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RESEARCH NOTE

THE IMPACT OF INFORMATION TECHNOLOGY AND TRANSACTIVE MEMORY SYSTEMS ON KNOWLEDGE SHARING, APPLICATION, AND TEAM PERFORMANCE: A FIELD STUDY[1]

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Abstract

In contemporary knowledge-based organizations, teams often play an essential role in leveraging knowledge resources. Organizations make significant investments in information technology to support knowledge management practices in teams. At the same time, recent studies show that the transactive memory system (TMS)—the specialized division of cognitive labor among team members that relates to the encoding, storage, and retrieval of knowledge—is an important factor that affects a team's performance. Yet little is known of how IT support for knowledge management practices in organizations affects the development of TMS. Furthermore, the precise role of TMS on knowledge sharing and knowledge application, which in turn influences team performance, has not been fully explored. In order to close this gap in the literature, we conducted a field study that involved 139 on-going teams of 743 individuals from two major firms in South Korea. Our results show that IT support in organizations has a positive impact on the development of TMS in teams, and that both TMS and IT support have a positive impact on knowledge sharing and knowledge application. Furthermore, we found that knowledge sharing has a positive impact on knowledge application, which in turn has a direct impact on team performance. However, contrary to our expectation, knowledge sharing does not have a direct impact on team performance and its impact on team performance was fully mediated by knowledge application. Our research shows that organizations can improve team members' meta-knowledge of who knows what through the careful investment in information technology. Finally, our results show that sharing knowledge alone is not enough. Organizations must ensure that shared knowledge is in fact applied in order to improve team performance.

Keywords: Transactive memory system, knowledge management, team performance, field study

[1]Dorothy Leidner was the accepting senior editor for this paper. Gabriele Piccoli served as the associate editor.

Introduction

> Organizational performance often depends more on how skilled managers are at turning knowledge into action than on knowing the right thing to do. Knowledge and information are obviously crucial to performance. But we now live in a world where knowledge transfer and information exchange are tremendously efficient, and where there are numerous organizations in the business of collecting and transferring best practices. So, there are fewer and smaller differences in *what firms know* than in their *ability to act on* that knowledge (J. Pfeffer and R. Sutton, *The Knowing-Doing Gap*, p. 243).

Knowledge is indispensable to contemporary organizations. An organization's ability to create, identify, share, and apply knowledge directly affects its competitive advantage (Alavi and Leidner 2001; Nonaka 1994). Teams are often considered to be an important building block in today's knowledge-based organizations (Cummings 2004; Rico et al. 2008). As such, organizations have made significant investments in implementing information technology that is specifically designed to support the sharing of knowledge among team members in the organization (Bock et al. 2005; Wasko and Faraj 2005).

At the same time, in a series of recent studies on teams, socio-cognitive processes have emerged as an important factor affecting team performance (Faraj and Sproull 2000; Kanawattanachai and Yoo 2007; Liang et al. 1995; Moreland 1999; Rico et al. 2008). A key problem underlying the socio-cognitive process in teams is the fact that knowledge in teams is unevenly distributed among individuals and artifacts (Boland et al. 1994; Hutchins 1995). In particular, recent studies found that a socio-cognitive structure called the *transactive memory system* (TMS) plays a particularly important role in a team's ability to leverage team members' knowledge in team performance. A TMS refers to a specialized division of cognitive labor that develops within a team with respect to the encoding, storage, and retrieval of knowledge from different domains (Wegner 1987). Through a TMS, team members know who knows what and who knows who knows what (Jarvenpaa and Majchrzak 2008). Recent studies have shown that a well-developed TMS can indeed improve team performance under various conditions (Faraj and Sproull 2000; Kanawattanachai and Yoo 2007; Lewis 2004; Liang et al. 1995).

Despite growing recognition of the importance of TMS in supporting a team's knowledge work and the increasing reliance on information technology in organizations to support knowledge work, no prior empirical studies that we know of have directly explored the role of information technology on the development of TMS. Furthermore, in the literature, the precise roles of TMS on knowledge sharing and knowledge application have not been fully explored. In this study, we integrate research on knowledge management systems and TMS to develop and test a set of hypotheses that explore the role of information technology in the development of TMS and its impact on knowledge sharing and application, which in turn are hypothesized to influence team performance in organizations. In so doing, we also note that past research on knowledge management tends to focus on knowledge sharing, while neglecting knowledge application. Therefore, we further explore the relationship between knowledge sharing and knowledge application. To test our hypotheses, we conducted a field study of 139 teams consisting of 743 individuals from two major companies in Korea.

In what follows, we first develop our hypotheses drawing on the TMS and knowledge management literature. We then describe our research design, followed by our findings. We conclude our paper by discussing implications for future research and management.

Theoretical Model and Hypotheses

Transactive Memory Systems in Teams

The idea of TMS was originally developed through the observation of dating couples (Wegner 1987). A TMS entails three substructures: (1) the specialization of knowledge; (2) cognitive trust in others' knowledge; and (3) an ability to coordinate knowledge according to the task structure and members' unevenly distributed knowledge. Wegner (1987; see also Wegner et al. 1991) found that dating couples in a close relationship treat their partners as an external memory device. Liang et al. (1995) found that a well-developed TMS can enhance team performance in a controlled laboratory setting. Subsequent empirical studies have explored different factors, such as feedback, learning, and communications, that affect the development of TMS (Hollingshead 1998a, 1998b; Moreland 1999; Moreland et al. 1996; Moreland and Myaskovsky 2000). Recently, Lewis (2004) and Kanawattanachai and Yoo (2007) found that the development of TMS affects team performance over time. Using simulation, Ren et al. (2006) explored the impact of TMS on team performance in varying conditions. More recently, scholars have begun exploring the impact of TMS on team performance in field settings, including new product development teams (Akgun et al. 2006), emergent response groups (Majchrzak et al.

2007), and law enforcement teams (Jarvenpaa and Majchrzak 2008).

Taken together, past studies on TMS have shown that TMS is an important antecedent that affects team performance under varying conditions. At the same time, organizations are investing in various types of information technology in order to improve knowledge management practices. Given the important role of TMS in team performance and the heavy reliance on information technology to support knowledge management, it is imperative to explore if and how information technology influences the development of TMS in teams. Therefore, our study attempts to make important contributions to the literature by explicitly focusing on the relationship between the use of information technology and the development of TMS. Furthermore, it is important to explore how TMS affects different aspects of knowledge management processes in teams. Finally, with few recent exceptions (Akgun et al. 2006; Jarvenpaa and Majchrzak 2008), past studies on TMS have focused on temporary teams or student teams. Our study contributes to the TMS literature by examining the impact of TMS on team performance in the context of continuing teams in organizations.

Information Technology and the Development of TMS

Information technology can play an important role in leveraging knowledge resources in organizations (Sambamurthy and Subramani 2005). Organizations often implement information systems that are specifically designed to support various aspects of knowledge management activities in organizations (Alavi and Leidner 2001). These systems include features such as intranets, search engines, document repositories (Hansen and Haas 2001), and collaboration tools that allow virtual communities of practices to be organized (Wasko and Faraj 2005; Wenger 1998).

IT tools that support knowledge management activities provide features that encourage certain communication and collaboration practices that facilitate the development of TMS in teams. For example, according to Jarvenpaa and Majchrzak (2008, p. 262), dialogic practices are "semi-structures that provide rules of conversations," and lead to the development of TMS in teams. Prior research shows that information technology can facilitate dialogic practices. For example, Boland et al. (1994) propose that information technology can be designed to facilitate dialogic practices by supporting ownership (indicating the authorship of the document), easy travel (enabling users to move effortlessly among documents), multiplicity (enabling easy comparisons of perspectives), indeterminancy (allowing partial and tentative documents), emergence (allowing the construction of new categories and constructs), and mixed form (allowing different forms of representations). Drawing on Boland et al., Majchrzak et al. (2005) find that information technology can indeed provide communication contexts that are conducive to dialogic practices. Information technologies supporting knowledge management practices often include many of these features that support dialogic practices. For example, the most basic tool for knowledge management is a document repository, which supports ownership, easy travel, and multiplicity. Organizations also employ information technologies such as online discussion boards or groupware tools that support multiplicity, indeterminancy (in the form of questions and answers), and mixed forms (as they often allow different types of content to be posted). Therefore, we argue that the use of information technology to support knowledge management will lead to the development of TMS in teams.

In addition, past research on TMS also suggests that frequent communication among team members positively influences the development of TMS (Hollingshead 1998a; Kanawattanachai and Yoo 2007). Information technology is used to support effective and frequent communication among team members through personalization (Alavi and Leidner 2001; Hansen et al. 1999). Therefore, the use of information technology is likely to positively influence the development of TMS.

Furthermore, KMS also has certain features that offer direct support for the development of TMS. For example, as Gray (2000) notes, KMS provides a knowledge map of who knows what in organizations. Yoo and Ifvarsson (2001) report that consultants in a global consulting firm they studied often use the document repository of the firm's KMS not only as a document storage tool, but as an external expertise directory. Individuals use the search function to find documents as well as authors who might possess the specific knowledge they need. Therefore, the storage, search and access of information using these tools often helps teams formalize their TMS (Nevo and Wand 2005). Taken together, we hypothesize that

> ***H1**: The use of IT to support knowledge management practices will lead to a more developed sense of TMS in teams.*

The Development of TMS and Knowledge Management Practices

When a team performs a task, its members need to share and utilize their unique knowledge. An effective TMS may enhance each team member's ability to coordinate knowledge effectively. Alavi and Leidner (2001) note that knowledge management practices in organizations consist of knowledge creation, storage, sharing, and application. Among these, in this paper we focus on knowledge sharing and application as they have the most direct impact on the performance of a team that has distributed knowledge (Alavi and Tiwana 2002, p. 1030).

First, TMS provides essential meta-knowledge that enables team members to effectively share knowledge among one another. Knowledge sharing refers to the process of locating distributed knowledge in an organization and transferring it to another context where the knowledge is needed (Alavi and Leidner 2001). Members of a team that has a well-developed TMS are likely to be able to effectively pull knowledge from other team members, drawing on their knowledge of who knows what. In fact, past studies on TMS show that a well-developed TMS can lead to effective knowledge sharing among team members (Akgun et al. 2006; Hollingshead 1998a; Hollingshead et al. 2002; Moreland and Argote 2004). Furthermore, as a team develops its TMS, its members can also anticipate what others may need to know based on their knowledge specialization; thus, they can provide their own knowledge to others more effectively (Faraj and Sproull 2000; Ren et al. 2006). These earlier studies indicate that a team with a well-developed TMS will share knowledge effectively.

> ***H2:*** *A more developed sense of TMS will lead to more effective knowledge sharing in teams.*

Second, TMS is also likely to influence a team's ability to apply its existing stock of knowledge. Knowledge application refers to "the phase in which existing knowledge is brought to bear on the problem at hand" (Alavi and Tiwana 2002, p. 1030). Knowledge application is important as knowledge creation or sharing do not necessarily lead to performance improvements unless they are applied (Alavi and Leidner 2001; Alavi and Tiwana 2002). Pfeffer and Sutton (2000) call this the *knowing–doing gap*. Therefore, merely sharing and transferring knowledge in organizations is not enough if they are not effectively applied to solving problems and delivering products and services.

Alavi and Tiwana (2002) argue that TMS can enhance the ability of groups to integrate knowledge, which is "a key facet of knowledge application" (p. 1030). They further argue that TMS enables team members to pool knowledge to solve problems. Similarly, Rico et al. (2008) argue that team members' meta-knowledge of others' knowledge allows them to anticipate what types of knowledge are needed and dynamically adjust in order to meet the need. Indeed, empirical studies in different contexts have provided support for these predictions (Faraj and Sproull 2000; Jarvenpaa and Majchrzak 2008; Kanawattanachai and Yoo 2007). Furthermore, past studies of TMS have found that it can facilitate effective knowledge application. For example, Lewis et al. (2005) found that TMS can help teams apply prior knowledge to a given task in a similar domain. Their study shows that TMS acts as a learning mechanism by which team members can apply knowledge acquired from a prior task in a new context. Thus, we hypothesize

> ***H3:*** *A more developed sense of TMS will lead to more effective knowledge application in teams.*

Information Technology and Knowledge Management Practices

Alavi and Leidner have suggested that information technology can enhance group members' ability to share knowledge. Past studies on computer-mediated communication have also shown that the use of IT can indeed facilitate the sharing of knowledge among group members (Valacich et al. 1993; Wheeler and Valacich 1996). Based on these early studies, many organizations built knowledge repositories and supported forms of practice communities using various types of information technology to promote knowledge sharing in teams (Bock et al. 2005; Hansen 2002; Majchrzak et al. 2004; Wasko and Faraj 2005). In the context of distributed teams, Gupta et al. (2009) found that IT facilitates knowledge sharing in teams. Drawing on these early studies, we hypothesize

> ***H4:*** *The use of IT to support knowledge management practice will lead to more effective knowledge sharing in teams.*

IT can also facilitate more effective knowledge application in teams (Alavi and Leidner 2001). Studies have shown how the use of advanced IT influences the way team members integrate knowledge (Argyres 1999; Carlile 2002; Yoo et al. 2006). These studies have shown how IT allows team members to solve complex problems and invent new solutions by taking diverse perspectives into consideration (Boland and Tenkasi 1995). IT also allows tacit knowledge to be captured in a more standardized format so that it can be readily applied in different contexts (Hansen et al. 1999; Nonaka and Takeuchi 1995). Thus, we hypothesize

> ***H5:*** *The use of IT to support knowledge management practice will lead to more effective knowledge application in teams.*

Knowledge Management Practices and Team Performance

The literature on knowledge management suggests that knowledge sharing and knowledge application will have a positive impact on team performance. First, past research has clearly shown that knowledge sharing has a positive impact on team performance in many different contexts (Argote and Ingram 2000; Cummings 2004; Hansen 2002). In fact, knowledge sharing has taken on the quality of a truism in many organizations, similar to the often-repeated expression, "Don't reinvent the wheel." Drawing on these earlier works, we hypothesize

> ***H6**: Knowledge sharing will lead to higher team performance.*

Teams must not only share knowledge, but also apply it effectively in order to address the given challenge. Majchrzak et al. (2004) argue that applying shared knowledge is a distinctively different knowledge management practice from knowledge sharing. Dennis (1996) found that team members often fail to utilize *shared* information in making collective decisions, thus leading to suboptimal outcomes. Similarly, drawing on the work by Grant (1996), Alavi and Tiwana note that knowledge application in virtual teams should be explored as a separate construct from knowledge sharing. Pfeffer and Sutton lament that most *shared* knowledge is not effectively applied in organizations. Faraj and Sproull (2000) find that team members' ability to bring knowledge to bear is a significant antecedent to team effectiveness. Kanawattanachai and Yoo also report that a virtual team's ability to apply knowledge in a given context is an important antecedent to team performance. Taken together, prior studies suggest that a team's ability to integrate their existing stock of knowledge and apply it within a new context is an important factor that contributes to team performance. Thus, we hypothesize

> ***H7**: Knowledge application will lead to higher team performance.*

Finally, we note that the concept of knowledge application in part implies *a priori* knowledge sharing. Knowledge needs to be acquired before it can be used. Of course, individuals can acquire knowledge through their own learning and experiences. However, in an organizational setting, both formal and informal knowledge sharing serve as important mechanisms by which individuals acquire knowledge (Alavi and Leidner 2001; Argote et al. 2000). Thus, we hypothesize

> ***H8**: Knowledge sharing will lead to higher level of knowledge application in teams.*

Figure 1 shows the theoretical model that was tested. Individual hypotheses were depicted in the figure.

Method

Study Context

We tested our hypotheses with a cross-sectional survey from two leading firms in South Korea, OilCo and SteelInc. We chose these two firms as they have well-established knowledge management tools and practices. The survey was administered separately to team members and team leaders. The knowledge management staffs of two firms endorsed and facilitated the data collection through e-ail, although the participation was voluntary.

OilCo is one of the largest energy and petrochemical companies in the world. Its business covers oil import, refinery, and retail, as well as other petroleum-based energy and chemical sectors. In 2008, its annual sales volume exceeded \$36 million (U.S.) with a refinery capacity of almost 1.2 billion barrels per day. While the main market is South Korea, its business activities span 22 different countries with 5,000 employees. SteelInc is one of the largest steel manufacturers in the world with an annual production capacity of 33 million tons. In 2008, its annual sales revenue exceeded \$33 billion (U.S.) with over 17,400 employees. Both firms started as public companies and were later privatized.

Both OilCo and SteelInc have vibrant and well-established knowledge management practices supported by dedicated knowledge management teams who also maintain knowledge management systems. OilCo started its formal investment in knowledge management in 2001 and currently has nine full-time knowledge management staff members. SteelInc started its knowledge management efforts in 2000, and today has six full-time staff members supporting its knowledge management activities. Knowledge management systems at both firms have been built around the notion of communities of practice with the combination of knowledge repositories, bulletin boards, and integrated search engines. The systems are designed to support knowledge sharing and learning for different teams to enable continuous quality improvement. These systems, combined with the concerted efforts of the firms' management and knowledge management teams, have ensured the majority of teams at these companies actively use the systems to share knowledge. At the time of our data collection, there were over 1,800 and 1,600 communities of practices at OilCo and SteelInc, respectively. OilCo stores over 150,000 documents in their system, while SteelInc stores

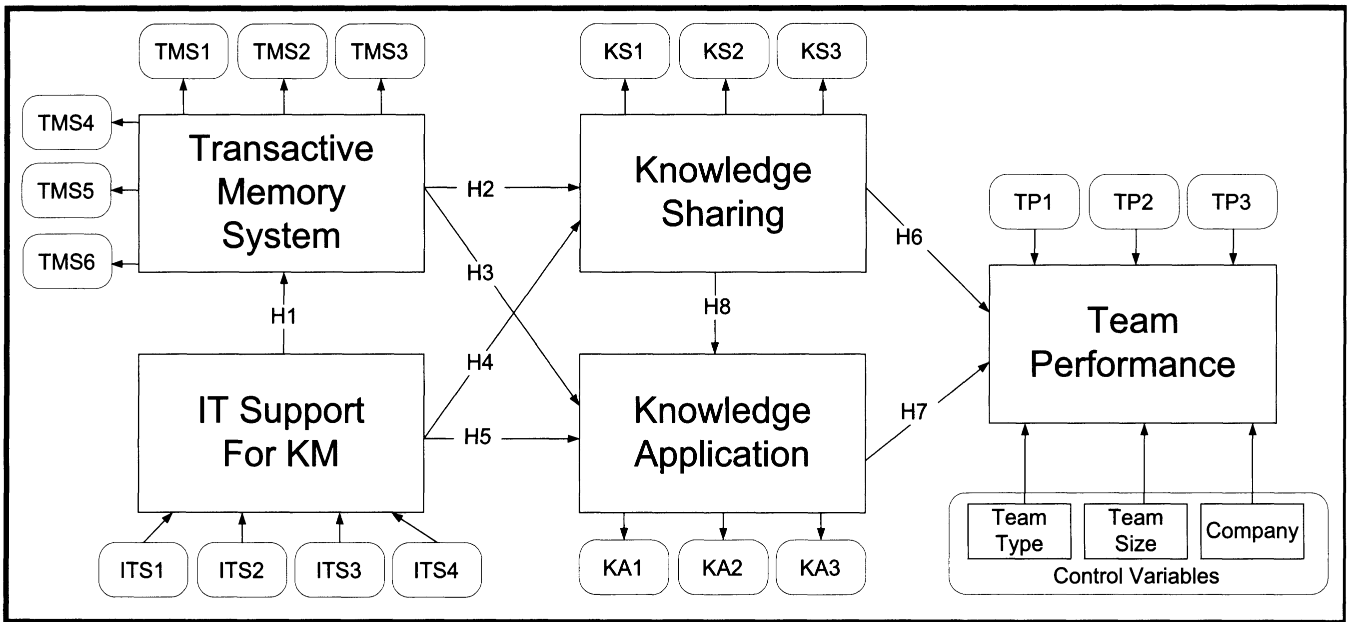

Figure 1. Research Model

over 280,000. Both firms have been recognized for their knowledge management practices and have been benchmarked numerous times for their effective knowledge management practices.

Survey Sample

We conducted a survey through the knowledge management teams at these firms. The survey was administered through the firms' internal websites over a period of one month. A total of 942 individuals from 259 teams across both firms responded. After discarding incomplete responses and teams with fewer than three individual responses (without including the team leader), we were left with 743 individuals in 139 teams. Table 1 provides demographic characteristics of the survey participants. In order to avoid the common-method bias, we administered surveys on team performance to team leaders separately.

Survey Measures

We measured *transactive memory systems* (TMS) using six items developed by Lewis (2003). We asked individuals to rate their team's TMS based on their interactions with others on the team. We measured *IT support for knowledge management practices* (ITS) using four items from Lee and Choi (2003). We asked individuals to rate their perceptions of their organization's IT support with respect to collaboration, communication, storage, search, and access of information. Although Lee and Choi used a reflective construct with five items, based on the recommendations of Petter et al. (2007), we specify them as formative measures as each of these items represent distinctly different functions of IT that support knowledge management practices. Among the five original items, we dropped the item that measures IT support for simulation as it was not directly relevant to knowledge management practices at OilCo and SteelInc.

We developed a three-item scale for *knowledge sharing* (KS) based on the knowledge sharing intention measured by Bock et al. (2005). Their original instrument was designed to measure the intention to share knowledge in an organizational setting with five items. We modified their items to measure individuals' perceptions of the degree to which their team members share different forms of knowledge. We dropped two items in order to improve the reliability of the scale based on our preliminary data analysis. Similarly, we developed a three-item scale for *knowledge application* (KA) based on the knowledge application capability measure developed by Gold et al (2001). Their original instrument was designed to capture an organization's capability to apply knowledge at the firm level. From the 12 original items, we selected five that were applicable to the team setting and modified them to measure knowledge application within a team. After the preliminary analysis, we further dropped two items in order to improve reliability.

Table 1. Summary of Sample Profile							
Individual				**Team**			
Characteristics		Frequency	Percent	Characteristics		Frequency	Percent
Gender	Male	626	84.2	Company	OilCo	87	62.6
	Female	117	15.8		SteelInc	52	32.4
Total		743	100.0	Total		139	100.0
Job position	Managing Director	156	21.0	Function	Manufacturing	96	69.1
	Director	89	12.0		Non-manufacturing	43	30.9
	Manager	162	21.8				
	Chief Employee	45	6.1	Size	5–25	65	46.8
	Employee	267	35.9		25–50	67	48.2
	No response	4	3.2		50+	7	5.0
Total		743	100.0	Total		139	100.0

Finally, we measured *team performance* (TP) using three items from the team performance measure developed by Janz et al. (1997). Their measure of team performance consists of quality, efficiency, and timeliness in the context of knowledge workers, which is appropriate for our study. Again, following the suggestion by Petter et al., we specify it as a formative measure with three indicators as they reflect distinctly different aspects of team performance. The details of survey items are given in Appendix A.

All items were measured using a seven-point, Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Before the actual survey, in order to make sure the questions were appropriate to these two firms, we asked managers of these two firms to review the instruments. We further conducted a separate pilot study in order to improve the validity and reliability of our scales.

Analysis Strategy

Preliminary analyses across the two companies showed no significant differences. Therefore, we pooled the data for our analysis. However, to control any possible impact of each firm's idiosyncratic knowledge management practices, we included company as a control variable. In addition, we included two team characteristics, team size and team type (manufacturing and non-manufacturing), as control variables (He et al. 2007; Rico et al. 2008). Among five key constructs, TMS, KA, and KS were modeled as reflective measures as we expected that items measuring these constructs would covary (Petter et al. 2007). For example, three items for knowledge sharing all measure the underlying construct of knowledge sharing through three separate means.

We conducted our analysis in three steps. First, we examined the psychometric properties of the measures using exploratory and confirmatory factory analyses, employing individual-level data (Kanawattanachai and Yoo 2007). Second, we performed statistical tests to examine the appropriateness of aggregating individual-level responses into a team-level score. At the same time, we checked the common-method bias. Finally, we tested hypotheses by testing the proposed path model using a principle component-based structural equation modeling tool, partial least square (PLS).

Results

The results are presented into two parts. First, we discuss the measurement model to confirm the convergent and discriminant validity, as well as the reliability, of the constructs. We also demonstrate the appropriateness of aggregating the data at the team level and the test for a possible common method bias. Then, we discuss the structural model to test the hypothesized relationship among the constructs.

Test of the Measurement Model

Exploratory Factor Analysis

We conducted an exploratory factor analysis of all reflective measures (TMS, KS, and KA) using the maximum likelihood method to extract the initial factors, and employed an oblique method in the rotation phase to take into account the correlation among factors (Pedhazur and Schmelkin 1991). Table 2 shows loading and cross-loading. Although there is some

Table 2. Exploratory Factor Analysis and Cronbach's Alpha

Item	Factor		
	1	2	3
TMS1	**0.70**	0.14	0.03
TMS2	**0.85**	-0.06	-0.15
TMS3	**0.89**	-0.07	-0.11
TMS4	**0.88**	-0.10	-0.09
TMS5	**0.73**	0.21	0.25
TMS6	**0.74**	0.16	0.28
KS1	0.55	**0.68**	0.17
KS2	0.47	**0.76**	0.08
KS3	0.49	**0.75**	0.11
KA1	0.54	0.14	**0.66**
KA2	0.61	0.13	**0.69**
KA3	0.62	0.17	**0.67**
Cronbach's α	**0.90**	**0.88**	**0.90**

cross loading, all items load more highly on their own constructs than on other constructs, supporting a three-factor solution for TMS, KA, and KS. All factor loading scores were as expected. The three factors account for almost 75 percent of total variance. All factors show a high reliability with Cronbach's alpha greater than .85 (see Table 2).

Confirmatory Factor Analysis

Since reflective items show fairly high cross-loading scores and the constructs were also correlated, we conducted a separate confirmatory factor analysis of the three reflective constructs, using AMOS. We constrained the confirmatory factor analysis model in such a way that each item loads on only one underlying factor and error terms among items are not allowed to be correlated (Anderson and Gerbing 1982). Thus, the model has three factors that are freely correlated (M_3 in Figure 2). The results (Table 3) show that all loadings were significant and greater than .70. All goodness of fit indexes clearly indicate that the model fit well with the data.

To further ensure discriminant validity, we compared the theorized measurement model against three alternative measurement models using a hierarchical model comparison strategy (Anderson and Gerbing 1988): (1) a null model (M_0); (2) a single-factor model having each of the final 12 items loaded on a single factor (M_1 in Figure 2); and (3) a three-factor model with any correlation among factors fixed to one (M_2, see Figure 2). The difference in chi-square statistics was used to test the superiority of one measurement model over another in these comparisons. Table 3 shows the results of the hierarchical comparisons we conducted. The first three comparisons demonstrate the superiority of the three-factor model over the null and one-factor models. The last comparison (M_2–M_3) demonstrates that the three underlying factors are indeed distinct from one another and that the correlations among them are statistically different from unity (Pedhazur and Schmelkin 1991, p. 681).

We further examined the discriminant validity using the square root of the average variance extracted (Fornell and Larcker 1981). As shown in Table 4, all square roots of the average variance extracted and displayed on a diagonal of a correlation matrix are greater than the off-diagonal construct correlations in the corresponding rows and columns. Combined with the results of the confirmatory factor analysis, this indicates that each reflective construct shared more variance with its items than it shares with other reflective constructs, thereby demonstrating the convergent and discriminant validity.

In order to test the construct validity of formative measures (ITS and TP), we first inspected the weight of each item in the inner model following the recommendation of Petter et al. As shown in Table 5, all the weights were statistically significant at the target construct, except one item for ITS. Petter et al. also suggest that the VIF (variance inflation factor) score for

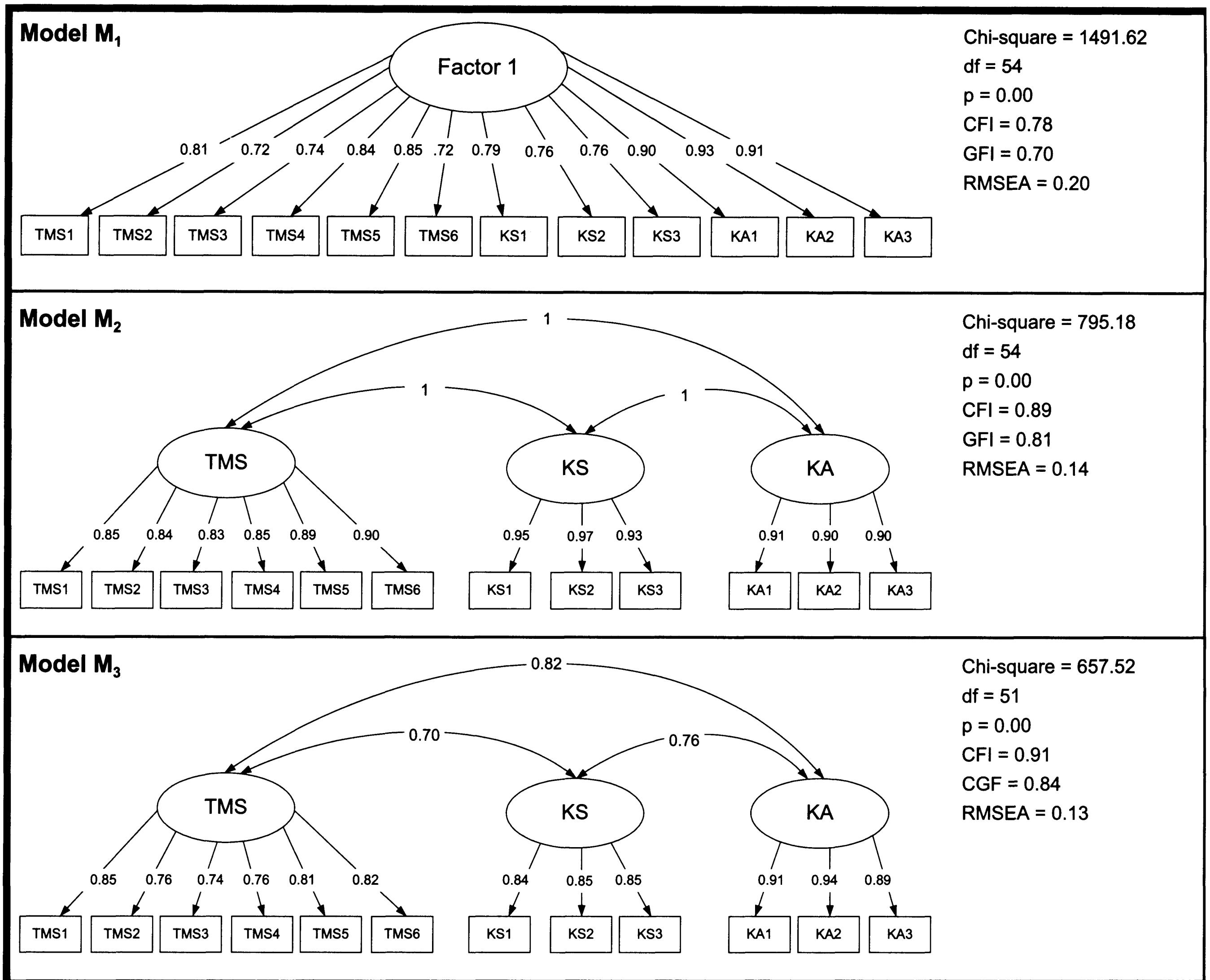

Figure 2. Confirmatory Analysis

Table 3. Hierarchical Comparisons of Measurement Models

Model	**Description**	χ^2	**df**	
M_0	Null model	6544.70	66	
M_1	One-factor model	1491.62	54	
M_2	Three-factor model (factor correlations fixed to 1)	796.18	54	
M_3	Three-factor model (factors are freely correlated)	657.62	51	
Model Comparisons		$\Delta\chi^2$	**Δdf**	**p**
M_0–M_1	Test for the fit of the one-factor model over null model	5053.08	12	0.00
M_0–M_3	Test for the fit of the three-factor model over null model	5749.52	15	0.00
M_1–M_3	Test for the fit of the three-factor model	834.00	3	0.00
M_2–M_3	Test for the discriminant validity of the three factors	137.56	3	0.00

Table 4. Correlation Matrix of Latent Variables

Construct	TMS	ITS	KS	KA	TP
TMS	**0.99**				
ITS	0.65	**0.93**			
KS	0.63	0.64	**0.88**		
KA	0.78	0.66	0.68	**0.92**	
TP	0.37	0.30	0.30	0.36	**0.87**

Table 5. Loading Scores of Formative Constructs

Construct		Loading Score	t-value
ITS	ITS1	0.80	2.57**
	ITS2	0.89	5.29**
	ITS3	0.96	3.94**
	ITS4	0.88	1.13
TP	TP1	0.91	7.66**
	TP2	0.92	5.99**
	TP3	0.89	5.85**

*p < 0.05; **p < 0.01

formative constructs should be within less than 3.3. Both formative constructs of our study show VIF scores of less than 3 (ITS = 1.87, TP = 2.76). Therefore, our analysis reveals no multicollinearity among items for the formative constructs we used in the study. Finally, to ensure the content validity of the formative measures, we ask the managers at two participating companies to confirm that these measures adequately cover different aspects of IT support for knowledge management practices and team performance in their organizations.

Aggregation Analysis and Common Method Bias

In order to make certain that we can aggregate individual responses at the team level, we calculated inter-rater reliability using the interclass correlation coefficient (ICC) (Shrout and Fliess 1979) and James' index (rwg) (James et al. 1993). Both ICC values and rwg values all exceeded 0.7.

Finally, we examine the possible common method bias. Following the recommendation by Podsakoff et al. (2004) and Liang et al. (2007), we ran a PLS model with a common method factor and calculated each indicator's variances as explained by the principal construct and by the method. Our results show that the average variance of indicators explained by the construct is .799, while the average variance explained by the method is .006. The ratio between the two is 133.2:1. Furthermore, all of the method factor loadings are not significant. Therefore, we conclude that the common-method bias is not a threat to the validity of our study.

Structural Model

Figure 3 depicts the PLS results. The hypothesized path from IT support to TMS is significant, supporting H1. As predicted, TMS has a significant impact on both knowledge sharing (H2) and knowledge application (H3). Similarly, IT support has a significant impact on both knowledge sharing (H4) and knowledge application (H5). Finally, contrary to our expectation, knowledge sharing does not have a direct impact on team performance, thus rejecting H6. On the other hand, we find that knowledge application has a positive impact on team performance, supporting H7. While knowledge sharing does not affect team performance directly, it has a positive impact on knowledge application, supporting H8.

Among the control variables (team size, team type, and company), only team type was significant. Manufacturing teams performed better than non-manufacturing teams.

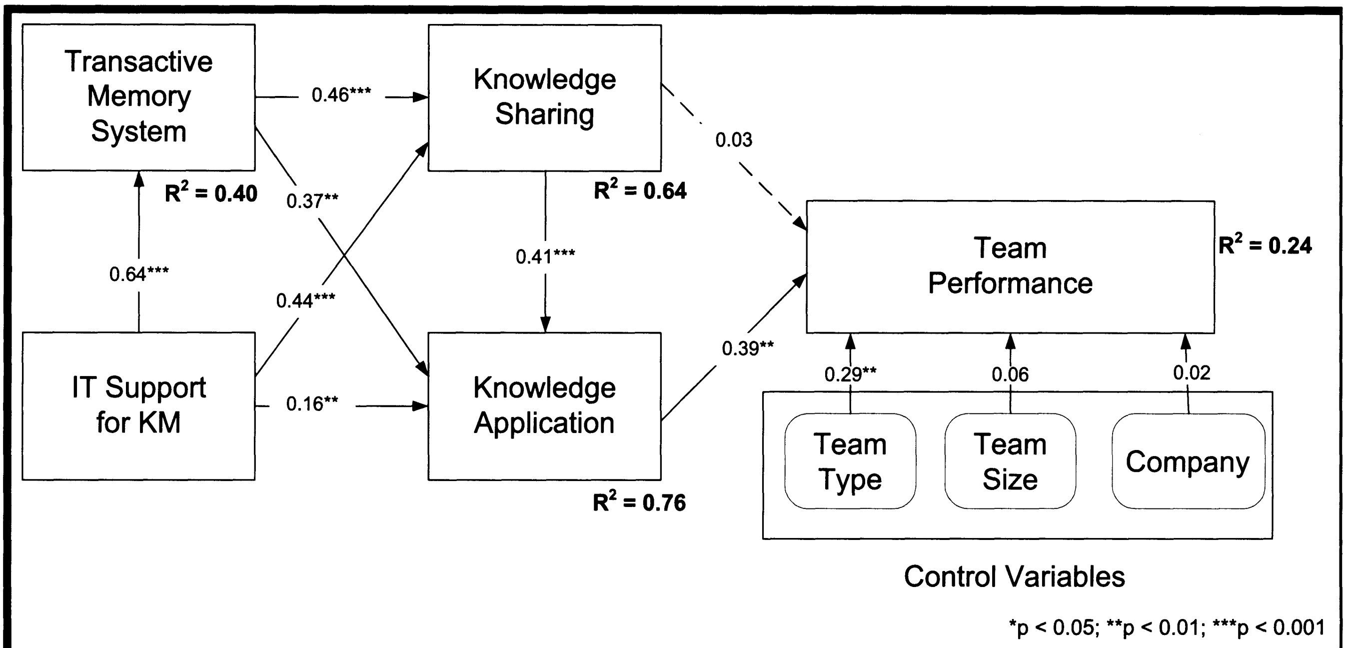

Figure 3. Analysis Results

Discussion and Conclusion

In this study, we explore the impact of IT on the development of TMS in teams within organizations. We also examine how IT and TMS influence knowledge sharing and knowledge application, which in turn are hypothesized to influence team performance. Our findings provide important implications for knowledge management research and practice.

Implication for Knowledge Management Research

Our results clearly demonstrate that information technologies that are designed to support knowledge management practice in organizations facilitate the development of TMS. OilCo and SteelInc provide typical IT tools to support knowledge management practice, including knowledge repositories (storage), bulletin boards (communication and coordination), and search engines (search and access of information). While we did not explicitly explore the role of dialogic practices at these firms, these tools certainly have features that support dialogic practices, such as ownership, multiplicity, easy travel, mixed form, and emergence, as discussed in the literature (Boland and Tenkasi 1995; Majchrzak et al. 2005). Given that these firms did not implement IT tools that might provide more direct support for TMS (such as expertise directory), the substantive path coefficient from ITS to TMS suggests that even conventional IT support can enhance the effectiveness of knowledge management by significantly enhancing teams' TMS. It is also possible to speculate that the impact of ITS on TMS is likely to be stronger if firms implement tools such as an expertise directory that are aimed at providing more direct support for TMS among team members. Given the recent interest in IT materiality (sustained and substantive attributes and characteristics of IT artifacts; Leonardi and Bailey 2008; Leonardi and Barley 2008; Orlikowski and Scott 2008), our study suggests that a fruitful avenue for future research lies in examining the linkage between specific IT materiality to the development of TMS.

Our results also suggest that when IT support is co-present with TMS, it is much more effective in enhancing knowledge sharing and application among team members than without TMS. In particular, the impact of ITS on knowledge application is much smaller than the impact of TMS on knowledge application. This suggests that if one measures only the direct impact of IT on knowledge sharing, the impact might be overestimated (Gupta et al. 2009). Our results show that much of the impact of ITS on knowledge sharing and knowledge application is mediated through TMS. This does not minimize the important role of IT tools in knowledge management in any way. Instead, our finding reflects a much more elaborate route by which IT affects knowledge sharing and application in teams.

Our finding also shows that IT has a much weaker direct impact on knowledge application when compared to its impact on TMS development and knowledge sharing. It seems to suggest that different types of IT support might be needed to effectively support knowledge application, compared to typical IT support primarily developed for knowledge sharing, as knowledge application and knowledge sharing require different socio-cognitive faculties in teams. When teams are trying to apply knowledge in different contexts, they need to be able to integrate different perspectives (Alavi and Tiwana 2002; Grant 1996). Past research shows that such knowledge integration requires *pragmatic boundary objects* (Carlile 2002), or that teams need to create *trading zones* (Boland et al. 2007). Also, Rico et al. (2008) argue that the explicit coordination that requires deliberate communication among team members is different from implicit coordination that emphasizes improvisation and mutual adjustment for unanticipated situations. The idea of explicit coordination is similar to knowledge sharing as both require explicit and deliberate communication. On the other hand, their idea of implicit communication is similar to knowledge application as both emphasize the idea of coping with new contexts. Drawing on these works, future research will have to examine more closely the different types of IT tools that support knowledge sharing and knowledge application.

Our study also shows that TMS is indeed a very important factor that affects both knowledge sharing and knowledge application in teams. Past studies have shown that TMS affects team performance (Jarvenpaa and Majchrzak 2008; Kanawattanachai and Yoo 2007; Lewis 2004). Our finding shows that TMS influences team performance through knowledge sharing and knowledge application, and that future TMS research must consider the role of knowledge sharing and application along with other variables as they examine the role of TMS on team performance.

Perhaps the most surprising finding of our study is the lack of direct impact of knowledge sharing on team performance. Our study clearly shows that the impact of knowledge sharing on team performance is fully mediated by knowledge application. This clearly echoes the concern about the *knowing–doing gap* (Pfeffer and Sutton 2000). Our results show that no matter how much knowledge is shared among team members, it cannot enhance team performance unless it is effectively applied. Furthermore, our finding shows that IT has a much larger direct impact on knowledge sharing than knowledge application. Taken together, if a firm blindly implements information technology for knowledge sharing, but fails to help teams develop TMS among team members, it is likely to suffer from the knowing–doing gap. In this case, knowledge management is not likely to provide an expected return as evidenced through performance improvements. This finding should raise caution among the knowledge management research community, who were predominantly interested in the role of information technology on knowledge sharing (Alavi and Tiwana 2002). Our study suggests that more research needs to be done on knowledge application and its relationship to other key constructs that have received significant attention from scholars in recent years.

Implications for Practice

Our finding has a few clear implications for knowledge management practice in organizations. First, firms must design information technology so that it can effectively enhance TMS in teams. Firms must recognize that blind investments in knowledge management systems alone may not produce expected outcomes. They must carefully consider how IT tools are supporting the development of TMS in teams. Past research also shows a number of other factors that affect the development of TMS such as training, feedback, and communication (Lewis 2004; Lewis et al. 2005; Liang et al. 1995; Moreland 1999). Therefore, if the investment in information technology to support knowledge management practice is made in the absence of these other factors that are known to positively affect TMS, the firm might be better off by addressing these other issues first.

Second, firms must pay close attention to knowledge application as well as knowledge sharing. Often, firms use various aspects of knowledge sharing as an important metric of knowledge management practices. While knowledge sharing is certainly important (particularly as an antecedent of knowledge application), knowledge sharing alone cannot improve team performance: the shared knowledge must be effectively applied. Teams must understand the barriers and opportunities for knowledge application, which may not be the same as knowledge sharing. This might suggest different incentive mechanisms as well as different types of IT tools.

Future Research Opportunities

Like other studies, ours has a few limitations. Those limitations, however, offer future research opportunities. We have identified four such opportunities. First, past studies on TMS clearly suggest that TMS is a multidimensional construct with three distinctively different sub-dimensions (Kanawattanachai and Yoo 2007; Liang et al. 1995). Yet, our study treated TMS as a uni-dimensional construct. Future research must explore how different dimensions of TMS interact with knowledge sharing and application, as well as different IT tools.

Second, as noted above, past studies of TMS also suggest that there are several factors such as team characteristics that influence the development of TMS (Lewis 2004; Lewis et al. 2005; Liang et al. 1995; Moreland 1999). Our study only included team size and team type as control variables. Future research should take into consideration the more direct effects of these factors as they examine the impact of IT tools on the development of TMS.

Third, past research has shown that TMS is dynamic and evolves as teams spend more time together (Brandon and Hollingshead 2004; Kanawattanachai and Yoo 2007). Our study, however, treated TMS as a static construct. Future research must explore how the relative impact of TMS and IT tools on knowledge sharing and knowledge application change over time as a team develops. Most teams participating in our study were established teams with significant experience among team members. It is possible to conjecture that the impact of TMS is likely to be much weaker when the team is new, thus leaving the impact of IT tools on knowledge sharing and application much greater than in the case of established teams. Future research must consider the temporal and dynamic aspects of TMS.

Finally, past research shows that both organizational norms and national cultures have a significant impact on knowledge sharing (Bock et al. 2005; Yoo and Torrey 2002). Both firms have very strong organizational norms relative to knowledge sharing with strong management support. Also, South Korea has a relatively strong collective culture. Both of these factors might have increased the relative importance of TMS over IT tools in influencing knowledge sharing and application. Future research should replicate our findings in a less collective culture and in organizations with weaker organizational norms surrounding knowledge management.

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Appendix A

Survey Items

Construct	Item		Mean (Std. Dev.)
Transactive Memory System	TMS1	Our team members have specialized knowledge of some aspects of our task.	5.95 (0.50)
	TMS2	Our team members are comfortable accepting procedural suggestions from other team members.	5.46 (0.51)
	TMS3	Our team members trust that other members' knowledge about the project is credible.	5.64 (0.46)
	TMS4	Our team members are confident of relying on the information that other team members bring to the discussion.	5.79 (0.61)
	TMS5	Our team members know each other and have the ability to work together in a well-coordinated fashion.	5.80 (0.51)
	TMS6	Our team members have the capability to respond to the task-related problems smoothly and efficiently.	5.76 (0.50)
IT Support for KM	ITS1	Our team is provided with IT support for collaborative work regardless of time and place.	5.56 (0.54)
	ITS2	Our team is provided with IT support for communicating among team members.	5.73 (0.45)
	ITS3	Our team is provided with IT support for searching and accessing necessary information.	5.72 (0.51)
	ITS4	Our team is provided with IT support for systematic storing.	5.55 (0.49)
Knowledge Sharing	KS1	Our team members share their work reports and official documents with other team members.	5.66 (0.59)
	KS2	Our team members provide their manuals and methodologies for other team members.	5.73 (0.59)
	KS3	Our team members share their experience or know-how from work with other team members.	5.81 (0.55)
Knowledge Application	KA1	Our team members apply knowledge learned from experience.	5.91 (0.43)
	KA2	Our team members use knowledge to solve new problems.	5.92 (0.45)
	KA3	Our team members apply knowledge to solve new problems.	5.79 (0.45)
Team Performance	TP1	The team's deliverables were of excellent quality.	5.83 (0.71)
	TP2	The team managed time effectively.	5.68 (0.77)
	TP3	The team met important deadlines on time.	5.84 (0.81)