational studies has created a number of research corollaries on transactive memory (Hollingshead, 1998; Moreland, 1999), collective mind (Weick & Roberts, 1993), and collaborative learning (Dillenbourg et al., 1996). Distributed cognition refers to the division of cognitive labor (Hutchins, 1991) that enables groups and organizations to reach cognitive goals that would be more difficult to reach individually. In the context of information exchange, knowledge sharing can be translated into a process of distributed cognition, where individuals are involved in socially constructed processes such as narration (Brown & Duguid, 1991) and sense-making (Weick, 1995). Team members act autonomously with an understanding of their interdependence (Boland et al., 1994), but the collective knowledge links individual knowledge repositories to the larger knowledge network. Knowledge networks help to explain the diffusion of knowledge across a network of individuals (Contractor et al., 1998), and represent "who knows what" in an organization. Cognitive knowledge networks are similar to the concept of *transactive memory*, which describes a specialized division of cognitive roles with respect to the encoding, storage, and retrieval of information from different knowledge domains that develop during the course of relationships (Hollingshead, 1998). Transactive memory systems are developed through four interrelated processes: expertise recognition, retrieval coordination, directory updating, and information allocation (Moreland, 1999). Developing an effective transactive memory system allows team members to rely on one another as memory stores. This study extends theory and research on transactive memory to knowledge-intensive work teams in computer-supported environments. Based on the grounding that organizations are information-processing systems (March & Simon, 1958), complex knowledge sharing activities may be governed by characteristics of social interaction in these technology-mediated environments.

2.2 Social Networks and Trust

The importance of social relationships that coexist with the formal structures within organizations has been well-promulgated. One of the possible explanations for inconsistent knowledge-sharing outcomes is the network of social ties (Hansen, 1999; Rulke & Galaskiewics, 2000). Some scholars emphasize a large number of weak ties to other social actors as sources of novel information (e.g., Granovetter, 1973; Burt, 1992), while others claim that strong embedded ties are instrumental to information exchange (e.g., Uzzi, 1997). A similar bi-polarity can be seen in the social capital literature - certain scholars favor open network structures (Burt, 1992), while others favor closed structures, in which trust and norms create sanctions that guide behavior

(Coleman, 1990). The team literature on social ties has included studies that examined the overall amount of communication among team members (e.g., Shah & Jehn, 1993), how much each team member speaks (e.g., Brown & Miller, 2000), and who says what (e.g., Larson, Christensen, Abbott, & Franz, 1996). Communication is usually captured at the individual level, but seldom at the dyadic level (i.e., who speaks to whom). Empirical studies focusing on dyadic relationships tend to examine only direct dyadic ties. For instance, trust is often studied between the trustor and the trustee, and seldom extended to examine whether the trustee is also trusted by other actors in the network. The underlying dynamics of sharing knowledge with an actor who is not trusted by others may differ with that of sharing knowledge with an actor who is highly trusted by others. Focusing on indirect ties (a trust network where there is trust in a focal actor who is also trusted by others) may help illuminate some fine-grained information about how trusting ties motivate information exchange.

Trusting ties involve perception of the trustor on the attributes of trustee. A trustor may trust the trustee based on (1) competence – group of skills that enable a trustee to be perceived competent within some specific domain, (2) integrity – adherence to a set of principles (work habits) thought to make the trustee dependable and reliable; and (3) benevolence – extent to which a trustee is believed to feel interpersonal care and concern, and willingness to do good to the trustor beyond egocentric profit motive (Jarvenpaa et al., 1998). A trusting tie is established when one member believes in the competence, integrity, and benevolence of another member in exchanging information. A set of such trusting ties thus builds up a network of trust relationships. Examining trust relationships around a focal actor helps to determine network density of trusting ties in a team. A dense network of trusting relationships among individuals may facilitate information exchange better than a stand-alone trusting tie between two people. One possible explanation of why trust networks may develop such transactive memory is to examine the underlying social exchanges between members.

2.3 Social Exchange Theory

Social exchange theory explains how people obtain valued resources through their interactions with others (Homans, 1958). This theory does not originally include information or knowledge as an exchange resource (Jarvenpaa et al., 1998). Constant et al. (1994) explicitly addresses social exchange when advocating a theory of information sharing in organizations that make extensive use of technology. Kim & Mauborgne (1997), for instance, argue that the rules of social exchange govern knowledge sharing. There are several forms of social exchange, including *reciprocal exchange* (Emerson, 1976), and *negotiated exchange* (Molm et al., 1999). Reciprocal exchange is characterized by direct reciprocation that does not involve explicit bargaining about the nature and timing of reciprocation. Members do not openly discuss the terms of exchange and the value of the information exchanged. This kind of exchange stipulates information sharing based on reciprocation. On the other hand, negotiated exchange is characterized by an open discussion of the benefits of receiving or giving. Terms of exchange are explicitly outlined. This form of exchange entails a deliberate act of information sharing with transaction partners based on expectations of prospective benefits. Some theorists have used social exchange theory as a starting point for examining related areas such as trust and affective ties (Nooteboom, 1996; Molm et al., 1999). For instance, an individual embedded in a dense network of trust relationships is likely to exchange information reciprocally as strong implicit trusting ties have been established. On the other hand, an individual in a sparse network of trust

relationships may require explicit and openly negotiated exchanges due to the nature of the weak trusting ties. The form of social exchange may provide a reason for why trust networks facilitate specialization of expertise and coordination of information.

3. Research Hypotheses

3.1 Trust Networks and Transactive Memory

Transactive memory is purported to be affected by social relationships among team members. One critical aspect of social relationships is the network of trusting ties that may be developed over the course of work. In a seminal study, Granovetter (1973) seeded an interest for the role of weak ties in enhancing dissemination and exchange of information. Using a network study of product development teams, Hansen (1999) highlighted the role of weak ties in searching for useful knowledge. Information flows and trust are increased in networks that are dense and consist of strong ties (Coleman, 1990). An employee can trust that a coworker knows the information that the employee needs (competence), but may not trust that he will be forthcoming at the time when the information is needed (benevolence). Conversely, the employee can be confident that there may be other people who are willing to assist the employee (benevolence), but these people might not possess the knowledge or skills required (competence). Previous results reveal that knowledge exchange is more effective when the knowledge recipient views the knowledge source as being both benevolent and competent.

In a study on social networks, Coleman (1990) emphasized network closure as it reduces the risk of cooperation and trust, and facilitates sanctions that monitor behavior. This closure argument suggesting that dense networks facilitate trust is similar to Granovetter's (1973) argument that trust is socially embedded. In the context of knowledge sharing among individuals, social ties and trust are conduits for effective information exchange. Computer-supported teams in dense networks of trusting ties are likely to communicate frequently as strong trusting ties represent frequent interaction that may replace the requirement for physical co-existence. Given the evidence of previous studies, it is likely that teams with dense networks are more willing to share knowledge among trusted others than those networks that are less dense. Hence, transactive memory is hypothesized a function of the density of trust networks, with dense networks of trusting ties leading to greater transactive memory than sparse networks of trusting ties.

Hypothesis 1: Computer-supported teams with denser networks of trusting ties will have greater transactive memory than those with less dense networks of trusting ties.

3.2 Moderating Effects of Social Presence

Social presence reflects the degree of salience of other members in an interaction, and the consequent salience of the interpersonal relationships (Short et al., 1976). The social presence theory predicts linear knowledge sharing benefits from the use of technologies transmitting more verbal and nonverbal cues. In a distributed environment, a higher level of social presence can be created engendering higher levels of intimacy and immediacy in the interaction (Weiner & Mehrabian, 1968). Operationalized as low to high in most studies, social presence is typically viewed as low in electronic communication media, and high in face-to-face communication.

It is generally more difficult for communication to take place in dispersed settings. The removal of visual cues, for example, might have reduced social presence sufficiently to cause group

members to pursue self rather than group interests (Sia et al., 2002). A reduction in social presence might cause difficulties in arriving at mutually agreeable communication (Lewicki & Litterer, 1985), decreasing effective social construction in the learning process (Carlson & Zmud, 1999). This calls for the development of a sense of social presence relating to the technologies in use. Evidently, trust networks are expected to enhance the development of transactive memory when teams are supported by high degree of social presence among members, regardless of density of trust networks.

Hypothesis 2: The degree of social presence will moderate the impact of trust network density on transactive memory. Members of computer-supported teams with dense networks of trusting ties will have greater transactive memory when social presence is high than when social presence is low; members of computer-supported teams with sparse networks of trusting ties will have greater transactive memory when social presence is high than when social presence is low.

3.3 Mediating Effects of Reciprocal Exchange

Social exchange can be circumscribed by the voluntary actions of individuals who are motivated by the returns these actions are expected to bring. Dense networks of trusting relationships may inculcate a norm of reciprocal exchange that facilitates development of transactive memory. Reciprocal exchanges involve intrinsic obligations and indirect exchanges. In a reciprocal exchange, members' contributions to the exchange of informational resources are performed separately and non-negotiated (Molm et al., 1999). A member may make an offer (e.g., providing a piece of critical information) without knowing when, whether, or to what extent the other members will reciprocate. A reciprocal exchange takes places over time when an individual performs sequential and contingent acts that vary in timing and reciprocity. Conventional studies usually investigate such reciprocal exchange relations in social settings (e.g., Homans, 1958). Hence, it is predicted that networks consisting of denser trusting ties are likely to improve transactive memory by facilitating more reciprocal exchanges which lead to greater transactive memory developed in the team.

Hypothesis 3: The amount of reciprocal exchange among members will mediate the relationship of trust network density and transactive memory. Trust network density will be positively related to reciprocal exchange; reciprocal exchange will be positively related to transactive memory.

3.4 Mediating Effects of Negotiated Exchange

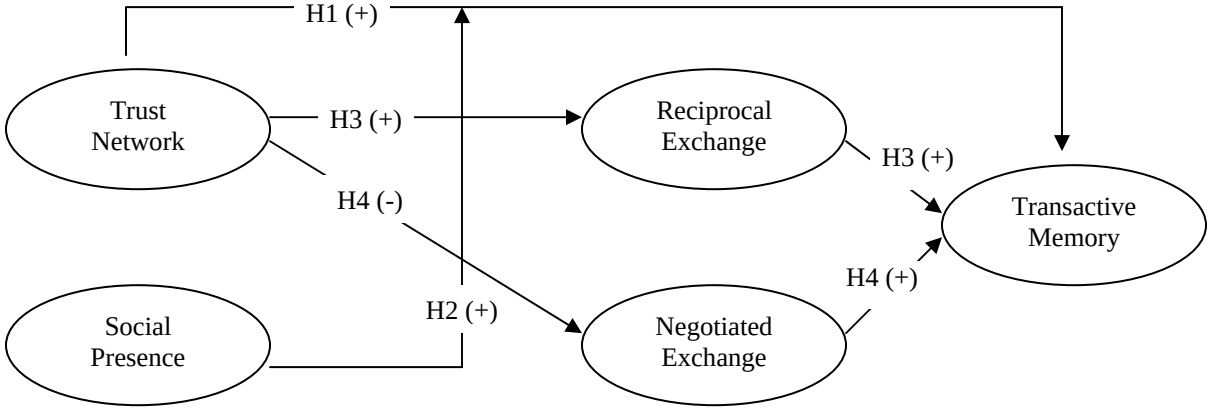
Negotiated exchanges involve extrinsic obligations and direct exchanges. In a negotiated exchange, members are usually involved in a joint decision process to determine the terms of exchange (Molm et al., 1999). These terms are agreed at the same time even though the 'transactions' of information do not occur simultaneously. Although socially close relationships may encourage greater information exchange, dense trusting ties may inhibit the development of transactive memory because of the taken-for-granted nature of the interaction. Socially-isolated members have been found to participate more in discussion and emphasize more of their unique knowledge than socially-connected members (Thomas-Hunt et al., 2003). Sparse trusting networks, characterized by weak trusting ties, may cause members to deliberately and explicitly state the terms of exchange. This form of negotiated exchange as a result of sparse trusting networks may still facilitate coordination of information. Despite the benefits of dense trusting

networks, sparse networks are predicted to improve transactive memory by creating more negotiated exchanges among team members.

Hypothesis 4: The amount of negotiated exchange among members will mediate the relationship of trust network density and transactive memory. Trust network density will be negatively related to negotiated exchange; negotiated exchange will be positively related to transactive memory.

The research model and the hypotheses are shown in Figure 1.

Figure 1. Research Model



4. Method

The experiment used a 2 x 2 factorial design with two independent variables - "trust networks" and "social presence". There were two types of trust networks: "dense networks", in which a large number or all of the possible relationships in a team were trusting ties, and "sparse networks", in which only a few or no trusting ties existed between members. Social presence was operationalized as either "high" or "low". Participants in high social presence teams communicated face-to-face while working on their own computer systems, and those in low social presence teams communicated via technological networks without physical contact. There were four treatment conditions: (1) teams with dense networks of trusting ties supported with high degree of social presence, (2) teams with dense networks of trusting ties supported with low degree of social presence, (3) teams with sparse networks of trusting ties supported with high degree of social presence, and (4) teams with sparse networks of trusting ties supported with low degree of social presence. A trust-building exercise (Jarvenpaa et al., 1998) was first conducted to develop trusting ties within the teams. A social network analysis (Burt, 1992) was then applied to determine the density of trusting ties. Each team member played a functional role that existed in a business company. Members were given a hidden profile task (i.e., each member possessed different elements of information essential to the team). Every session was videotaped and computerized messages were archived.

4.1 Participants

A total of two hundred and forty senior undergraduates at a large university participated in this experiment. There was about the same number of males and females. The average age was 22.

These subjects had some experience working in teams and with computers. Each experimental treatment involved twenty three-person teams.

4.2 Determination of Trust Networks

All participants underwent a team building exercise that helped to develop trust within the team (Jarvenpaa et al., 1998). Members exchanged information about themselves, including information assessing project-related skills (ability), work habits believed to be compatible with successful effort (integrity), and motivation for contributing to team effort (benevolence). Trusting ties were predetermined using a social network questionnaire that participants completed one day before the start of the experiment. This questionnaire assessed the trust network by requiring each participant to (1) list the names of members whom he/she trusted, and (2) indicate how well he/she trusted each member for the three dimensions of trust (ability, integrity, and benevolence) on a 7-point scale. Relationships of those who reciprocally listed *each other* in the names of the people they trusted and indicated they trusted each other very much in the three dimensions of trust were assigned as trusting ties. Adopting the social network perspective for computing trust networks, density of trust networks was measured by the presence of third party trust connections around a relationship (Burt, 1992). For example, team X consisted of three members – Alex, Beth, and Cathy. A third party trust connection is established when Alex is trusted by both Beth and Cathy. The trust network is considered dense if Beth is also trusted by Alex and Cathy, and Cathy is trusted by Alex and Beth. It is considered sparse if there is no reciprocal trust relationship between any two members.

4.3 Task and Procedure

This research is premised on the belief that developing transactive memory is necessary because no single individual possesses all the requisite information to make an informed decision or to successfully carry out a task. A business simulation game where information was distributed in the team such that there was a hidden profile was deployed. In all treatments, the teams began with the same position in three major functional areas of business – marketing, production and operations, and human resources (Yoo & Kanawattanachai, 2001). Each member was randomly assigned to play a role in each of the business areas. The team managed a $200 million company producing and selling networking software, with the goal of maximizing the stock price of the company. During the four weeks, team members discussed how they should run the company to achieve its goal. In each week, teams were required to make a decision on twelve variables in the three functional areas. An administrator who was blind to the research variables and hypotheses processed submitted decisions and distributed the performance results back to the team.

4.4 Dependent Measures

The survey was administered to the subjects every week. Weekly *team performance* was assessed using five criteria – profit, return on asset (ROA), return on equity (ROE), stock price, and units sold (Yoo & Kanawattanachai, 2001). Performance index of each team was ranked relative to other teams and normalized to arrive at a score between 1 (low) to 100 (high). In high social presence condition, videotapes were transcribed into written transcripts by a transcriber, who was blind to the experimental treatments and hypotheses. In the low social presence condition, messages using the computer system were archived. The transcripts and archives were then coded by two independent coders, who were blind to the treatments and hypotheses, for sets of behavior to measure transactive memory (Moreland, 1999). In addition, because transactive

memory as a group-level cognitive concept appeared to have behavioral attributes that could be assessed by perceptions of individual members (Lewis, 2000), a 7-point Likert scale questionnaire adopted from Faraj (1998) and Lewis (2000) was administered to the subjects at the end of each week as a surrogate measure of the transactive memory index. To ensure an appropriate level of reliability and validity, constructs were measured using tested items from previous studies. There were a total of 41 items for the 5 constructs, measured on 7-point interval scales. This questionnaire was randomly pre-tested by 22 subjects. No changes were made after verification with cronbach alpha tests and correlation matrices.

4.5 Control Variables and Manipulation Checks

Control variables such as demographic factors were included to suppress the effects of biases in rating. Pertinent factors (e.g., communication frequency) were recorded to investigate potential confounds. To control for facilitator effects, teams in all treatment conditions had the assistance of a facilitator who helped them only in technical problems and not discussion content. An ex post analysis of participant responses was conducted to ensure no significant differences in facilitator impacts for all treatment conditions. To ensure that the subjects were assigned the correct treatment, and that they were paying attention to the experiment, the questionnaires included a section that required the subjects to provide information of their team. They were first asked whether they trusted the other two group members. The subjects were also asked to indicate the extent to which the business information they were given was similar with their team members. There were no significant differences in the perceptions of the team members in terms of the information distribution, which indicated that each team member was holding some unique information that had to be shared to come to decisions.

5. Results

Analysis of the data was conducted in two steps. First, the relationships between density of trust networks, social presence, and transactive memory were investigated (Hypotheses 1 and 2). Descriptive statistics for the four treatment conditions are summarized in Table 1. ANOVA test on transactive memory is depicted in Table 2. Main effects of trust networks were found on transactive memory, supporting Hypothesis 1. Dense networks of trusting ties were associated with greater transactive memory than sparse networks of trusting ties. The results also showed significant interaction effects involving trust networks and social presence on transactive memory (see Figure 1). Hypothesis 2 was partially supported. As hypothesized for sparse networks, transactive memory was found to be greater when social presence is high ($t = 2.18$, $p < 0.01$). However, contrary to the hypothesis for dense networks, transactive memory was found to be greater when social presence is low ($t = 3.12$, $p < 0.01$).

Second, mediating effects of reciprocal exchange and negotiated exchange in Hypotheses 3 and 4 were tested using partial least squares (PLS), a structural equation modeling technique that examined path relations of the variables. PLS allowed simultaneous analysis of the relations between the items and each construct, and enabled testing of the hypothesized relations at the theoretical level. Analysis of the proposed research model was centered on validating the measurement model (primarily through factor analysis) and fitting the structural model (primarily through path analysis). The measurement model assessed each construct and linked the items to the construct they measure. The results suggested that the hypothesized model met the criteria for convergent validity, internal consistency (see Table 3), and discriminant validity

(see Table 4). For the structural model, bootstrap resampling procedure was used to conduct significance tests for all paths (Cotterman & Senn, 1992). The test of each hypothesis was mapped to each specific path (see Figure 2), and the support of each hypothesis was determined by the direction and statistical significance of the corresponding path. Trust networks were significant predictor of reciprocal exchange, negotiated exchange, and transactive memory over three phases. Social presence was found to influence reciprocal exchange, negotiated exchange, and transactive memory in the initial phase, but its impacts became insignificant over time. Reciprocal and negotiated exchanges were strong mediators of trust networks and transactive memory in all phases.

Table 1. Means (Standard Deviations) of Measures

	N	M (SD)
Dense Trust Network and High Social Presence		
Transactive Memory (TM)	60	6.02 (.63)
Reciprocal Exchange (RE)	60	5.41 (.80)
Negotiated Exchange (NE)	60	1.77 (.62)
Sparse Trust Network and High Social Presence		
Transactive Memory (TM)	56	2.35 (.45)
Reciprocal Exchange (RE)	56	1.78 (.61)
Negotiated Exchange (NE)	56	5.11 (.57)
Dense Trust Network and Low Social Presence		
Transactive Memory (TM)	56	6.33 (.58)
Reciprocal Exchange (RE)	56	5.37 (.62)
Negotiated Exchange (NE)	56	1.54 (.31)
Sparse Trust Network and Low Social Presence		
Transactive Memory (TM)	60	1.75 (.71)
Reciprocal Exchange (RE)	60	1.55 (.36)
Negotiated Exchange (NE)	60	5.40 (.66)

Table 2. ANOVA on Transactive Memory

Variation	SS	DF	MS	F-ratio	P
Trust Density	20.79	1	20.79	62.41	<.01
Social Presence	194.48	1	194.48	583.74	<.01
Trust Density x Social Presence	.84	1	.84	2.51	<.02
Error	72.30	217	.33		

Adjusted R^2= .744

Table 3. Tests for Validity of Items

Constructs[i]	Items	Reliability of Items	Composite Reliabilty	Cronbach Alpha	Constructs[i]	Items	Reliability of Items	Composite Reliabilty	Cronbach Alpha
TR			0.90	0.889	TM			0.91	0.890
	TR1	0.78				TS1	0.83		
	TR2	0.85				TS2	0.79		
	TR3	0.91				TS3	0.80		
	TR4	0.88				TS4	0.81		
	TR5	0.86				TS5	0.83		
	TR6	0.82				TC1	0.75		
RE			0.82	0.813		TC2	0.87		
	RE1	0.80				TC3	0.87		
	RE2	0.88				TC4	0.82		
	RE3	0.82				TC5	0.76		
	RE4	0.85				TN1	0.84		
NE			0.85	0.824		TN2	0.82		
	NE1	0.85				TN3	0.80		
	NE2	0.87				TN4	0.88		
	NE3	0.87				TN5	0.78		
	NE4	0.86							

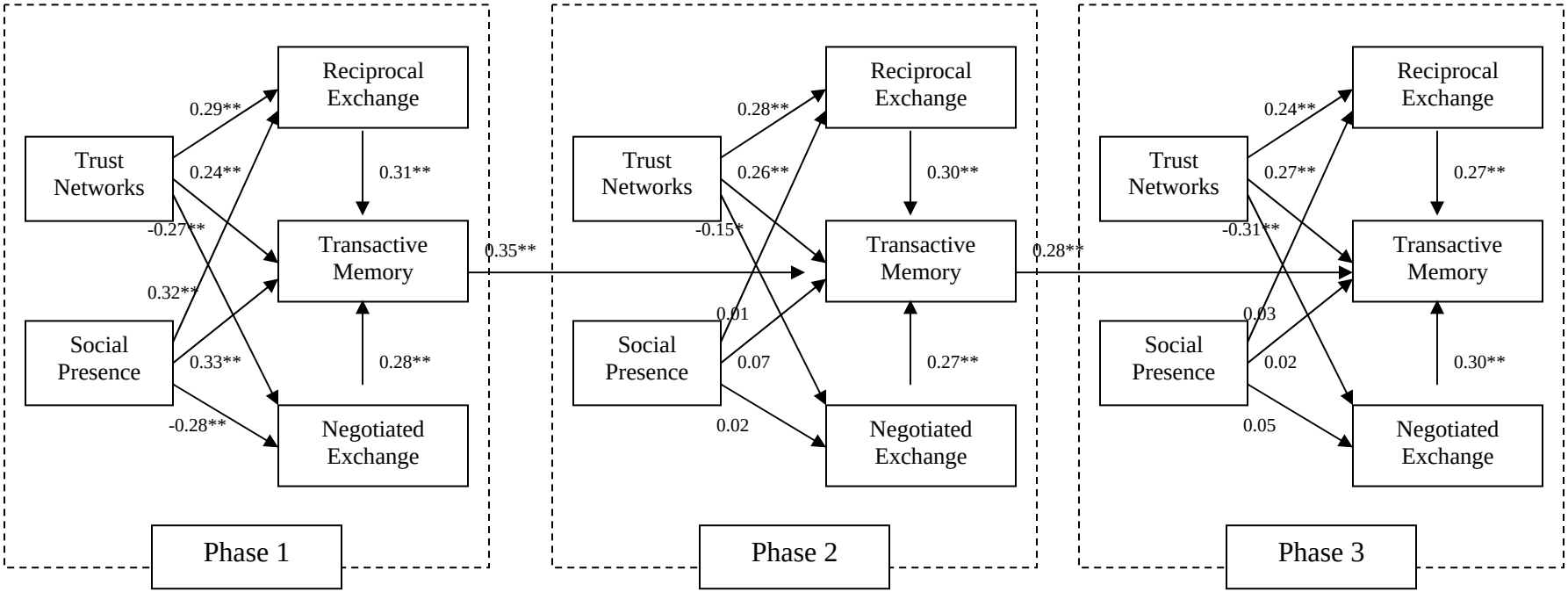
[i] TR: Trust; RE: Reciprocal Exchange; NE: Negotiated Exchange; TM: Transactive Memory

Table 4. Factor Analysis of Model Constructs

Construct[i]	Item No.	Factor 1	Factor 2	Factor 3	Factor 4
TR					
	TR1	**0.77**	0.03	-0.01	-0.04
	TR2	**0.75**	0.11	0.04	0.02
	TR3	**0.80**	0.01	0.02	0.13
	TR4	**0.84**	-0.04	0.13	0.01
	TR5	**0.78**	0.05	0.01	0.01
	TR6	**0.85**	-0.02	0.05	0.05
RE					
	RE1	-0.04	-0.15	**0.85**	0.01
	RE2	0.05	0.12	**0.82**	0.05
	RE3	0.11	0.04	**0.81**	0.02
	RE4	-0.01		**0.87**	-0.03
NE					
	NE1	0.08	0.03	0.11	**0.75**
	NE2	0.03	0.04	-0.01	**0.83**
	NE3	0.03	0.01	0.08	**0.80**
	NE4	0.04	0.08	0.02	**0.77**
TM					
	TS1	0.02	**0.75**	-0.12	-0.12
	TS2	0.03	**0.83**	0.08	0.04
	TS3	0.01	**0.89**	0.03	0.02
	TS4	0.08	**0.85**	-0.04	0.13
	TS5	0.01	**0.84**	0.05	0.01
	TC1	-0.05	**0.80**	0.11	0.01
	TC2	0.03	**0.83**	-0.01	0.02
	TC3	0.04	**0.88**	-0.15	0.02
	TC4	0.01	**0.79**	0.12	-0.03
	TC5	0.02	**0.89**	0.04	0.09
	TN1	0.02	**0.85**	0.03	0.03
	TN2	-0.03	**0.81**	-0.02	0.05
	TN3	0.05	**0.80**	0.09	0.01
	TN4	0.02	**0.82**	0.03	0.08
	TN5	0.03	**0.88**	0.05	0.01

[i] TR: Trust; RE: Reciprocal Exchange; NE: Negotiated Exchange; TM: Transactive Memory

Figure 2. Path Analyses Over Three Phases



* p < 0.05; ** p < 0.01

Arrows indicate path relationships. Positive values indicate positive relationships, and negative values indicate inverse relationships. For e.g., in phase 1, dense trust networks is associated with greater reciprocal exchange and lesser negotiated exchange than sparse trust networks. High social presence is associated with greater reciprocal exchange and less negotiated exchange than low social presence.

6. Discussion

6.1 Trust Networks and Transactive Memory

Transactive memory is an important vehicle for leveraging knowledge networks, as well as a shared resource for gaining access to more knowledge that any individual could possibly possess alone (Hollingshead, 1998). Knowledge hoarding due to the nature of distributed teams and knowledge loss caused by members' departure can be prevented with an effective system of transactive memory. From a relational perspective, recent research has found optimal mixture of strong and weak ties beneficial (Hansen, 1999), but it does not specifically explain why relational networks enhance knowledge sharing activities. The data analysis supports the first hypothesis that dense trust networks foster greater transactive memory than sparse trust networks. Previous studies have identified that social networks between distributed and co-located sites differed in communication network size and frequency (Herbsleb & Mockus, 2003). Distant colleagues may understand less about who has expertise in what area as a result of restricted information flow across sites and the lack of rapport (Kiesler & Cummings, 2002). However, this study suggests that developing trust relationships may help to alleviate problems arising from restricted information flow. Similar to social network analysis, the trusted third party behaves as information gate keepers (Constant et al., 1994) occupying distinctive positions to pass on their knowledge.

6.2 Role of Social Presence

The results from the study provide support for the hypothesis that sparse trust networks have greater transactive memory when social presence is high. Social presence plagues the effectiveness of teams with dense trusting ties. Close physical proximity and spontaneous communication may privilege interaction with people, but they may not be the right colleagues to communicate with for productive collaboration (Kraut et al., 2002). Hence, to some extent, trust and social presence are conceptually and empirically distinct. In this study, trust is found to improve over time, and its impact on transactive memory is significant in all three phases. However, social presence appears to influence transactive memory only in the beginning phase, suggesting that trust plays a stronger role over time (see Figure 2). Whether face-to-face interaction is required for transactive memory thus becomes an empirical question. Despite these inconsistent answers, an alternative perspective of trust networks and transactive memory is to view the social exchanges inherent in the teams.

6.3 Social Exchange Perspectives

The third research question examines the mediating effects of social exchange on the relationships of trust networks and transactive memory. The findings suggest that dense trust networks encourage reciprocal exchanges, while sparse trust networks encourage negotiated exchanges. In a social exchange transaction, enticing people to share knowledge involves creating an incentive structure that persuades them to enter into the transaction in exchange for other resources. Assuming that knowledge is a private good, Coleman (1990) visualizes a repayment system where obligations are represented as credits to be traded between people. Explicit forms of rewards include access to information in cases such as availability of production-related knowledge to any member of the network (Dyer & Nobeoka, 2000), and anticipation of help (Wasko & Faraj, 2000).

There is expectation of getting valuable knowledge in return for giving it, and this generates a need to contribute own knowledge to become part of the knowledge network which success depends on (Cohen, 1998).

A preliminary analysis of the data over three time phases shows that social exchange not only requires trust in others to discharge their obligations, but also develops trust in the process of exchange. More reciprocal exchanges in the first phase are associated with denser trust networks in the second phase ($r = 0.44$, $p < 0.05$). More reciprocal exchanges in the second phase are associated with denser trust networks in the third phase ($r = 0.36$, $p < 0.05$). Contrary to pure economic exchanges, social exchange may engender feelings of obligation and trust. Exchange relations may begin with minor transactions requiring little trust when risk is small. For example, one member may help another a few times. If the recipient fails to reciprocate, the member may cease further assistance or provision of information. Reciprocation helps to prove one's trustworthiness of continued favors and exchanges. By discharging their obligations for information rendered and demonstrating trustworthiness, individuals may induce mutual trust and expansion of future information supply. The processes of reciprocal exchange may generate trust in social relations recurrently. These findings set the stage for future directions in research efforts.

7. Future Research

What has emerged in this study is a new way of looking at distributed cognition in computer-supported teams. A culture of reciprocal exchange emerge in a dense network of trusting ties, in which social presence plays an important role in increasing transactive memory. An interesting question for future research is to extend the study to teams with more members and larger social networks, and determine whether occupying strategic positions in the teams could affect knowledge flow within and outside the team. As transactive memory is a group-level construct (Moreland, 1999), investigating a collective measure of transactive memory as well as objective measures such as performance of the team could also bring insights into the dynamics of trust networks and social presence. This study provides some evidence that social behaviors play a major role in motivating knowledge-building effort. Past studies typically focus on barriers to knowledge sharing rather than enabling factors (Homburg & Meijer, 2001). Underscoring the differences between dense and sparse networks of trusting ties, this study contributes empirically to the efforts in understanding cognitive and relational aspects highlighting the dynamics of computer-supported teams. Future research should continue to address the changes that dispersed work environments bring to organizations, and how distributed cognition can be enhanced with growing prevalence of knowledge-intensive activities.

8. References

Blau, P. M. (1964). Exchange and Power in Social Life. New York: Wiley.

Boland, R. J., Tenkasi, R. V. & Te'eni, D. (1994). Designing Information Technology to Support Distributed Cognition, *Organization Science*, 5, 456-75.

Brown, J. S. & Duguid, P. (1991). Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning and Innovation. *Organization*

Burt, R.S. (1992). *Structural Holes*. Cambridge, MA: Harvard University Press.

Carlson, J. R., & Zmud, R. W. (1999). Channel expansion theory and the experiential nature of media perceptions. *Academy of Management Journal*, 42, 153–170.

Cohen, D. (1998). Towards a knowledge context: Report on the first annual U.C. Berkeley forum on knowledge and the firm. *California Management Review*, 40(3), 22-39.

Coleman, J. (1990). *Foundations of social theory*. Cambridge, MA: Harvard University Press.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. Information *Systems Research,* 5, 400–421.

Dyer, J. H. & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal,* 21(3), 345-367.

Emerson, R. M. (1976). Social exchange theory. *American Sociological Review,* 35, 335-362.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 78, 1360-1380.

Hansen, M. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly,* 44, 82-111.

Herbsleb, J.D. & Mockus, A. (2003). An Empirical Study of Speed and Communication in Globally-Distributed Software Development. *IEEE Transactions on Software Engineering*, 29(3), 1-14..

Hollingshead, A.B. (1998). Distributed knowledge and transactive processes in groups. In M. A. Neale, E. A. Mannix, and D. H. Gruenfeld (Eds.), *Research on managing groups and teams* (Vol. 1). Greenwich, CT: JAI Press.

Homans, G. C. (1958). Social behavior as exchange. *American Journal of Sociology*, 63(6), 597-606.

Homburg, V. & Meijer, A. (2001). Would anyone like to share his knowledge? In the Proceedings of the 34th Annual Hawaii International Conference on System Science, Maui, Hawaii.

Jarvenpaa, S., Knoll, K., & Leidner, D. (1998). Is Anybody Out There? Antecedents of Trust in Global Virtual Teams. *Journal of Management Information Systems*, 14(4), 29-64.

Kiesler, S. and Cummings, J.C. (2002). What do we know about proximity and distance in work groups? A legacy of research. In P. Hinds & S. Kiesler, (Eds.), *Distributed Work.* (pp. 57-82). MA: MIT Press.

Kim, W. & Mauborgne, R. (1997). Fair process: managing in the knowledge economy. *Harvard Business Review*, 65-75.

Lewis, K. (2003). Measuring transactive memory in the field: Scale development and validation. *Journal of Applied Psychology*, 88(4), 587-604.

March, J. G. & Simon, H. A. (1958). *Organizations*. New York,, Wiley.

Molm, L. D., Peterson, G., & Takahashi, N. (1999). Power in Negotiated and Reciprocal Exchange. *American Sociological Review*, 64, 876-890.

Moreland, R. (1999). Transactive memory: learning who knows what in work groups and organizations. In L. Thompson, J. Levine, & D. Messick (Eds.), *Shared cognition on organizations* (pp. 3-31): Lawrence Erlbaum Associates.

Rulke, D., and Galaskiewicz, J. (2000). Distribution of knowledge, group network structure, and group performance. *Management Science*, 46(5), 612-625.

Short, J., Williams E., and Christie B. (1976). *The Social psychology of telecommunications*. London: John Wiley & Sons.

Sia, C. L., Tan, B. C. Y., and Wei, K. K. (2002). Group Polarization and Computer-Mediated Communication: Effects of Communication Cues, Social Presence, and Anonymity. *Information Systems Research,* 13(1), 70-90.

Thomas-Hunt M. Ogden T. and Neale M. (2003). Who's Really Sharing? Effects of Social and Expert Status on Knowledge Exchange Within Groups. *Management Science*, 49(4), 464-477.

Townsend, A. M., DeMarie, S. M. and Hendrickson, A. R. (1998). Virtual teams: Technology and the workplace of the future. *Academy of Management Executive,* 12(3), 17-29.

Uzzi, B. (1996). Sources and consequences of embeddedness for the economic performance of organizations. *American Sociological Review*, 61, 674-698.

Wasko, M. & Faraj, S. (2000). "It is what one does"; Why people participate and help others in electronic communities of practice. *Journal of Strategic Information Systems,* 9(2), 155-173.

Wegner, D. (1987). Transactive memory: a contemporary analysis of the group mind. In B. Mullen & G. Goethals (Eds.), *Theories of group behavior* (pp. 185-208). New York: Springer-Verlag.

Weick, K. E . (1995). *Sensemaking in organizations*, Sage, Thousand Oaks, CA.

Weiner, M. and Mehrabian, A. (1968). *Language Within Language: Immediacy, A Channel in verbal Communication*. New York: AppletonCentury-Crofts.

Yoo, Y and Kanawattanachai, P. (2001). Developments of Transactive Memory Systems and Collective Mind In Virtual Teams. *The International Journal of Organizational Analysis*, 9(2), 187-208.