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EXPLORING THE EFFECTS OF TURNOVER ON TRANSACTIVE MEMORY SYSTEMS

Theme: The Social Processes of OL and KM

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Abstract

This paper examines turnover effects on transactive memory (TM) under four task conditions. The first section employs a contingency framework and describes the structural features of knowledge networks and communication networks in TM systems that match each task condition. The second part analyzes the effects of turnover on TM from a network perspective. The findings suggest that, contrary to previous research, turnover can be beneficial and the magnitude of turnover effects on TM varies considerably across task conditions. Moreover, the strengths of turnover effects depend on the structures of knowledge networks and communication networks as well as the position the person who leaves the system occupies in the communication network. Implications of this analysis are discussed in light of organization design.

Introduction

Knowledge is a valuable asset for organizations especially in the era of knowledge economy when knowledge-intensive industries thrive more than ever. How to effectively manage knowledge resources emerges to be an urgent and important issue challenging many contemporary organizations. Organization researchers have been studying knowledge management from a wide variety of perspectives, among which is the theory of transactive memory (TM) originally formulated in the context of intimate couples (Wegner, 1987, 1995). The theory of TM sets its premise on distributed cognition by detailing the stages involved in the development of cognitive divisions of labor and the benefits associated with such cognitive divisions. Group and organizational cognition is inevitably distributed (Boland & Tenkasi, 1995; Boland, Tenkasi, & Te'eni, 1994) with individuals acting as knowledge storage repositories (Argote & Ingram, 2000; Walsh & Ungson, 1991). Therefore, the theory of TM is germane to knowledge management and learning in groups and organizations, especially cognitive learning that has not been investigated extensively in the traditional behavioral learning approach.

A TM system consists of two components: the knowledge stored in individual memories and the communication links that connect these discrete individual memory systems (Wegner, Giuliano, & Hertel, 1985). These two components constitute two networks: knowledge networks (i.e., networks of who knows what) and communication networks (i.e., networks of who knows whom) (Hollingshead, Fulk, & Monge, 2002). Wegner (1995) identified three processes involved in the development of TM systems: directory updating, information allocation, and retrieval coordination. Directory updating is a process of learning who knows what or who knows who knows what in the system; information allocation is a process by which new information is passed to relevant experts for storage, and information retrieval is a process of bringing back individually held information to complete a task (Wegner, 1995). Information allocation leads to increasingly differentiated memory structures. As a TM system matures, different individuals are responsible for processing and storing information pertinent to different knowledge areas, which significantly reduces the likelihood of new information passing the system without being properly processed and stored (Wegner, 1987). Having recognized experts responsible for the information relevant to specific knowledge domains also improves the quality of information processing and storage.

A well-developed TM system is characterized by low redundancy. That is, each member in the system possesses a unique set of domain-specific knowledge that can be retrieved for future task completion purposes. Redundant knowledge is thus kept at its minimum while unique knowledge increases, and hence the system's collective knowledge pool grows (Moreland, 1999). A review of the existent literature reveals that current research on organizational learning fails to examine how individuals and work groups locate task-related expertise and obtain it in an efficient manner (Huber, 1991). The theory of TM suggests that one way to accomplish such expertise search tasks is to develop accurate and up-to-date directories of who knows what in a collective knowledge system.

Although a differentiated TM system effectively maximizes the amount of knowledge available for task performance, it is extremely vulnerable to turnover. When experts leave the system, they take away their specialized knowledge as well. The absence of expert knowledge may have a devastating effect on the performance outcome. New members with similar expertise may be recruited, but it takes time for them to acquire the information on other members' expertise in the system, which inevitably reduces the efficiency in coordination. Turnover, in the form of either old members leaving the system and new members entering the system, or changes in report relationships, span of control, and scopes of tasks (Carley & Svoboda, 1996), will alter knowledge distribution patterns and break TM systems (Moreland, 1999).

Despite the detrimental effects turnover may possibly exert on TM systems, research exploring these effects is scarce. Although task demand is the primary determinant of an individual's choice in what information processing mode to adopt (Zajonc & Wolfe, 1966), there exist few studies on TM that explicitly incorporate the variable of task into their research designs. Whether turnover has a uniformly negative effect on TM and whether the magnitude of turnover effects is the same across task conditions remains unclear. This analysis is designed to delineate the effects of turnover on TM systems in four types of tasks generated from two dimensions of task complexity: component complexity and coordinative complexity.

Two perspectives are employed in this paper: the contingency perspective and the network perspective. Contingency theory argues for the best fit between the contingency factor or factors (e.g., task) and the structural requirement of the environment (Donaldson, 1996). Each of the four categories of tasks divided along two dimensions - component complexity and coordinative complexity – poses specific structural demands for knowledge networks and communication networks in TM systems to achieve optimal performance. The central thesis of this paper is that turnover has differential effects on TM depending on the characteristics of knowledge networks and communication networks and the position the individual who leaves the TM system occupies in the communication network. A person's position in the network affects the strength of turnover effects because it determines the amount and the type of information he or she has access to (Shaw, 1954) and how he or she processes that information (Zajonc & Wolfe, 1966). Presumably, the loss of key individuals in knowledge networks and communication networks who control and/or channel the flow of critical information is more detrimental to TM systems.

This paper starts with an overview of the concept of task with a special emphasis on two dimensions of task complexity: component complexity and coordinative complexity, based on which tasks are classified into four categories (high vs. low on each dimension). It is followed by a contingency analysis of the structural characteristics of the knowledge network (i.e., the degree of knowledge differentiation) and the communication network (i.e., density and centralization) in a TM system determined by each of the four categories of tasks. Turnover effects are analyzed in light of these structural features, and the position the person who leaves the TM system occupies in the communication network. The findings produced by this analysis provide practical implications for organization design and management of turnover in organizations.

The concept of task

Define task complexity

A task, if viewed as behavioral demands, can be defined as “the behavioral responses a person should emit in order to achieve some specified level of performance” (Wood, 1986, p. 61). If we conceive of a task as cognitive demands, a task can be construed as the knowledge and cognitive skills needed to accomplish a performance outcome. Following this cognitive view of a task, contingency theory stipulates that task is an important determinant of how knowledge should be structured and utilized in organizations (Lawrence & Lorsch, 1967).

Organization researchers have described tasks along various dimensions such as task variety (Daft & Macintosh, 1981), task analyzability and routineness (Perrow, 1967), task uncertainty (Van de Ven, Delbecq, & Koenig, 1976), task complexity (Campbell, 1988; Wood, 1986), and task diversity, unpredictability, and interdependence (Scott, 1998). These dimensions overlap to various degrees. For instance, both task uncertainty and routineness have been construed as tapping two factors, task variety and analyzability.

Task complexity is closely associated with all other dimensions. A task can be complex if it is uncertain, or nonroutine, or less analyzable, or highly variable. According to Wood (1986), task complexity has three facets: component complexity, coordinative complexity, and dynamic complexity. The component complexity of a task is determined by “the number of distinct acts” to be carried out and “the number of distinct information cues” to be processed in performing the task (Wood, 1986, p. 66). Coordinative complexity is a feature of the interaction between task inputs and outputs. “The form and the strength of the relationship between information cues, acts, products, as well as the sequencing of inputs” (Wood, 1986, p. 68) constitute various aspects of coordinative complexity. Component complexity and coordinative complexity, according to Wood (1986), are stationary complexity of task inputs. The “nonstationary” complexity is defined as dynamic complexity, which may result from changes in either component complexity or coordinative complexity, or both (Wood, 1986, p. 71). According to Wood (1986), tasks can be dynamically complex with an increase in component complexity but not in coordinative complexity. He also argues that although the three components of task complexity are not completely independent of one another, “the level of each complexity can vary quite considerably without affecting the levels of the other two complexities” (p. 73).

Why task complexity?

Among all task characteristics, task complexity proposed by Wood (1986) is selected as the contingency factor in this analysis for two reasons. First, task complexity embodies a variety of task characteristics and is most comprehensive at describing a task. An increase in task complexity will lead to an increase in uncertainty and the demand for information processing (Tushman & Nadler, 1978) and will potentially affect all other facets of activities in performing a task. Second, the three key aspects of task complexity have distinct effects on knowledge networks and communication networks. Specifically, component complexity largely determines the degree to which the knowledge network is differentiated. Coordinative complexity is closely associated with the structural properties of the communication network such as density and centralization. Since dynamic complexity is a product of the changes in component complexity, or coordinative complexity, or both, the complex combinations of the configurations of the two networks reflects dynamic interactions between component complexity and coordinative complexity. Since the effect of dynamic complexity is not independent, but instead, can be generated from the two aspects of stationary complexity, the effect of dynamic complexity is not analyzed separately in this paper.

Task complexity and network configurations

A TM system is a collective information-processing system that evolves through the interactions of its members. TM defines the cognitive structure of a collective which, upon its formation, may exert a significant influence on its members (Wegner, 1987). The structural properties of the knowledge network and the communication network in a TM system have significant implications for learning and performance. Carley and Svoboda (1996) found that performance improved when members had non-redundant knowledge tapping multiple dimensions of a task and when they were well connected in the communication network. The structure of a communication network channels information flow. Individuals working in different communication structures are exposed to different information, which may lead to different perceptions of the task and different approaches to complete the task (Oldham & Hackman, 1981). Communication patterns also affect the information transmission ability of a system (O'Reilly & Roberts, 1977), and hence what individuals learn (Carley, 1992). The structural configurations of the knowledge network and the communication network in a TM may be contingent on task complexity.

Task has a direct effect on the configuration of a knowledge network. The information load determined by the component complexity of a task affects the need for cognitive divisions of labor in a TM system, which in turn, determines the degree of knowledge differentiation in the knowledge network. Task has both direct and indirect effects on the configuration of a communication network. A task directly influences the structural features of a communication network if the completion of the task requires complex coordination of physical labor. Task exerts its indirect effects on communication through knowledge when coordination of cognitive labor is involved. The level of knowledge differentiation places different demands for such coordination, and hence the amount and the type of communication among the members in a TM system. Research has found that the nature of a task also determines what structures are adopted by an organization, and thus has an indirect effect on communication through formal organization structures as well (Hage, Aiken, & Marrett, 1971).

Component complexity and knowledge network configuration

The importance of knowledge to task performance has been well documented in the literature on organizations (O'Reilly & Roberts, 1977). Knowledge differentiation is an important index to organizational complexity (Child, 1973). Theoretically, knowledge differentiation can be assessed by differences in the number of unique knowledge domains individuals claim expertise in and/or by differential scopes of expertise across individuals in the same knowledge domain. Since the theory of TM is primarily concerned with differentiation in knowledge domain rather than in scope, the subsequent analysis will focus on domain differentiation.

Different tasks place differential demands on knowledge structures in TM systems. Wegner (1987) presented two extreme memory structures: “differentiated” TM and “integrated” TM. A differentiated TM system is characterized by unique knowledge stores in discrete individual memories. The only redundant information in such a system is the common labels for various knowledge bits and expertise directories that are indispensable to allocation and retrieval. A more differentiated memory system is capable of subsuming more knowledge than a less differentiated system (Zajonc & Wolfe, 1966). An integrated (i. e., redundant) TM system is one in which all members store the same knowledge and are aware of such redundancy. A differentiated TM has a minimal degree of redundancy while an integrated TM is a completely redundant knowledge system. These two memory structures occupy the two ends of a TM spectrum.

Component complexity is the primary determinant of the extent to which a knowledge network is differentiated to ensure an optimal performance outcome. The inputs of a task have three levels: subtask, act, and information cue (Wood, 1986). The level of component complexity is determined by aggregating unique inputs at all three levels. An integrated knowledge structure is only possible in tasks with low component complexity. As component complexity increases, the number of task inputs such as unique subtasks and acts to be performed and distinct information cues to be processed increases. More diverse expertise is required for the successful completion of the task. No single person has a broad enough knowledge and skill base required to perform all aspects of the task and process all the information. Work-related expertise has to be retrieved from experts in respective knowledge domains to get the job done. With an aim to building an efficient collective knowledge store to cope with all facets of the task, each member in a TM system is motivated to gather knowledge in a unique area and develop a set of expertise that nobody else in the system has. Overlapping knowledge is reduced. An increase in component complexity facilitates the formation of a differentiated knowledge network in a TM system.

Let’s take sales as an example to make this argument more concrete. Compared with selling large production lines, selling cosmetics is a task with relatively low component complexity. The sales people in a cosmetics sales team may share the same knowledge about the products ranging from skincare to make-up. It is possible to provide the same training to everybody because the component complexity involved in this task is so low that one person is capable of processing all the information concerning the features of a variety of products. There is not much of a need for knowledge allocation or retrieval. Integrated knowledge networks allow for easy coordination and are most appropriate for cosmetics sales teams.

The picture is quite different for tasks of selling complex production systems such as ice cream production lines. Such teams may consist of sales people with superb sales skills and general knowledge about the product, designers who are well acquainted with the specific features of the product, and engineers who specialize in troubleshooting and maintenance of the production system. Organizations have to develop separate training programs for these people because the amount of knowledge and skills required for performing these tasks is beyond the cognitive ability of any single individual. When people from different functional areas work together on a common task, a differentiated TM system is likely to evolve to cope with the high information load. Sales people may pass clients’ questions on the specific features of the product to engineers. Engineers may keep salesmen informed of clients' concerns about the price and let salesmen handle bargaining tasks. Engineers may develop a directory among themselves on who is good at solving what technical problem and turn to the relevant expert for help. High component complexity featuring complex production lines sales requires a highly differentiated knowledge network.

> *Proposition 1*: High component complexity is associated with differentiated knowledge networks while low component complexity is associated with integrated knowledge networks in a TM system.

Task complexity and communication network configurations

Communication network is an important facet of organization structures (Malone, 1986) and has a direct impact on work processes. The discrepancy between actual work practices and the procedures described in work manuals (Brown & Duguid, 1991) is a result of continuing on-job communication among task performers. Although communication is the "heart" of all collaborative work processes (Shaw, 1964, p. 111) and a key mechanism linking cognitive activities to behavioral outcomes, it is often ignored in studies of distributed cognition (Schneider, 1991). The theory of TM marks a fundamental departure from the theory of group mind because it emphasizes the communication linkages between discrete individual minds (Wegner, 1987). The structural features of the communication network in a TM system determine its ability to channel information flow, reduce occurrences of information overload, and improve the effectiveness of information search (O'Reilly, 1980).

Task complexity may influence communication network structures. The complexity of a task influences the amount and the overall pattern of communication with more complex tasks requiring a greater amount of communication and a decentralized communication pattern (Katz & Tushman, 1979). To examine the relationship between task and communication, Poole (1978) proposed an information-task approach to organizational communication studies. He argued that task could be described in terms of the information required for its completion and that a major function of communication was to acquire such task-related information. A match between communication structure and information demand placed by task complexity largely determines the performance outcome (Tushman, 1979b). Since maintaining communication links and exchanging messages through those links can be quite costly, it is critical to design the most cost-efficient communication structure for a given task (Malone, 1987). Besides, communication overflows or irrelevant communication may create confusions and should be consciously controlled in organizations (Porter & Roberts, 1976).

The level of coordinative complexity is determined by three factors: the order in which task inputs to be arranged, the type (e.g., linear function, non-linear function) and the strength (i.e., the frequency of associating a specific task input with an output) of the relationship between acts, information cues, and outputs (Wood, 1986). The first two factors are related to task interdependence and the third factor concerns task uncertainty. As coordinative complexity increases, organizations face a higher demand for designing the acts (e.g., timing, frequency, sequence) of each member in performing the task (Wood, 1986). In this design process, individually held expert knowledge needs to be coordinated. An increase in coordinative complexity leads to an increase in the extent to which knowledge in a variety of domains is integrated, and hence the need for communication. Communication exercises an influence on performance by affecting members' ability to mobilize expertise resources (Guetzkow & Dill, 1957) in a TM system.

Communication examined in this paper includes both written communication and oral communication. It has been reported that oral communication is the primary means by which workers share knowledge in organizations (Katz & Tushman, 1979). Oral communication often occurs in informal networks. Informal communication can be highly effective in disseminating information and exercising control (Krackhardt, 1990). Written communication is preferred when information concerning important decision making is transmitted in a network. Roberts and O'Reilly (1979) classified the information exchanged in communication networks in organizations into three categories: "expertise communication" (i.e., job-related communication), "social interactions" (i.e., non-job-related communication), and "authority interactions" (i.e., communication concerning formal control) (p. 43). All three contents are important to the formation of TM systems. Expertise communication is the key to the three TM processes: directory updating, information allocation, and retrieval coordination. Social interactions exchange information on one another's interests, values, past experiences, goals, and priorities, etc. People may infer others' domains of expertise from such information (Wegner, 1987). Authority interactions delegate knowledge storage responsibilities and coordinate knowledge retrieval activities.

Two communication network properties are considered here: density and centralization. Density is the ratio of the number of existing links in a network to the number of possible links (Wasserman & Faust, 1994). Network centralization is a measure of "how variable or heterogeneous the actor centralities are" (Wasserman & Faust, 1994, p. 176). The variability in members' centralities reflects the differences in the amount of information resources they have access to. Research has shown that network density and centralization systematically vary with the nature of a task. For instance, task uncertainty has been reported positively related to the amount of internal communication within a network (Katz & Tushman, 1979) and network centralization (Oldham & Hackman, 1981).

Tasks are divided into four categories according to their levels of component complexity and coordinative complexity: tasks with low component complexity and low coordinative complexity (Category I), tasks with low component complexity and high coordinative complexity (Category II), tasks with high component complexity and low coordinative complexity (Category III), and tasks with high component complexity and high coordinative complexity (Category IV) (see Table 1). The effects of task complexity on density and centralization of the communication network in a TM system are analyzed in each of the four task categories.

Task categories I & II

Tasks in these two categories are low in component complexity. As discussed earlier, the knowledge structure in a TM system is highly integrated in tasks with low component complexity. That is, members are likely to share similar expertise when they perform tasks with low component complexity because the relatively small amount of task-related information can be effectively handled by one single individual. A redundant knowledge system reduces the need for central nodes in the communication network where members allocate knowledge storage responsibilities and retrieve expert knowledge. There is a relatively even distribution of individual centrality scores in the communication network. In tasks with low component complexity, the communication network in a TM system is characterized by low centralization.

Category I tasks also have low coordinative complexity. Such tasks are highly analyzable (i.e., task performers face few exceptions). The guidelines for performing these tasks are largely predetermined and clearly specified. Institutionalized work procedures and routines where organizational knowledge accumulated overtime is stored (Huber, 1991), may be employed as a simple tool for coordination (Kerr & Jermier, 1978). Workers don't need to consult one another for individually held unique information. The communication network is characterized by low density. Moreover, low coordinative complexity may lead to less interdependence between subtasks, and hence less frequent communication among task performers as well.

> *Proposition 2*: In tasks with low component complexity and low coordinative complexity, the communication network in a TM system should have low density and low centralization.

Category II tasks, on the other hand, have high coordinative complexity and may require complex coordination among individual workers. The frequency of communication among task performers may increase as coordination becomes more complex. Tasks with high coordinative complexity are also more uncertain than tasks with low coordinative complexity (Tichy, 1981) and require more communication among task performers (Tushman, 1979a). This is because as task uncertainty increases, the number of exceptions to be handled increases and the search procedure for an optimal solution becomes less predictable (Perrow, 1967). The members in a TM system need to hold extensive discussions in the course of performing the task to develop an innovative solution to each exception and decide on how to proceed in the search process. Exception handling may also involve lots of novel decision making activities. Frequent and broadly distributed communication, both formal and informal, has been found to be critical to these "unstructured" decision processes (i.e., "decision processes that have not been encountered in quite the same form and for which no predetermined and explicit set of ordered responses exists in the organization") (Mintzberg, Raisinghani, & Theoret, 1976, p. 246). Moreover, trust is a prerequisite for a synergistic usage of knowledge acquired from multiple sources (Nonaka, 1994). Intense communication helps to clarify common goals, shared interest, and good will and breed trust among the members in a TM system. Shared meaning developed through communication may also facilitate the formation of a collective action (Donnellon, Gray, & Bougon, 1986) such as expert knowledge sharing.

> *Proposition 3*: In tasks with low component complexity and high coordinative complexity, the communication network in a TM system should have high density and low centralization.

Task categories III & IV

Tasks in these two categories have high component complexity. As discussed earlier, high component complexity leads to highly differentiated knowledge networks in TM systems. Task-related expertise is narrowly distributed within TM systems with each member serving as a repository for storing knowledge in a particular domain. Different members possess expert knowledge in different domains. New information needs to be passed to relevant experts for encoding and storage. Task-related expertise needs to be retrieved from experts. With expert knowledge narrowly distributed among task performers, it is critical that they keep an accurate and up-to-date expertise directory to ensure a smooth functioning of knowledge allocation and retrieval. Communication, especially expertise communication, is critical to an effective functioning of all three TM processes.

A person's network position determines what information he or she has access to (Carley, 1986). In face of tasks with high component complexity, a leader may be in the position where members' expertise location information resides. A differentiated knowledge network makes it increasingly difficult, if not impossible, for everybody to acquire expertise directory information on his own and keep track of changes in these directories because the volume of communication involved in such an effort can be very large. It may be more cost efficient to have a leader gather and disseminate such information. Each member may obtain this information from the leader and directly retrieve knowledge from the expert. This process only involves two communication links: one is between the information seeker and the leader, and the other is between the information seeker and the expert. Such an expertise search process is faster and more energy conserving than a random search. The leader, thus, will inevitably become a central node in the communication network.

Research has found that isolates who hold critical information in a particular knowledge domain may not be willing to share their expertise and/or refer information seekers to experts outside the TM system whom they have connections with (Roberts & O'Reilly, 1979). A leader may exercise his authoritative power through authoritative interactions, reconfigure the communication network, and create a structure to engage isolates in task activities. Sometimes the person who has most expertise location information is not the leader, but the one who occupies structural holes (Burt, 1992) or an "ombudsman" who carries the official duty of helping people locate sources of expertise (Marquardt, 1996, cited in Moreland, 1999). These people are also likely to have substantially higher centrality scores than others in the communication network. However, the leader, with institutionalized power, is in a more proper position to restructure the communication network to reduce isolates and ease information flows.

The increasing differentiation in members' expertise may create communication barriers. Individuals working in similar functional areas may find it easier to communicate with one another while those performing different functions may approach a task from different perspectives, harbor different priorities, and are more likely to encounter communication problems (Porter & Roberts, 1976). Centralized leadership may help to solve conflicting views and foster mutual understandings. A centralized network also makes communication more predictable and reduces uncertainty (O'Neill, 1984). Unnecessary or irrelevant communication may create distractions and complicate the task at hand (Guetzkow & Dill, 1957).

Category III tasks also have low coordinative complexity. When coordinative complexity is low, not much mutual adjustment is needed among task performers (Thompson, 1967). There may not be much communication between individual workers. The information they need most is expertise location information, which they can obtain from the leader. The communication network is characterized by low density and high centralization. The low flexibility afforded in a sparse and centralized communication network may not impede task performance when the demand for coordination is relatively low. A leader may function as the coordinator or integrator in these tasks (Galbraith, 2002; Mintzberg, 1979).

> *Proposition 4*: In tasks with high component complexity and low coordinative complexity, the communication network in a TM system should have low density and high centralization.

Category IV tasks, on the other hand, have high coordinative complexity. Mutual adjustment is critical to the successful completion of tasks with high coordinative complexity (Mintzberg, 1979). The greater amount of peer-to-peer communication necessary for flexible adjustment leads to an increase in network density. Furthermore, as tasks get more and more complex in coordination, members with unique expertise have substantially more interactions with one another than when tasks have low coordinative complexity. Individually held expert knowledge gets integrated and the boundaries of expertise domains become blurred. This may obstruct the effectiveness of expertise recognition.

Suppose Person A is an expert on Topic X and Person B is an expert on Topic Y. In the initial stage of a task, such expertise divisions are very clear. As the interaction between Person A and Person B increases, Person A may learn something about Topic Y and Person B may learn something about Topic X. Although Person A still has more knowledge about Topic X than Person B and Person B still holds more expertise on Topic Y than Person A, the overlap between Person A's and Person B's knowledge increases. Performing tasks with high component complexity and high coordinative complexity often involves collaboration among a large number of people with highly specialized knowledge. In such a large, differentiated network, it is highly possible that some people are not familiar with Person A or Person B, nor Topic X or Topic Y. They are particularly prone to errors in expertise recognition. They may mistakenly identify Person B as an expert on Topic X simply because Person B has a little knowledge about Topic X. Another error people, in general, may commit is to "overimpute," that is, assume others have the same knowledge as they do (Nickerson, 1999). An increase in communication may help to reduce these two types of errors and facilitate the development of an accurate expertise directory among the members in a TM system.

In addition, frequent face-to-face communication, be it expertise communication, social interactions, or authoritative interactions, increases the amount of observation and verbal interaction based on which members can infer others' expertise. Communication also enhances cohesion. Shah (1998) found that, compared with non-cohesive individuals, expert knowledge provided by cohesive individuals was perceived to be more credible. Thus, the members in a TM system with a dense communication network are more likely to accept the knowledge recalled by one another. Members' trust in knowledge sources is especially important to tasks with high component complexity because the knowledge involved in these tasks is concentrated in different individuals and is so specialized that others may not be capable of judging its quality. Besides, cohesive ties may provide shared social knowledge such as norms and behavioral codes (Shah, 1998). Such social information may improve the effectiveness of knowledge seekers' search effort by increasing the likelihood of obtaining the expertise they need. Non-job-related information is as important as job-related expertise to effective performance (Levine & Moreland, 1991, cited in Argote, 1995).

When coordinative complexity increases and component complexity remains high, not all coordination can be performed by the leader (as a coordinator rather than an ultimate decision maker) in order to avoid information overload of the leader (Galbraith, 1973) and allows for greater flexibility. The communication network inevitably becomes less centralized. Past research has consistently reported that decentralization is necessary to complex tasks (Roberts & O'Reilly, 1979) and to flexible communication (O'Neill, 1984). However, when a task gets so complex that average members are not capable of determining how to approach the task, a leader is needed to help them make sense of the task, set goals, develop plans, and assign subtasks. Members may pass feedbacks to the leader and let the leader decide on the course of the task. Besides, due to the complex nature of the task, lower-level supervisors may not have the complete information to make quality decisions. Important decision information needs to be passed to the leader who oversees the whole project. The final decision needs to be conveyed to general members through "authoritative interactions" (Roberts & O'Reilly, 1979) and provide them with an overall guidance of the course of the task and at the same time allow them flexibility to adapt to the uncertain task environment. Decision-making processes are embedded in communication (Hax & Majluf, 1981). The communication network in such tasks may be relatively centralized despite high density.

Moreover, performing tasks with high component complexity and highly coordinative complexity is more likely to involve multiple units in an organization. Tushman (1977) argued that different units working on tasks with high uncertainty might experience communication difficulties due to heterogeneous goals and priorities they have and different languages they speak. A densely connected network across units may not be as effective as having one person serve as a liaison or gatekeeper and responsible for communication across unit boundaries (Katz & Tushman, 1979). Having fixed individuals act as liaisons enhances a unit's ability to acquire external information. Research has found that structurally equivalent individuals share job-related information with one another more often than structurally non-equivalent individuals (Shah, 1998). Liaisons are structurally equivalent in their respective units and are more likely to exchange information necessary for coordination both within and outside a unit. Although an increase in intra-unit communication may also facilitate coordination, it has the risk of making the unit "overly inward focused" (Hansen, 1999, p. 109). A liaison may help to locate sources of expertise outside the unit (Schwartz & Jacobson, 1977), bring in an external focus, and broaden the boundary of the TM system. A liaison may thus become a central node from which others obtain coordination information (Farace, Monge, & Russell, 1977; Tushman, 1979b). The high centralities of a liaison and/or a leader lead to relatively high centralization in the communication network in a TM system.

> *Proposition 5*: In tasks with high component complexity and high coordinative complexity, the communication network in a TM system should have high density and high centralization.

The propositions 1-5 are summarized in Table 1.

Differential effects of turnover on TM in four categories of tasks

Turnover disrupts knowledge composition and instigates change and instability in organizations (Carley, 1991). Research has found that compared with changes in the content of the collective knowledge store in a group, changes in membership composition have a significantly stronger effect on group's stability because personnel turnover alters the social and cultural dynamics of group interactions (Carley, 1991). In seeking expert knowledge in a TM system, a search approach that conforms to the social norms and interpersonal dynamics of the system will yield higher probability of obtaining the knowledge. New comers may not be effective at accessing others' expertise because they lack "social knowledge" (defined as shared facts, Carley, 1991) which only evolves gradually through on-going interactions (Carley, 1986), and hence, the ability to develop such an effective search approach. Moreover, past experience with an old member also enhances the credibility of the knowledge he provides. A new member may share similar expertise with his predecessor, but it takes time for him to establish his reputation and demonstrate his capability. This disrupting effect of turnover may be more severe in a highly differentiated TM system because of a limited availability of specialized knowledge.

The effects of turnover are also closely associated with the structural properties of the communication network in a TM system. Research has found that people occupying structurally equivalent roles in communication networks are more likely to influence one another's decision on turnover (Krackhardt & Porter, 1986), and this influence may be stronger in a dense network. On the other hand, high density may function as a buffer against turnover if a central node is eliminated from the network. A person with high centrality (e.g., a leader) may be the store of all expertise directory information. If this person leaves the system, a well-connected network may help members acquire changes in such information faster.

Furthermore, the loss of a central node is likely to be more detrimental to a TM system than the loss of a person with low centrality and less critical information. Dalton and Todor (1979) argued quite convincingly that we couldn't infer turnover effects from an overall turnover rate because the loss of an individual with hard-to-master knowledge and skills would be more devastating than the loss of someone whose expertise could be easily replaced. In this section, the effects of turnover are analyzed in each of the four task categories. Such an analysis provides us with greater details about the nature of the turnover effects on TM in various task conditions and how strong these effects are.

Task categories I & II

The tasks in these two categories have low component complexity. Every member in a TM system has similar expertise. The loss of any member may not significantly reduce the amount of work-related knowledge available in the system. Since component complexity is low, the number of information cues to be processed in performing the task is limited. It is relatively easy for new comers to acquire the skills needed to carry out the task. Turnover may not have a conspicuous effect on the knowledge network in a TM systems when tasks have low component complexity.

Category I tasks also have low coordinative complexity. The work procedures involved in carrying out these tasks are routine. Members perform the tasks relatively independently of one another. Rules and guidelines are sufficient for coordination. Little communication is required. In fact, the communication network can be sparsely connected and completely decentralized. New comers do not need to develop complex social relationships that are indispensable to extensive coordination (Stewart & Barrick, 2000). Therefore, the lack of access to communication ties with others in the network will not slow down the process through which new comers take on newly assigned job responsibilities. Turnover will exert little impact on the communication network in a TM system in Category I tasks.

Turnover can even be beneficial to tasks with low component complexity and coordinative complexity. Since well-defined work procedures and routines often guide the completion of these tasks, workers are more likely to fall into a "competency trap" (Levitt & March, 1988). That is, a less-than-optimal procedure is mistaken as an optimal one and sustains in organizations. New members, by bringing into the system new perspectives, may help to break the "competency trap," improve existing routines, and facilitate organizational learning. New comers may also bring in non-redundant external ties and connect task performers with a broader range of expertise. Turnover may thus improve the quality and the quantity of the knowledge store in the knowledge network in a TM system.

> *Proposition 6*: In tasks with low component complexity and low coordinative complexity, turnover has little negative effects on the knowledge network and the communication network in a TM system, and may even bring benefits to the knowledge network.

Category II tasks, however, have high coordinative complexity. That is, either task uncertainty or task interdependence or both are high. As discussed earlier, the communication network in this task condition is featured by high density to allow for frequent communication to cope with high task uncertainty and interdependence. Centralization in the communication network is low to permit the flexibility necessary for mutual adjustment. Research has found that a decentralized network is more capable of absorbing uncertainty (Tushman & Nadler, 1978).

Although turnover does not have a noticeably negative effect on the knowledge network, it has a moderately negative effect on the communication network because the absence of previously existing nodes may break down normal communication flows and disrupt smooth coordination that has developed over time among task performers. This moderately negative effect turnover has on the communication network may be mitigated by high density after the initial turnover. Extensive interactions among task performers help to establish well-defined rules and norms for coordination (Stewart & Barrick, 2000), which may facilitate new comers' socialization process and quickly re-establish the missing communication links.

> *Proposition 7*: In tasks with low component complexity and high coordinative complexity, turnover has little negative effects on the knowledge network and has moderately negative effects on the communication network, especially in the initial stage.

Task categories III & IV

Tasks in these two categories have high component complexity. Much organizational knowledge (both declarative knowledge of know-what and procedural knowledge of know-how) is stored in the memories of individual members (Kim, 1993). The knowledge structure among performers of these tasks is highly differentiated. Each member's memory is a domain-specific knowledge storage repository. The loss of any member takes away substantive knowledge and brings severe damage to the knowledge network in a TM system. A remedy for the negative effect of turnover may be provided by the high degree of centralization of the communication network. A centralized structure such as a hierarchy has been found to be capable of alleviating the harmful effect of turnover (Carley, 1992). With a comprehensive directory of who specializes at what, the leader in a hierarchical structure, for instance, knows what expertise is lost, whom to recruit, and how to restructure the system to reduce the damage of turnover. However, this remedy only works when the lost expertise can be easily replaced. If few people have the kind of expertise needed, a centralized communication network won't be able to reduce the harmful effects turnover has on the knowledge network.

On the other hand, a centralized communication network can be highly vulnerable if the person who leaves the system is a central node (O'Neill, 1984). For instance, a leader is critical to work group's ability to share job-related information and lower the workload (Snyder & Morris, 1984). The loss of a leader may take away all expertise directory information and paralyze the communication network. This effect is especially devastating in Category III tasks because there exist few communication links between members due to the low demand for coordination and members' reliance on the leader for expertise location information. Although it is possible to ask the leader to pass this information to a coworker, such transfer may not be complete or accurate because of the complexity involved in matching expertise with task environments. Moreover, a leader is often the source of social information (e.g., values, norms) in a system (Rice & Aydin, 1991). The absence of a leader may disrupt the provision of such social information and leave the members in a TM system less cohesive, which will impede knowledge sharing.

An alternative to this interpersonal approach to TM is the technological approach (Moreland, 1999). We may reduce the negative effects of turnover by adopting the technological approach. That is, instead of having a leader act as the central node in the communication network and members' memories serve as knowledge storage repositories, an electronic knowledge base can be created. Each member's expertise is codified and stored in the knowledge base. A searchable expertise directory can be developed. Organizations often face the problem of not knowing what they know (Huber, 1991). Codifying explicit knowledge and storing it in an electronic form may help to solve this problem. Other forms such as newsletters and training programs may also help individual workers find the expert knowledge they need (Argote & Ingram, 2000). The drawback, though, is that such an approach only applies to explicit knowledge.

> *Proposition 8*: In tasks with high component complexity and low coordinative complexity, turnover has a significantly negative effect on the knowledge network in a TM system. If the person leaving the system is a central code, turnover may negatively affect the communication network as well. An electronic knowledge base may reduce this negative turnover effect on both the knowledge network and the communication network, but it applies to explicit knowledge only.

The tasks in Category IV, on the other hand, have high coordinative complexity. The communication network developed in the course of performing these tasks is well connected and highly centralized. The members in a dense network are relatively autonomous and capable of processing high volumes of information (Tushman & Nadler, 1978). The loss of an expert not only reduces the amount knowledge available in the knowledge network, but also blocks communication flows. Another expert with similar expertise may join the system. However, it will take time for this new member to learn about the task and other members' expertise. This learning process is not easy because the amount of information required to perform Category IV tasks is very high. This information includes both task-related information and coordination information. The complex coordination involved in the task and high communication density require the new member to be the sender and the recipient of a large number of information requests. It is likely that a new member becomes overloaded and fails to respond to those requests in an efficient manner. The system's communication capacity will be impaired.

Compared with strong ties, weak ties are more economical at connecting individuals to sources of expertise because of the low cost associated with their maintenance (Hansen, 1999). Liaisons bridging network boundaries are likely to have more weak ties across units. These boundary roles have access to the key resources outside their own work units and are efficient at collecting and disseminating information (Tushman, 1977). The loss of such individuals may be detrimental to the knowledge network and the communication network in a TM system, especially in highly complex tasks involving innovation where information is critical to positive performance outcomes. Moreover, the loss of a leader may leave coordination in danger. Highly specialized experts often don't speak the same language. Having a person capable of bridging the communication gap among the experts is the key to effective performance.

> *Proposition 9*: In tasks with high component complexity and high coordinative complexity, turnover has significantly negative effects on both the knowledge network and the communication network in a TM system.

Conclusion

Previous research on TM has suggested uniformly negative effects of turnover on TM systems (Moreland, 1999). However, the details on how such effects differ for different tasks are largely unknown. This study examines the effects of turnover on TM systems under four task conditions divided along two dimensions: (1) tasks with low component complexity and low coordinative complexity; (2) tasks with low component complexity and high coordinative complexity; (3) tasks with high component complexity and low coordinative complexity; and (4) tasks with high component complexity and high coordinative complexity. The first half of the paper employs a contingency framework and proposes the structural features of the knowledge network and the communication network that meet the information processing requirement of each of the four categories of task. The second half of the paper analyzes the differential effects of turnover from a network perspective.

The findings suggest that, contrary to earlier findings on TM (Moreland, 1999), turnover effects may not be necessarily negative and may be beneficial when tasks have relatively low component complexity and coordinative complexity. Moreover, the magnitude of turnover effects on TM varies considerably across task conditions. The effects of turnover also depend on the structural characteristics of the knowledge network and the communication network as well as the position the person who leaves the system occupies in the communication network.

The results of the contingency analysis provide valuable practical implications for organization design. The knowledge network and the communication network in a TM system should be structured to match specific task characteristics in order to reach the optimal performance level. Organization design is an on-going process (Tushman & Nadler, 1978). The task environment an organization faces is extremely fluid. This is especially true in fiercely competitive industries such as the high-tech industry. The demand for information processing changes with the changes in task environment. So do knowledge and communication network structures. Research has suggested that a well-established TM system may help members achieve consensus on what expertise is needed and whom to recruit (Moreland, 1999). The results on the effects of turnover may help an organization identify its needs, recruit the person with the kind of expertise that best meets the demand, and quickly adjust its structures of knowledge networks and communication networks to reduce the loss.

Table 1. Summary of propositions 1-5

		Coordinative Complexity	
		Low	High
Component Complexity	Low	Knowledge network Highly integrated Communication network Low density Low centralization I	Knowledge network Highly integrated Communication network High density Low centralization II
	High	Knowledge nework Highly differentiated Communication network Low density High centralization III	Knowledge network Highly differentiated Communication network High density High centralization IV

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