A SIMULATION BASED EXPLORATION INTO THE EFFECTIVENESS OF IT-ENABLED KNOWLEDGE MANAGEMENT INITIATIVES

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ABSTRACT

As organizations recognize their knowledge as a source of competitive advantage, they are increasingly investing in Knowledge Management (KM) initiatives in an attempt to realize both firm- and operational- level benefits. However, many KM initiatives fail to yield the desired outcomes due to our lack of understanding of the antecedents to successful KM. Prior studies have established that organizations' cultural values are one of the key enablers of KM. This study investigates the relationship between the success of KM initiatives and those aspects of organizational culture that govern the knowledge-seeking and knowledge-sharing propensities of the organization's members. We examine the impacts of these propensities on the effectiveness of a KM initiative in terms of its impact on one measure of organizational performance. We develop a conceptual model of the organization where performance depends on the effectiveness of knowledge reuse within the organization. Numerical simulations are employed to gain insights into the relationship between the knowledge-sharing propensities of the organization's employees and the success of a KM initiative.

Our results show that the effectiveness of a KM initiative is determined to a greater extent by the employees' predispositions towards knowledge seeking than their predisposition towards knowledge sharing. When the employees exhibit moderate knowledge seeking and sharing propensities, the KMS has a greater positive impact of their collective performance than when the employees exhibit either low or high propensities for knowledge seeking and sharing. We find that organizations whose employees are highly predisposed towards both knowledge sharing and seeking experience higher performance gains when the KM initiative also institutes KM processes that embed knowledge seeking activities into the employees' work routines. Based on our findings, we present guidelines for future research and implication for practitioners.

KEYWORDS

Knowledge Management, Knowledge Sharing Propensities, Organizational Culture

1. INTRODUCTION

Successful Knowledge Management (**KM**) initiatives have resulted in remarkable returns on investments. Shell International Exploration and Production, for example, attributes an annual return of $200 million in cost savings and additional income to a Knowledge Management System (**KMS**) that costs about $5 million a year (Paul 2003). Unfortunately, a majority of KM initiatives are unable to deliver such returns (Fahey and Prusak 1998), with 70% of projects reported to be unable to achieve the stated objectives (Ambrosio 2000). Moreover, many KM initiatives initially labeled as success stories are unable to deliver on their promises in the long term, perhaps due to the lack of scalability or due to inappropriate usage of the system (Chua 2007). Lessons learned from these successes and failures have led both academics and practitioners to believe that people and processes are at least as important to the success of KM as the technology itself (e.g., Leidner and Kayworth 2006; Zack 2003).

Thus, in an effort to better understand when and why KM initiatives fail (or succeed), this study investigates one of the antecedents of successful IT-enabled KM initiatives, namely organizational culture. There is a growing consensus among researchers that organizational culture is one of the key enablers of (or barriers to) effective KM (Balthazard and Cooke 2004). Davenport and Prusak (1998) recognized the need to develop a knowledge-intensive culture that encourages knowledge sharing, while Alavi and Leidner (2001) and Nonaka (1994) identify the relationship between corporate culture and knowledge creation capabilities. Janz and Prasarnphanich (2003) even assert that "… organizational culture is believed to be the most significant input to effective KM and organizational learning in that corporate culture determines values, beliefs, and work systems that could encourage or impede knowledge creation and sharing" (p. 353).

Organizational culture is a complex phenomenon that has been studied by a variety of disciplines including organizational theory, organizational behavior and psychology. Despite conflicting definitions, researchers generally agree that organizational culture constitutes a "set of social norms that define the rules or context for social interaction through which people act and communicate" (Nadler and Tushman 1988). In the context of KM, these social norms and values not only shape the organization's perception of knowledge, but also define the relationships between individuals and create the context for social interactions for knowledge sharing (DeLong and Fahey 2000).

Existing studies on the antecedents to effective knowledge sharing focus primarily on explicating the employees' motivations for sharing their expertise with others Osterloh and Frey (2000). In contrast, it is relatively silent about the other party involved in knowledge sharing – i.e., the knowledge recipient or knowledge seeker. Such a one-sided focus may be misleading as the "knowledge market" perspective of the organization highlights the importance of examining the behaviors of both the recipient (or seeker) and the sender (or sharer) of knowledge (Davenport 1999). In the context of KMS, both sides of the transaction need to be taken into consideration when investigating the impact of such systems on the organization's performance. While employees' knowledge sharing propensities account for their contributions to the KMS, their knowledge seeking propensities determine if and how they use the knowledge in the KMS.

The goal of this study is to investigate how the organization's cultural characteristics that govern both the knowledge seeking and sharing propensities of individuals in the organization influence the success of KMS implementations. For our purposes, we consider the impact of KMS as the value it creates for the organization and its impact on organizational performance. This impact on performance is considered in terms of increased efficiency and accuracy of knowledge work such as decision making and problem solving. Through this study, we seek to answer two questions: (1) How is an IT-enabled KM initiative's effectiveness, in its ability to have a positive impact on organizational performance, influenced by the knowledge sharing and seeking propensities of the organizational members? (2) How can these behaviors be leveraged to extract the most value from a KM initiative? This research differs from prior studies on KM and organizational culture in two ways. *First*, we examine *both* the knowledge seeking and sharing propensities of the organization's members and *second*, we explicitly conceptualize KMS effectiveness in terms of its *actual* impact on organizational performance rather than rely indirectly on proxies such as members' willingness to share or volume of knowledge artifacts contributed to knowledge repositories as these can only represent *potential* benefits of KMS.

The purpose of this research is to generate new theoretical insights into the relationship between organizational culture and the effectiveness of KMS. KM is a dynamic and continuous set of processes and practices embedded in individuals, groups and physical structures of the organization, where individuals and groups may be involved in different aspects of knowledge management process simultaneously (Alavi and Leidner 2001 p. 123). Since the phenomena that we are interested in studying are essentially non-linear emergent processes, they are challenging to isolate, observe and quantify in empirical settings. Therefore, we employ simulation modeling as the primary research methodology in an effort to develop new insights from established constructs (Davis et al. 2007; Harrison et al. 2007). Simulations have been used widely in the field of organizational sciences to study similar phenomena, including organizational learning (e.g., Carley 1992; March 1991) and culture (e.g., Axelrod 1997). Simulation models have been found to be an effective substitute in situations where it is challenging to collect time variant data at the individual and organizational levels for empirical analysis (Davis et al. 2007). Simulations allow us to address "what if?" questions more efficiently than other research methods, especially when explaining longitudinal, non-linear and processual phenomena such as learning, individual behaviors and KM activities. Furthermore, we are interested in the impacts of individual behaviors (at the micro-level) on the organization's performance (at the macro-level). Simulations have been found to be particularly useful tools for studying such impacts, as they allow us to isolate, model and systematically experiment with micro-level behaviors and objectively monitor macro-level dynamics (Lomi and Larsen 1996). While simulation modeling affords precision and internal validity, it also requires precise definitions of the constructs and relationships. These definitions may entail restrictive assumptions and threaten the external validity of the analysis. We acknowledge the limitations of simulation methods and stress that the purpose of this study is to generate theoretical insights that can (and should) later be examined empirically. We recognize that our model does not attempt to capture all constructs, variables and relationships identified in the literature and focus on developing a simple model of the central phenomenon to develop new theoretical insights.

With this in mind, in the next section we present a conceptual model of an organization engaged decision making activities. In addition to the decision making activities, our model also captures the basic KM processes, which include knowledge creation, transfer and application, both in the presence and the absence of a KMS implementation. Since we concentrate on those aspects of organizational culture that affect the KM processes and KMS usage, the representation of the organizations' culture is restricted to the employees' knowledge seeking and sharing propensities in our model. Thus, our model captures the organizations' knowledge work, KM processes and knowledge culture. Additionally, this model also allows us to measure the organization's performance as an emergent outcome both of the KM processes as well as the knowledge seeking and sharing propensities of the employees.

The computational model for this organization is derived and formalized in the following section, which is followed by the description of the model calibrations. Using this model we systematically experiment with the employees' knowledge seeking and sharing propensities and the complexity of the organization's knowledge domain to examine how a generic KMS implementation impacts the performance of organizations represented by different combinations of these variables. We then discuss the results of the simulations which reveal a number of interesting findings. We find that while the cultural characteristics that govern both the knowledge seeking and sharing propensities of the organization's employees influence the effectiveness of the KMS, the knowledge seeking propensities have a greater influence than the knowledge sharing propensities. Thus, the employees' predisposition towards the reuse and application of knowledge from the KMS has a greater influence on the value created by the KMS than their predisposition to contribute their knowledge to the KMS. We also find that organizations with moderate propensities for knowledge seeking and sharing seem to experience the greatest performance gains from the KMS implementation when compared to organizations with high (or low) propensities for the same. Moreover, while we do see performance gains with the KMS, these performance gains are not substantial.

Therefore, we propose an alternative model to the simple KMS implementation that incorporates the institutionalization of certain KM processes, such that knowledge seeking is embedded into the employees' work routines (given their knowledge seeking propensities). The results of this augmented KMS implementation reveal the performance gains of organizations that implement KMS in conjunction with process changes are significantly higher than when they implement the KMS alone. Moreover, these performance gains are greater when the knowledge complexity and the employees' knowledge seeking and sharing propensities are high. Finally we conclude this paper with a discussion of the implications of our findings for both practitioners and academics. Based on our results, we also suggest directions for future research.

2. A CONCEPTUAL MODEL OF ORGANIZATIONS

Organizations can be conceptualized as information processors that use knowledge to make decisions (Tushman and Nadler 1978). Prior studies of organizational knowledge-centric processes (such as learning, knowledge transfer and decision making ability) have frequently used this abstraction (e.g., Carley 1992) and measured the organization's performance by its ability to make correct decisions over time. In this context, KM processes such as knowledge creation, sharing and utilization, influence the organization's decision making ability (Miller et al. 2006) as these processes aid in the formulation of informed solutions and responses to current problems. Continuing in this line of research, we also consider organizations to be decision making entities, wherein individuals within the organization make informed decisions based on the past knowledge and experiences acquired by the individuals themselves and the organization as a whole.

Moreover, organizations are also integrators of specialized knowledge under the knowledge based view of the firm (Grant 1996). Different units of the organization possess knowledge specializations, or subsets of organization's knowledge domain that they are most proficient in. Knowledge specializations not only create a setting that is conducive to knowledge creation (Grant 1996; Nonaka 1991), but also create opportunities for knowledge transfer within and across specialized units of the organization (Kogut and Zander 1996). Thus this conceptualization of organizations as a collection of groups with specific and unique knowledge capabilities allows us to capture the organization's KM processes, as knowledge may be created, shared and applied within groups and across group boundaries.

The organization's employees continually augment their knowledge and skills over time by learning from their experiences and interactions with the external environment (Walsh and Ungson 1991). In contrast, learning at the organizational level cannot be thought of as the sum of individual learning alone (Levitt and March 1988) and is dependent on the utilization and application of knowledge possessed by the organization as a whole. Thus organizational learning is contingent on the effective use of organization's knowledge through the sharing, transfer and application of knowledge across the different units of the organization (individuals, groups or departments). KMS may facilitate the above mentioned KM processes by increasing the visibility and availability of organizational knowledge, however, their ability to do so and create value for the organization is determined by how the employees use the KMS (Ba et al. 2001). Depending on the nature of the knowledge work, individuals engage in knowledge exchange through direct social interactions or indirectly through knowledge artifacts or KMS (Haas and Hansen 2007).

The two parties involved in knowledge exchange are the knowledge source and the knowledge recipient. The knowledge recipient must first seek out a knowledge source, and this knowledge source must consent to sharing her knowledge before the actual transfer of knowledge takes place. Thus, the actual occurrence of knowledge exchange (through both social interactions and the KMS) is contingent on the organizational members' predispositions towards seeking and sharing knowledge. These predispositions of the employees may be governed by either or both intrinsic and extrinsic motivations (Osterloh and Frey 2000). While extrinsic motivations are induced through monetary compensation or other rewards, intrinsic motivations arise from the individuals' own perception of the value for engaging in knowledge sharing activities (Calder and Staw 1975). The employees' intrinsic predisposition for engaging in knowledge sharing is induced by the organization's social norms and climate (Bock et al. 2005) and are more critical to knowledge transfer than their extrinsic motivations (Osterloh and Frey 2000), which have, in fact, been found to be a hindrance to knowledge sharing in certain circumstances (Bock et al. 2005).

Since organizational culture constitutes shared beliefs, ideologies and the norms that influence the actions of the organization's members (e.g., Beyer 1981; Mitroff and Kilmann 1976), the cultural values of the organization also influence the actions of individuals engaging in KM activities. For our purposes we concentrate on the organizations' cultural values that govern the employees' predispositions or willingness to seek (or buy) and share (or sell) knowledge. We adopt the integration perspective of organizational culture which suggests culture as being homogenous collection of values that acts as an integrative mechanism or social/normative glue that holds a potentially diverse group of organizational members together (Meyerson and Martin 1987). Based on this perspective, we can assume that all organizational members have the same knowledge buying and selling propensities since they share the same cultural values.

In the context of KM, these predispositions determine how the organization's members seek knowledge from others and how they share knowledge with others. Moreover, these predispositions are not only pertinent for knowledge exchange through interpersonal interactions, but also the usage of the KMS. As KM is "… the generation, representation, storage, transfer, transformation, application of organizational knowledge" (Schultze and Leidner 2002, p. 218), information systems designed to support these functions must allow for the creation, transfer and utilization of the organizational knowledge (Alavi and Leidner 2001). KMS can be thought of as centralized knowledge repositories that store knowledge codified by employees, which can be later used by others as per their requirements. This representation exemplifies the codification strategy (Hansen et al. 1999), wherein individuals can search, retrieve and utilize this codified knowledge as required. In the case of the KMS, knowledge transfer and applications occurs when individuals retrieve knowledge from the system and apply it to current problems. Unlike the interpersonal exchanges, this knowledge transfer is primarily dependent on the knowledge seeker's propensity to utilize the KMS. However, the required knowledge can be retrieved only if other individual(s) have previously contributed this knowledge to the KMS, and is therefore also dependent, to a certain extent, on the knowledge sharers' propensity to contribute their expertise to the KMS.

3. A FORMAL MODEL FOR ORGANIZATIONS

Based on the framework presented above, in this section we formalize the model for organizations. We use Carley's (1992) as a starting point to model the organization's decision making problems and organizational performance measures. Our model also incorporates the knowledge specialization across organizational units, the organization's KM processes (specifically knowledge creation, sharing, transfer and application), and a generic KMS implementation that facilitates the KM processes. We also incorporate the organization's knowledge culture as the employees' knowledge seeking and sharing propensities that govern how the employees engage in different KM activities. Thus, this model allows us to capture organizational knowledge work and examine how the KMS impacts the performance of organizations (in terms of the quality of the knowledge work) with different knowledge cultures.

3.1. The Organization's Structure and Knowledge Work

The organization is modeled as a collection of *G* groups, each with *m* individual members. As discussed in the previous section, each group within the organization specializes in certain aspects of the organization's knowledge domain. Therefore, in accordance to what Brown and Duguid (1998) term as the "division of labor", in each decision making period, a group faces a new problem that is similar, but not necessarily identical, to previous problems it has already encountered. Moreover, the group's problem is partitioned into individual problems that are assigned to the individuals. Thus, each of the *m* group members autonomously evaluates the information on her portion of the new problem, and a final decision is made by the group by considering the inputs from all the group members. We assume that problem faced by the group has sufficient complexity to ensure that individuals do not have the necessary information, skills or resources to independently make a decision for the overall problem. The group's decision making process follows from Carley's (1992) *team* organizational structure, wherein the group members receive a subset of the available information (or a subproblem) and make their recommendation independent of others. The final group decision is the majority vote of the group members' recommendations. At the end of the decision making period, the group receives feedback from the environment, which is the correct (or "true") response for that problem. The feedback received is for the entire group-level problem and is the decision that would be made by a clairvoyant decision maker given the entire problem and having perfect knowledge of the pattern matching scheme. In other words, the group has a whole gets to know whether the group-level decision was correct but the individual members do not know whether their portion of the recommendation was correct.

The structure of the problem is borrowed from Carley's (1992) model as it provides a very general task structure involving stochastic pattern matching. More specifically, the problem is modeled as an N bit string where each bit may take a binary value of 0 or 1 representing a *yes* (1) or *no* (0) decision for parts of the entire problem. Here, N represents problem complexity implying 2^N possible distinct problems. Consequently, as N increases, the likelihood of encountering identical problems in consecutive decision periods decreases exponentially. The group must determine which pattern of 1's and 0's corresponds to a *yes* or *no* answer. Initially, the organization's members do not know if the correct pattern-response is majority classification, even/odd classification, parity etc. The problem is a decomposable task, and group members use the following heuristic to formulate a decision for the problem. Each group with m members receives a problem of complexity N, therefore, a group member is assigned a subproblem of length $n=N/m$ (where n is the subproblem complexity[1]). Individuals submit a *yes* or *no* recommendation for their assigned subproblem (a string of n contiguous bits) as their contribution to the group's final *yes* or *no* decision which is determined by a majority vote (see Figure 1).

Each group $g \in G$ is assigned a unique and non-overlapping set of subproblems S_g (or specialization sets of size $2^n/G$) that represent the specialization of the group. The non-specialization set ($S_{\sim g}$ of size $2^n(1- 1/G)$) comprises of all possible subproblems that are not in S_g. A problem is formulated by concatenating m draws (with replacement) of n bits each from S_g with higher probability than from $S_{\sim g}$ resulting in a group-level problem of length N. This ensures that each group receives problems in its specialization set more frequently than problems

[1] There are 2^n possible subproblems that an individual can be assigned.

in its non-specialization set. Thus groups face problems that are generally pertinent but not necessarily limited to their knowledge specializations.

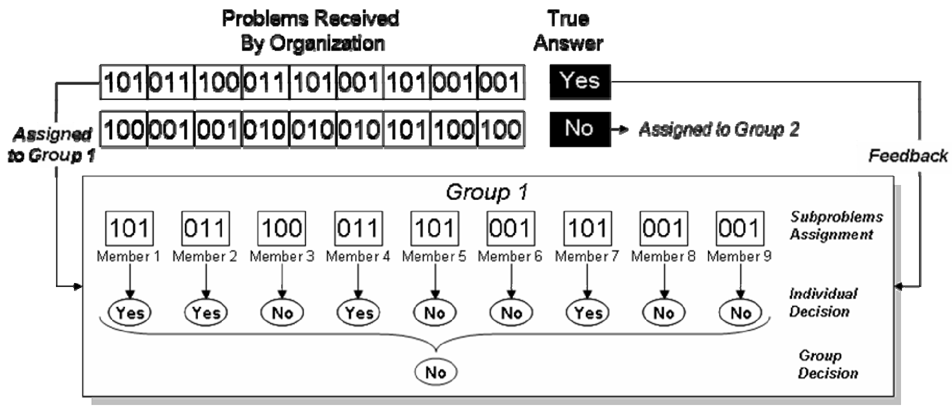


Figure 1: Organizational Decision Making & Feedback [N = 27, n=3, G=3, m=9]

3.2. The Organizations' Members

The individual members of the organization are modeled as imperfect statisticians who adjust their expectations for decision outcomes based on experience (Carley 1992). Individuals learn by retaining past experiences as knowledge stored in their memory (Walsh and Ungson 1991). In addition to their own past experiences, individuals may also utilize organizational knowledge (e.g., experiences of colleagues, knowledge artifacts stored in knowledge repositories etc.) to aid their decision making. The search for knowledge begins locally and proceeds to more distant sources of knowledge if the initial search fails to generate a *satisficing* outcome (Cyert and March 1963). Therefore, we model the individuals' decision making process based on the assumption that individuals are biased towards knowledge sources that are closest to them (Miller et al. 2006), and will resort to other sources of knowledge only if they are unable to make a principled decision based on their own experiences. Since the closest knowledge source is one's own memory, individuals will first try to formulate a decision based on their own knowledge and experience. We term this process as *Internal Search*. If the individual does not possess the required knowledge to make an informed decision for the current problem, he or she will proceed to more distant sources of knowledge, such as his colleagues (i.e., perform a *Local Search*) and/or the KMS (i.e., perform a *Lookup*). Detailed descriptions of *Internal Search, Local Search* and *Lookup* are provided below.

Theories in cognitive psychology state that individuals' memories are not perfect and knowledge is susceptible to decay over time. According to "trace decay theory" of human memory, forgetting occurs due to the automatic fading of "memory traces" (Baddeley 1997). Therefore, consistent with the Search of Associative Memory (SAM) model[2], we model an individual's memory as a cumulative record of past experiences within a fixed time frame. In other words, an individual retains information regarding the subproblems encountered for the past τ time periods only. This information includes the subproblem and the feedback (or correct group-level decision) received from the environment, and is recorded as follow. For each distinct subproblem that an individual has encountered in the past τ time periods, separate counts for the *yes* and *no* feedbacks are maintained. At the end of each decision making period, the correct group-level decision is revealed to the individuals and they update their expectations for the current subproblem as follows: if the feedback received is *yes* (*no*), the *yes* (*no*) counter for the current subproblem is incremented. For example, an individual may recall that for the subproblem '101', the feedback received from the environment was *yes* 4 times and *no* 3 times, while for subproblem '110', the feedback received from the environment was *yes* 3 times and *no* just once, and so on. In addition, the subproblem encountered at time τ is forgotten (i.e., the

[2] According to the SAM model, memories consist of a set of associations between items (e.g., subproblems and feedback) (Raaijmakers and Shiffrin 1981). The strength of these associations is determined by the frequency with which they co-occur. Therefore, if an individual has encountered a subproblem X 10 times, and the feedback associated with this subproblem has been *yes* 7 times and *no* 3 times, the individual will associate the correct response to problem X as *yes* in future time periods. The SAM model is applicable in the context of both episodic and semantic memory. Our model of individual memory is also consistent with the reinforcement learning (Sutton and Barto 1998).

corresponding counter is decremented appropriately). Thus, by incorporating forgetting into our model we are also able to capture the recency effect in human memory[3].

3.3. The Knowledge Management System Implementation

We incorporate a generic KMS into our model as a centralized knowledge repository that stores knowledge codified by members of the organization, and can be used as an additional source of knowledge in the organizational members' decision making process. The KMS representation is based on the following assumptions that ensure that the KMS is technologically efficient, consistent and reliable: (a) All knowledge contributed to the knowledge repository is codified accurately and completely, and (b) Knowledge extracted from the knowledge repository is precise, complete and accurately reflects the search criteria. Our assumptions bias the representation of KMS in that it performs as desired under all conditions, and does not degrade the quality or content of knowledge due to either tacitness or stickiness. In more realistic scenarios, where the codification of knowledge deteriorates it richness, the performance gains due to KMS can be expected to be quantitatively lower.

The KMS is modeled as a knowledge repository that retains a cumulative record of subproblems and corresponding feedback that organizational members contribute to it. Unlike the individuals' memories, the KMS is not constrained by the limitations of human memory and is not subject to forgetting, recency effects and salience. Therefore, all knowledge contributed to the KMS is retained permanently in the form of knowledge artifacts. In addition to the list of possible subproblems, the KMS also maintains two counters: one for the *yes* and one for the *no* decision outcomes. The KMS acquires and stores new knowledge when individuals contribute to their knowledge by codifying and adding newly acquired experiences to the KMS. Formally,

[3] The serial position effect in cognitive psychology posits that things most recently learned are best remembered (Talmi and Goshen-Gottstein 2006).

when an individual contributes to the KMS, the *yes* (or *no*) counter corresponding to the last subproblem she was assigned is incremented appropriately (i.e., based on the received feedback).

3.4. Individuals' Decision Making Process and Knowledge Sharing

Figure 2 depicts a flowchart for the individuals' decision making process described below.

Internal Search: As mentioned above, when an individual is faced with a subproblem she first performs an *Internal Search* and tries to make an informed decision based on her own knowledge. More formally, *Internal Search* entails the following procedure: (1) Identify the *yes* and *no* counts for the subproblem; if the *yes* count is greater than the *no* count, return *yes* as the decision; otherwise, return *no*; (2) if the *yes* and *no* counts are equal (or both are zero), seek an alternative knowledge source (i.e., perform *Local Search* or *Lookup*); (3) if either or both *Local Search* or *Lookup* do not yield a recommendation, return a *yes* or *no* decision with equal likelihood (i.e., *Improvise* or guess the decision). This process is depicted in Figure 2 under *Internal Search*.

If the *Internal Search* fails to yield a decision (i.e., step (2) above), the individual can approach other sources of knowledge for recommendations to aid the decision making process. If an individual solicits and obtains a recommendation from a group member, this process is termed as a *Local Search*. Alternatively, if an individual extracts a recommendation from the KMS, the process is termed as a *Lookup.* Each individual has a preference for either *Local Search* or *Lookup* based on his past experience of recommendations from the KMS and his group members. In essence, an individual will prefer *Local Search* over *Lookup* if, in the past, the recommendations from his colleagues have resulted in a greater number of correct decisions than the recommendations from the KMS. If the converse is true, the individual will prefer *Lookup* over *Local Search*. We model this preference as follows: for each individual we compute the expectation *Exp*(*Local Search*) for *Local Search* as the ratio of correct recommendations and total recommendations obtained from *Local Search* (the expectation for *Lookup*, *Exp*(*Lookup*) is computed in a similar manner). Thus if *Exp*(*Local Search*) > *Exp* (*Lookup*) the individual prefers *Local Search* over *Lookup*. These expectations are updated after each decision making period, when the individual receives feedback from the environment and is able to evaluate the correctness of the recommendation. In Figure 2, the expectation for *Local Search* and *Lookup* are represented by e_{LS} and e_{LO} respectively.

Local Search: The social relationships between individuals are an important aspect of interpersonal knowledge exchange (Levinthal and March 1993). During the process of identifying a colleague who may have the required knowledge, there exists an inherent bias towards searching locally and interacting with proximate neighbors rather than searching in a broader/extended network (Cyert and March 1963) as individuals tend to share knowledge within close knit networks (Robertson et al. 1996). Therefore, the scope of *Local Search* is limited to other members in the individual's group.

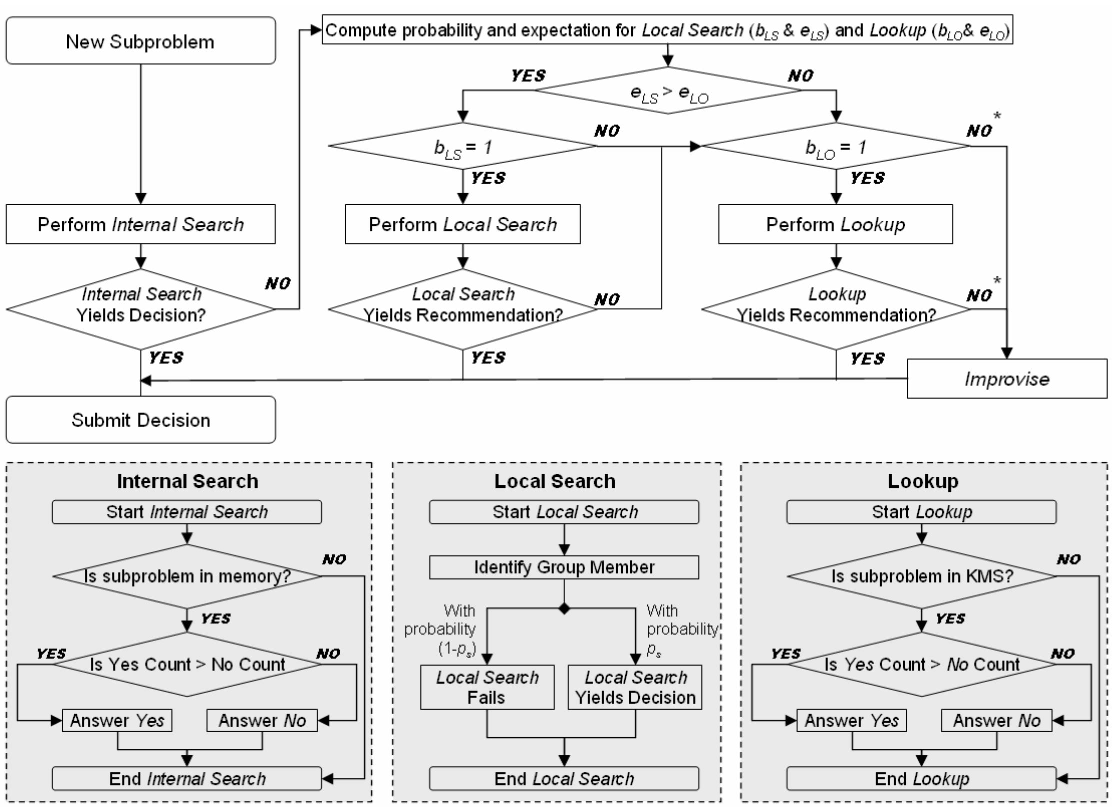
Prior studies on small groups recognize that the creation of transactive knowledge systems necessitate knowing one's own expertise as well as the expertise and knowledge of others in the group (Wegner 1986). Such transactive knowledge systems enable the retrieval of the knowledge from others in the group in an efficient and effective manner (Moreland et al. 1998) as well as enable the group to implement knowledge as needed (Stasser 1998). We assume that such transactive knowledge systems exist within all the groups of the organization and enable the following: (a) the identification of group members who possess the required knowledge; (b) efficient and accurate transfer of knowledge between the sender and the recipient; (c) efficient utilization of the knowledge in decision making by the recipient. These assumptions reflect the efficient transfer of knowledge between the knowledge seeker and sharer, through face-to-face interactions (Orlikowski 2002).

Local Search and entails the following: (i) Identify an organizational member who possesses the required knowledge; (ii) If a knowledgeable colleague is identified, employ her recommendation to make the decision (i.e., rely on the colleague's *yes*/*no* counter to make the decision); (iii) If no knowledgeable colleague is identified or the colleague is unable or unwilling to provide a recommendation, improvise the decision (i.e., step (3) above). In Figure 2, this process is depicted under *Local Search*.

An individual performs the *Local Search* or seeks knowledge within his/her group with probability p_b. If this individual seeks knowledge and is able to identify a group member who has the required knowledge, this group member shares this knowledge with the probability p_s. The probabilities p_b and p_s represent the propensity of an individual to seek (or buy) and share (or sell) knowledge. If the group member is willing to share his knowledge, his recommendation is submitted as the decision.

Lookup: An individual performs a *Lookup* or seeks knowledge from the KMS with probability p_b, which is the individuals' propensity to buy knowledge from external sources. The mechanics of knowledge retrieval are similar to that of the *Internal Search*. The *yes* and *no* counts for the subproblem are retrieved from the KMS and the recommendation is *yes* if the *yes* count is greater than the *no* count, and *no* otherwise. In Figure 2, this process is depicted under *Lookup*.

The KMS acquires and stores new knowledge, when members of the organization codify and add newly acquired knowledge (in the form of subproblems and feedback) at the end of a decision making period. Individuals contribute to the KMS with probability p_s in each time period, where p_s represents the individuals' propensity to sell their knowledge, or make it available to other members of the organization.



Note: * If b_{LS} = 1 and b_{LO} = 0 or *Lookup* fails to yield a decision, perform *Local Search* before proceeding to *Improvise.*

Figure 2: Individual Decision Making Process

3.5. Knowledge Buying and Selling Propensities

Individuals seek knowledge from their group members or from the KMS with probability p_b, and share their knowledge with their group members or contribute to the KMS with probability p_s. These probabilities (p_b and p_s) represent their propensities to seek or buy knowledge from an external source and share or sell their knowledge to others respectively, and are governed by the organization's knowledge culture. As mentioned previously, we adopt the integration perspective of organizational culture and therefore we assume that all members of the organization display the same propensities, i.e., for a given organization, all the employees have the same values for p_b and p_s.

The propensity to seek or buy knowledge (p_b) reflects the individuals' willingness to seek and retrieve knowledge from an external source and apply this knowledge (or the recommendation) towards formulating a decision for the current task at hand. Thus high knowledge buying propensities reflect individuals who proactively seek out knowledge from others and apply this knowledge appropriately. These individuals are receptive to new ideas and advice from others and thus actively solicit their colleagues and access the KMS to aid their decision making. On the other hand, low knowledge buying propensities reflect the "Not Invented Here" syndrome, wherein individuals are reluctant to accept advice and recommendation from others (Katz and Allen 1992). These individuals are unreceptive to external recommendations and the reuse of knowledge acquired elsewhere.

Similarly, the propensity to share or sell knowledge (p_s) reflects the individuals' willingness to share their own knowledge with others, either through direct interpersonal interactions (i.e., when a colleague solicits their help) or by continuously updating the contents of the KMS. High knowledge selling propensities reflect individuals who are willing to share their knowledge with others, even when they are not solicited directly (i.e., they autonomously update the KMS). Alternatively, low knowledge selling propensities reflect individuals who display "knowledge hoarding" behaviors and are reluctant to impart advice and recommendations to others.

We represent the organization's knowledge culture by the vector [p_b, p_s]. The two parameters p_b and p_s are modeled as probabilities and are random variables drawn from the interval [0,1]. Thus a knowledge culture defined as [0.1 0.6] reflects low knowledge buying propensities and high knowledge selling propensities, while a knowledge culture defined as [0.8 0.2] reflects high knowledge buying propensities and low knowledge selling propensities. In order to capture the entire spectrum of knowledge cultures, we consider p_b and p_s to be independent of each other.

4. MODEL CALIBRATION

In our simulation models, an organization is characterized by its structure (number of groups G, and number of organizational members m) and its knowledge culture (which is represented by the employees' knowledge buying and selling propensity). While keeping the structure constant (at G=3, m=9), we vary problem complexity (N) and the organization's knowledge culture (i.e., [p_b, p_s]). We consider three levels of N: Low (N = 27 or n = 3), Medium (N = 45 or n = 5) and High (N = 63 or n = 7)[4] and three levels for both p_b and p_s: Low (*probability* = 0.2); Medium (0.5); and High (0.8). We conduct the simulations using a full factorial design of $3(p_b)\times3(p_s)\times3(N)$ = 27 organizational configurations. The complete model calibrations are summarized in Table 1.All results reported below are based on 100 runs for each organizational configuration.

Recall that with problem complexity N and subproblem complexity $n = N/m$ there are 2^N possible problems that a group can receive and 2^n possible subproblems that can be assigned to an individual. Moreover, each group's knowledge specialization is captured as a unique subset of the possible subproblems. Therefore, each group is randomly assigned $1/G^{th}$(or half as G = 2) of the possible 2^n subproblems as the specialization set and each specialization set is independent (i.e., a subproblem can belong to only one specialization set).

As discussed above, individuals are susceptible to forgetting and are able to recall recent experiences only. To this effect, we limit the size of the individual memory (τ) to a 64 time periods, i.e., individuals are able to recall the feedback for the last 64 subproblems they

[4] The complexities (N and n) employed in the model are odd to ensure an unambiguous group decision.

encountered. By selecting $\tau = 64$, the individuals' capacity to retain information about all possible subproblems decreases as problem complexity increases. For instance, when $N = 27$, individuals have the capacity to retain past experiences for all 2^n possible subproblems. However, when $N = 45$, individuals have the capacity to retain their past experiences of the subproblems in their specialization set, but may forget subproblems that are not in their specialization sets. When $N = 63$, they forget subproblems that are in their specialization set as well as subproblems that are not in their specialization set.

Table 1: Model Calibrations

Parameter	Calibration
Number of groups (G)	2
Number of members in each group (m)	9
Individual Memory Size Limit (τ)	64 Time Periods
Organization Culture [p_b, p_s] *	
Knowledge Buying Propensity (p_b)	Low (0.2)
Knowledge Selling Propensity (p_s)	Medium (0.5) High (0.8)

* These variables are continuous random variables in the interval [0,1], however we consider select discrete values in order to simplify the classification of organizations based on the calibrations of their cultural characteristics.

4.1. Organizational Performance

In each decision making period, an organization submits G group-level decisions which may or may not be correct. Following from Carley (1992), organizational learning is not measured as the accuracy of the decision at a particular point of time but as the organization's ability to improve the accuracy of their decision over time. To this effect, we also measure an organization's performance at time t as the average number of correct decisions in the past 20 time periods[5]. For each run of the simulation, each organization operates over 2500 decision making periods. We consider the subproblems assigned to individuals as decisions made by knowledge workers multiple times a day. So if knowledge workers handle 5 subproblems daily

[5] We conducted sensitivity analysis with 20, 50 and 100 time periods and did not find any qualitative difference in the results. Quantitatively, higher time periods increased the fit of the statistical models.

on average, a timeframe of 2500 decision making periods reflects approximately 2 years. Thus, the performance at t = 2500 is representative of long term performance. Moreover, by t = 2500, we find that the performance and actions of the organization's members have stabilized. In the analysis presented in below, we focus on the ultimate performance of the organization, which is measured as the performance at t = 2500.

To measure the impact of the KMS on the organization's performance we employ the measure "change in performance" which is computed as the difference in ultimate performance for an organization with and without the KMS implementation at time t. Figure 3 depicts organizational performance with and without the KMS at different points of time for different levels of N. We can clearly see that for different levels of problem complexity (N), the difference in performance at t = 2500 is representative of long term change in the organizations' performance and remains consistent over time after the initial learning period (i.e., after approximately 200 time periods). In the following section, we employ the measure δp as the change in performance which is computed as the difference in ultimate performance with and without the KMS at t = 2500.

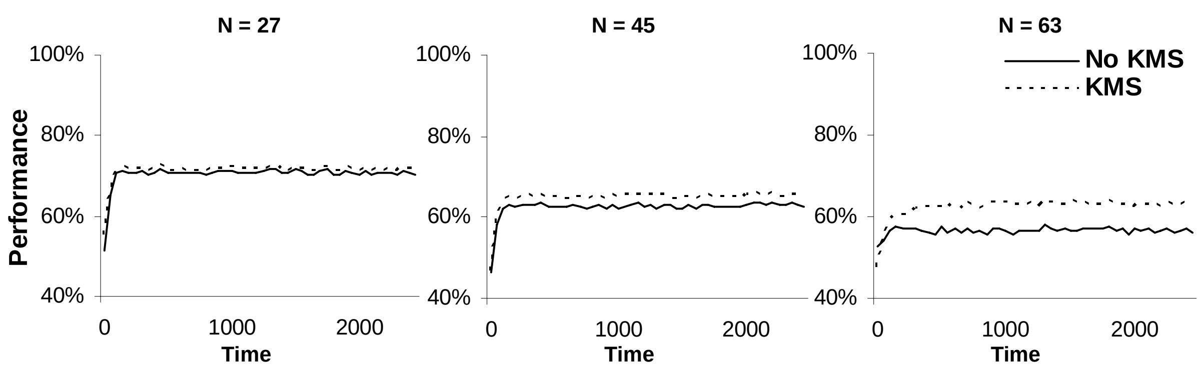
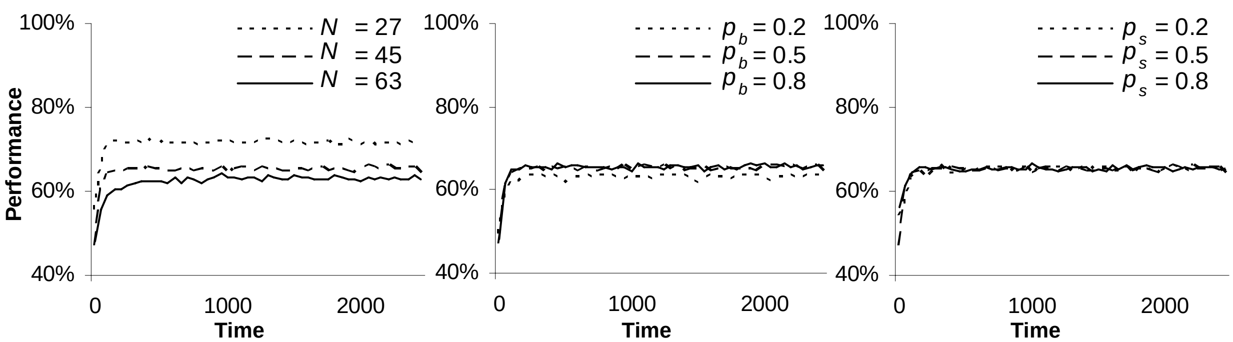


Figure 3: Organizational Performance with and without KMS
[N = 27, 45, 63, $p_b = p_s$ = 0.5]

Figure 4 depicts how the performance of organizations with KMS varies with time. In prior studies on organizational learning and decision making, problem complexity has been found to have a detrimental impact on organizational performance (e.g., Miller et al. 2006). Our results report a similar trend, and we find that the performance for organizations with the same knowledge buying and selling propensities (i.e., same p_b and p_s) are lower when N is high (63) than when N is low (27 or 45) (see Figure 4 (a)).

Moreover, the performance of organizations with low knowledge buying (or selling) propensities is lower than the performance of organizations with high knowledge buying (or selling) propensities (see Figure 4 (b and c)). Therefore, our model demonstrates that higher levels of knowledge buying and selling propensities result in superior performance. We also observe that there is a greater difference in organizational performance (with and without the KMS) for different levels of p_b (Figure 4 (b)) than for different levels of p_s (Figure 4 (c)). These preliminary results indicate that the knowledge buying propensities may influence the KMS' effectiveness to a greater extent that the knowledge selling propensities.



(a) Varying Problem Complexity (N) [p_b = p_s = 0.5] (b) Varying Knowledge Buying Propensity (p_b) [N = 45,p_s = 0.5] (c) Varying Knowledge Selling Propensity (p_s) [N =45, p_b = 0.5]

Figure 4: Organizational Performance and Time (KMS Model)

4.2. Actions of the Organization's Members

In addition to organizational performance, we also record how the individuals formulate their decisions in each decision making period. The individuals' actions (listed in Table 2) capture the knowledge source that was used to make a decision, i.e., if the decision was made based on one's own knowledge or on the recommendation of a colleague, the KMS or if the decision was improvised. In each decision making period we record $G{\cdot}m$ distinct actions of the organization's members, which we report as percentage values in the following sections[6].

Table 2: Possible Actions Taken By Individuals

	Action		Description
[1]	*Internal Search*	[IS]	Decision is based on the individual's own experience
[2]	*Local Search*	[LS]	Decision is based on group members' recommendation.
[3]	*Lookup*	[LO]	Decision is based on recommendation from KMS.
[4]	*Improvisation*	[IM]	Decision is improvised.

In the absence of the KMS, individuals are able to perform only *Internal Search, Local Search* and *Improvisation*, while with the KMS individuals are able to perform *Lookup* as well (see Figure 5). The impact of the KMS on organizational performance is therefore realized by the amount of *Lookup* that occurs within the organization, and therefore in the following section we concentrate our discussion of the individuals' actions on *Lookup*. Interestingly, we find that after the initial learning period, individuals rely primarily on their own knowledge and expertise to formulate their decisions (see Figure 5) both in the presence and absence of the KMS implementation. These findings and their implications are discussed in greater detail below.

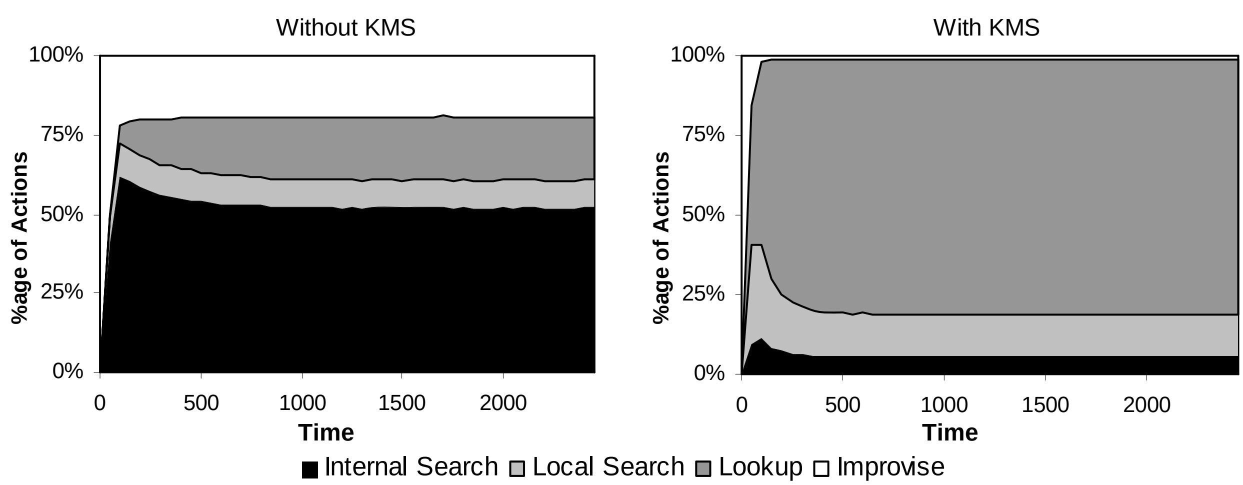


Figure 5: Organizational Members' Actions with and without KMS
[N = 45, $p_b = p_s = 0.5$]

[6] For example, the amount of *Lookup* (LO) is computed as LO = 100×[Number of *Lookups*]/($G{\cdot}m$). This ensures that in each decision making period IS + LS + LO + IM = $G{\cdot}m$.

5. SIMULATIONS RESULTS

We subjected the change in performance (δp) to a three way factorial ANOVA with independent variables N, p_b and p_s. The direct effects of all three variables were significant at $p<0.001$. The two-way interaction of Nxp_s and Nxp_b were also found to be significant (at $p<0.001$) while the interaction between p_bxp_s was found to be significant at $p=0.0115$. Interestingly, the three-way interactions were also significant at $p<0.001$.

Figure 6 shows the graphical representation of the ANOVA results. The ANOVA contrast shows that the direct effect of N on δp is positive and significant at $p<0.001$, indicating that δp is higher when N is high. As described above, higher N implies that the frequency with which similar problems (and subproblems) are encountered are lower and individuals may not possess the required knowledge to make informed decisions on their own. It is also highly probable that group members are unable to assist and provide appropriate recommendations due to lack of experience. Thus, organizations operating in environments of high problem complexity will benefit from additional sources of knowledge such as the KMS. Furthermore, since knowledge is retained indefinitely in the KMS while individuals retain knowledge from only recent subproblems, the KMS is a valuable resource. We find that organizations operating in environments of high problem complexity experience greater performance gains than organizations operating in environments of low problem complexity.

The significant three-way interaction effect between N, p_b and p_s in the ANOVA reveals that the impact of the knowledge buying and selling propensities (p_b and p_s) on the change in performance (δp) are dependent on the problem complexity N. When examining the interaction effects of p_b and p_s with N, we find that when N is low ($N = 27$) both p_b and p_s do not have a significant impact on δp (pair wise t-tests are insignificant with $p < 0.05$) However, when N is high ($N = 63$) both p_b and p_s have a significant and positive impact on δp (pair wise t-tests are significant at $p < 0.05$). Since organizations operating in environments with low problem complexity do not experience significant performance gains due to the KMS implementations, the knowledge sharing propensities of the employees of these organizations do not have a significant impact on performance gains either. However, for organizations that do experience performance gains due to the KMS implementation (i.e., when N is high), the knowledge buying and selling propensities have a significant impact.

Finally, when examining the effect of p_b and p_s, we find that δp is greater for moderate values of p_b and p_s (0.5) than for low or high values of p_b and p_s (0.2 or 0.8). Since individuals in organizations with high p_b and p_s (0.8) already share and seek knowledge to aid their decision making, these organizations do not experience high performance gains with the KMS implementation. Individuals in such organizations are able to get the required recommendations and advice from their group members even in the absence of KMS. Alternatively, individuals in organizations with low p_b and p_s (0.2) will rarely seek knowledge from external sources or share their knowledge with others. Consequently, the KMS in such organizations will fall into disuse, since the organizational members will rarely contribute their knowledge to it or rarely utilize it to aid their decision making. Thus, these organizations will not experience substantial performance gains from the KMS implementation. Organizations with moderate p_b and p_s (0.5) experience the highest performance gains, since the individuals in such organizations are unable to find the required knowledge within their groups when the seek it. However, by accessing the KMS, they are able to find the required knowledge and make informed decisions to the problems at hand as these individuals are not directly constrained by the knowledge sharing propensities of others with the KMS.

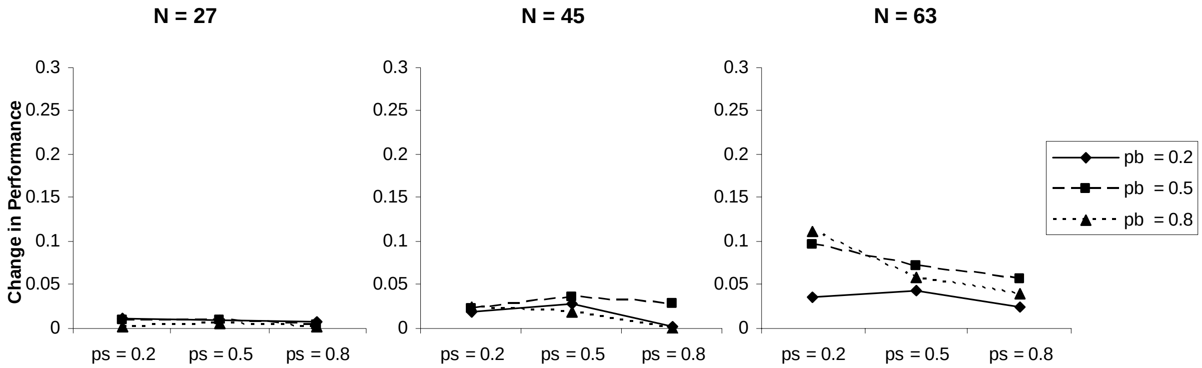


Figure 6: ANOVA Results for Change in Organizational Performance with and without KMS (δp)

The above results indicate that organizations operating in environments with high knowledge complexity experience higher performance gains from KMS implementations, however these gains are contingent on the employees' knowledge buying and selling propensities. Furthermore, organizations where the knowledge buying and selling propensities are low do not experience high levels of performance gains since the KMS is not utilized due to the employees' reluctance to share knowledge. On the other hand, in organizations where knowledge buying and selling propensities are high, knowledge is already being shared through interpersonal interactions and the KMS implementation does not augment the knowledge sharing within the organization to a great extent thus not resulting in high performance gains.

In addition to *Internal* and *Local Search*, the KMS implementation affords the organization's employees the ability to perform *Lookup*. Thus the utilization of knowledge in the KMS can be deduced from the number of decisions that are based on the recommendations obtained from the KMS i.e., the number of *Lookups*. Using a simple regression model ($\delta p = \beta_0 + \beta_1 LO + \varepsilon$, at t = 2500 where *LO* is the average number of *Lookups*), we find that *LO* has a significant and positive impact on δp (at $p < 0.01$). The interaction effects of *LO* and *N* are not significant, implying that more *Lookup* always results in higher performance.

We also subjected *Lookup* (at $t = 2500$) to a three-way factorial ANOVA with the dependent variables N, p_b and p_s. We find that all the direct effects and the interaction effects (including the three way interactions) are significant at $p<0.001$. Figure 7 shows the graphical representation of the ANOVA results. As in the case of δp, we find that $N = 27$ neither p_b nor p_s have a significant impact on *Lookup*, however when $N = 45$ (or 63), the impact of both p_b and p_s are significant. It is interesting to note that when p_s is low, there is more *Lookup* than when p_s is high. This is further magnified when either p_b and N are high. Though we find evidence for the fact that more *Lookup* results in higher performance, we also find that the actual amount of *Lookup* that occurs within the organization is relatively low (with a maximum of 30% of decisions made based on the knowledge in the KMS) as are the performance gains (with a maximum of 12% increase). Thus individuals rely on their own knowledge to formulate decisions to a greater extent than they do on external sources of knowledge (as we saw in Figure 5).

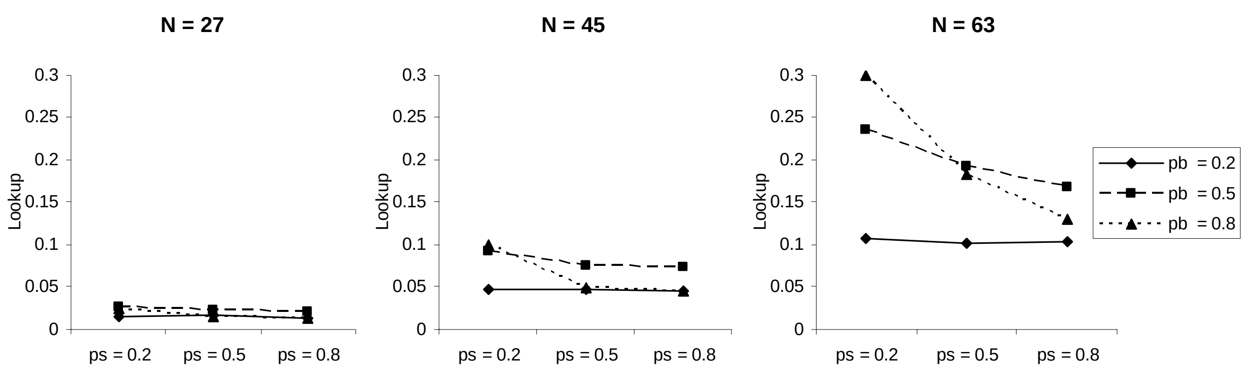


Figure 7: ANOVA Results of *Lookup* in the KMS Model

Individuals retain information regarding a maximum of τ subproblems (at any point of time $t > \tau$) of which a majority are from the individuals' group's knowledge specialization. On the other hand, the KMS accumulates, on average, $p_s \cdot m \cdot G$ new subproblems in each time period. As this knowledge is stored indefinitely, we can assume that after an initial break-in time period, the KMS will consistently have more knowledge than any individual possesses alone. Thus, we can ascertain that the KMS contains more records for each subproblem than the individual memories, and consequently a *Lookup* will yield a more accurate recommendation than an *Internal Search* or a *Local Search*. In the same vein, though each individual retains the same amount of knowledge, the contents of the memories of individuals within the same group may be different. Thus a group member may have greater knowledge for a particular subproblem than others in the group and *Local Search* may yield better recommendations than an *Internal Search*.

However, despite the existence of superior sources of knowledge within the organization, we find that individuals rely primarily on their own knowledge and experiences. As evidenced by the results presented above, the amount of *Lookup* does not reflect the actual knowledge buying propensities of the individuals as they access the KMS only if *Internal Search* fails to yield a recommendation. Since *Lookup* does positively impact the organization's performance gains, even higher levels of *Lookup* will result in greater performance gains for the organization.

6. INCREASING KMS EFFECTIVENESS

As described above, the suboptimal utilization of the KMS (in terms of *Lookup*) given the organization's knowledge buying and selling propensity can be attributed to the satisficing nature of the individual's decision making process. If this decision making process can be modified to integrate knowledge seeking activities more closely into the individuals' work processes and routines, we can expect to see higher KMS usage and higher performance gains.

We therefore propose an alternative decision making processes (termed as the KMS Rational or KMSR Model), wherein individuals evaluate the quality of the required knowledge in the available knowledge sources (namely their own memories, their group members' memories and the knowledge repository), and employ the recommendation of the source with superior knowledge to create the expectation for a *yes* or *no* decision. To gauge the quality of the recommendations of the available knowledge sources, we propose a *Confidence* measure, which can be computed for individual subproblems as follows:

$$\text{Confidence} = \left(\text{YesCount} + \text{NoCount}\right) \cdot \text{Reliability}$$

$$\text{where Reliability} = \left(\frac{\left|\text{YesCount} - \left(\text{NoCount+1}\right)\right| + \left|\left(\text{YesCount+1}\right) - \text{NoCount}\right|}{\left(\text{YesCount} + \text{NoCount} + 1\right)} \right)$$

This *Confidence* measure is indicative of both the experience with the subproblem (*YesCount* + *NoCount*) as well as the *Reliability* of the knowledge source. The *Reliability* (or volatility) measure is computed as the probability that the recommendation will change from a *yes* to a *no* (or vice versa) if either the *yes* (or *no*) count is incremented. Therefore, if the *yes* and *no* count are almost equal, then the reliability of the knowledge source is lower than if the *yes* and *no* counts were substantially different. We use *Experience* = (*YesCount* + *NoCount*) as a multiplier for the *Reliability* measure as higher experience levels result in more accurate computations of the expectations for the *yes* (or *no*) decisions.

In each decision making period, individuals compute the *Confidence* measure for each of the three available knowledge sources and use this measure to rank them. If the top-ranked source entails *Lookup* or *Local Search*, the individual will perform this knowledge buying action with probability p_b. When the individuals evaluate the *Confidence* of all the available knowledge sources, we find that there is a dramatic decrease in the amount of *Internal Search* and a substantial increase in the amount of *Lookup* that occurs in the organization (see Figure 8). We find that the *Lookup* in the KMSR Model is significantly higher than in the KMS Model (using pair wise t-test at p <0.001). Thus, in the KMSR Model, the amount of *Lookup* and *Local Search* reflect the knowledge buying and selling propensities more closely than in the KMS Model.

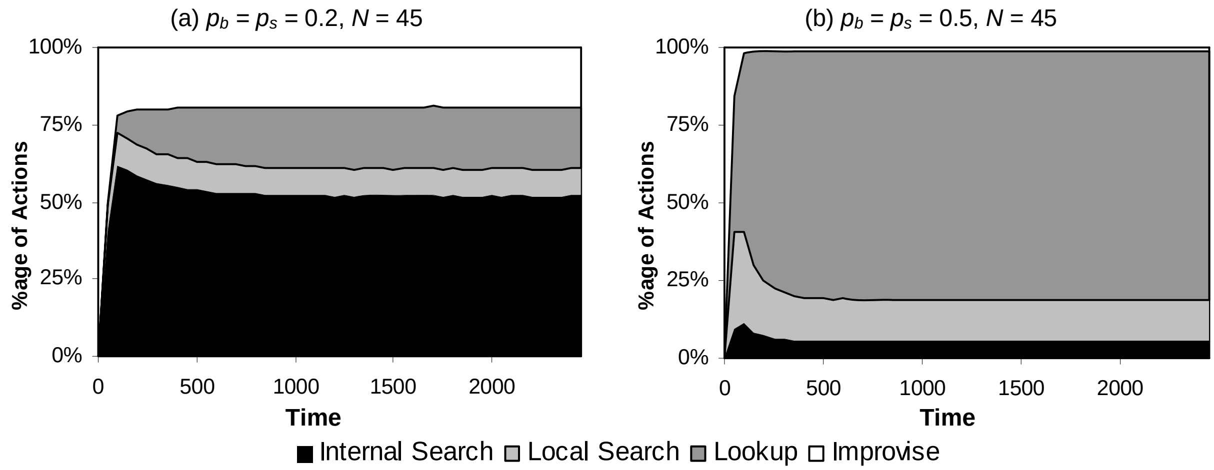


Figure 8: Organizational Members' Actions in the KMSR Model

When we subjected the difference in *Lookup* in the KMSR Model (from the KMS Model) to a 3-way factorial ANOVA with dependent variables N, p_b and p_s, and found that all three variables have significant direct effects and interaction effects (at $p<0.001$). Figure 9 shows the graphical representation of the ANOVA results. Once again, we find that the impacts of both p_s and p_b on the difference in *Lookup* are moderated by N. For example, when $N = 27$, there isn't a significant interaction effect between p_s and p_b. However, when $N = 63$ the interaction effects between p_s and p_b become more prominent. Specifically, the change in *Lookup* (i.e. difference in *Lookup* from the KMSR and KMS Models) is increasing in both p_b and p_s.

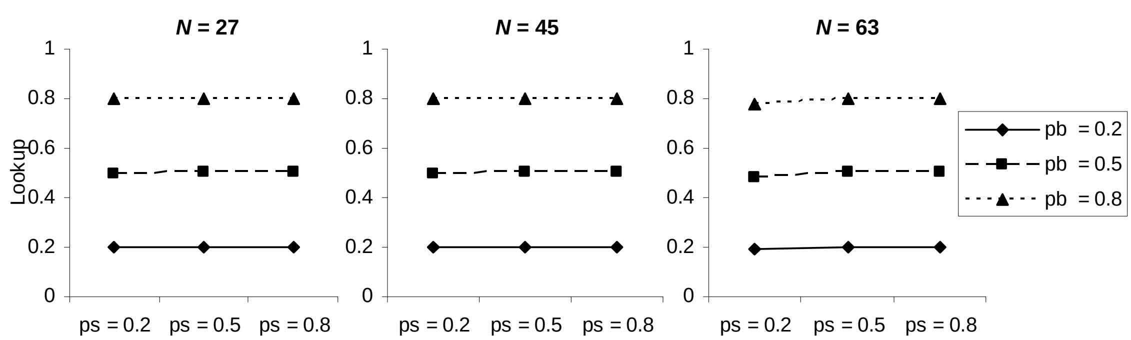


Figure 9: ANOVA Results of Difference in *Lookup* in KMS and KMSR Models

In addition the increase in the amount of *Lookup* and *Local Search,* we also find that there are substantial increases in the organization's performance in the KMSR Model when compared to the KMS Model (pair wise t-test $p < 0.001$). When we plot the organization's performance over time, we find that the slope of the KMSR Model is less than the KMS Model (see Figure 10), implying that organizational learning is slower in the KMSR Model. However the ultimate performance is substantially higher in the KMSR Model than in the KMS Model. In the following discussion, we denote the difference in organizational performance in the KMS and KMSR Models by $\delta\pi$.

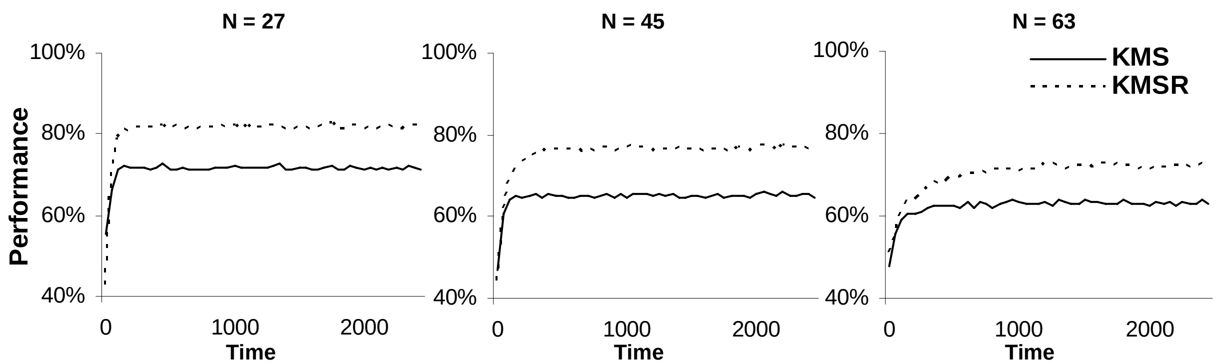


Figure 10: Organizational Performance in KMS and KMSR Models
[N = 27, 45, 63, $p_b = p_s = 0.5$]

In the KMS Model, we found that the difference in performance is greatest for moderate levels of p_b and p_s. In the KMSR Model, however, we find that the difference in performance ($\delta\pi$) is greatest when p_b and p_s are high. When we subject $\delta\pi$ to a three-way factorial ANOVA with dependent variables N, p_b and p_s, we find that all three variables have significant direct effects and interaction effects (at $p<0.01$). Figure 11 shows the graphical representation of the ANOVA results. We find that performance gains in the KMSR Model (compared to the KMS Model) are consistently high for all levels of N, implying that organizations operating in environments with high knowledge complexity stand to gain the most from KMS implementations. As in the case of the *Lookup*, we find that the direct effect of p_s on $\delta\pi$ is not significant, while the direct effect of p_b on $\delta\pi$ is significant across all levels of *N*.

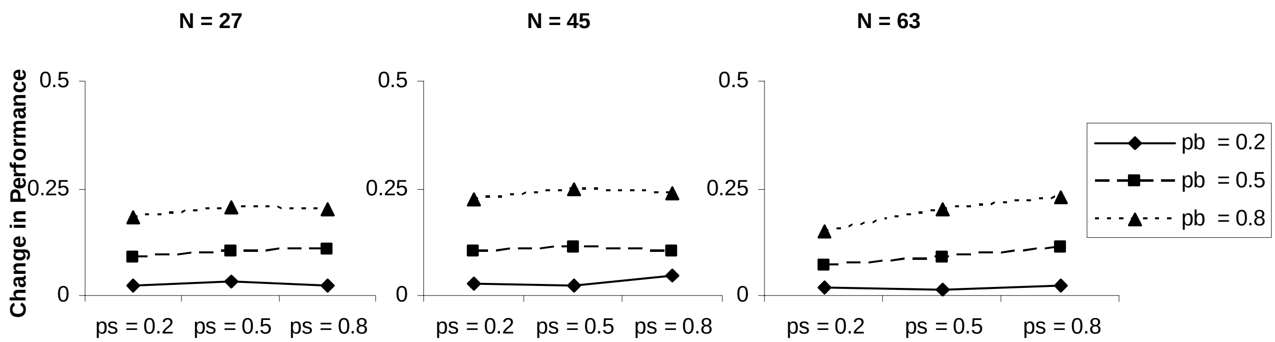


Figure 11: ANOVA Results of Change in Organizational Performance in KMS and KMSR Models ($\delta\pi$)

These results imply that under the KMSR Model there is a significant and consistent increase in the organization's performance when compared to the KMS Model. This marginal increase in performance is experienced by all organizations irrespective of the organization's p_b and p_s. However, when *N* is low, this marginal increase in performance is dependent primarily on p_b or the organization's knowledge buying propensity. On the other hand, when *N* is high, this marginal increase in performance is determined by both the organization's knowledge buying and selling propensities (p_b and p_s). Unlike the KMS Model, where organizations with moderate levels of both p_b and p_s experienced the greatest performance gains, under the KMSR Model, the organizations with the highest levels of p_b and p_s experience the greatest performance gains. Thus organizations where the employees engage in high levels of knowledge sharing are seeking will experience performance gains from the KM initiative.

7. DISCUSSION AND CONCLUSION

This study investigates the relationship between the organization's cultural characteristics that govern the employees' knowledge sharing propensities and the effectiveness of KMS. More specifically, we focus on the cultural characteristics that govern the individuals' propensities to both share and seek knowledge from external sources. Moreover, we measure KMS effectiveness in terms of its impact on knowledge work.

Drawing from prior empirical studies and computational models of organizational learning, we develop a conceptual model of organizations that captures the organization's knowledge work, the knowledge specialization of different organizational units and KM processes, while allowing us to measure the organization's performance as an emergent outcome of the KM processes. Within this framework we establish how the organization's knowledge culture influences the KM activities carried out by the employees, both with and without a KMS. Our model is based on a number of assumptions that create efficiencies for the organizations' knowledge creation, sharing and application activities. First, we instate an organizational structure (in the form of organizational units that specialize in specific knowledge areas) that is conducive to the creation, acquisition and retention of knowledge, while at the same time necessitates knowledge sharing and transfer within and across these units. Second, we assume the existence of transactive knowledge systems. The existence of such systems results in the efficient and accurate transfer and utilization of knowledge within small groups. Third, we assume that the KMS is technologically efficient, consistent and reliable in that the knowledge codification activities do not degrade the richness of the knowledge, and the knowledge retrieval is precise and accurate. With these assumptions, the possible benefits realized due to the KMS are under conditions that are representative of the "best case" scenario. Consequently, our results represent the upper bounds of the possible performance benefits, and the actual performance benefits in more realistic settings can be expected to be lower.

Using simulations we examine the impact of the KMS on the performance of organizations with different knowledge cultures (i.e., different combinations of knowledge seeking and sharing propensities of the employees) and different levels of knowledge complexity. Our results reveal the same KMS implementation yields varied outcomes in different organizational knowledge culture settings. In the context of knowledge work where decision making performance is contingent on knowledge sharing, we find the KMS' ability to enhance organizational performance is impacted to a greater extent by the cultural values that govern knowledge seeking propensities than those that govern knowledge sharing propensities of the employees. Moreover, we find that organizations where employees are moderately predisposed to knowledge seeking and sharing experience the greatest performance gains due to the KMS. When these propensities are low, the employees are reluctant to share knowledge through either interpersonal interactions or through the KMS. On the other hand, when these propensities are high, the employees already engage in high levels of knowledge sharing and the marginal benefit derived from the KMS is not significantly high.

Our results also show that the impact of the KMS on organizational performance is magnified by the knowledge complexity of the organization's environment. The KMS appears to be of limited value to organizations operating in environments of low knowledge complexity. Consequently, the knowledge seeking and sharing propensities do not influence the KMS's impact on performance either. Conversely, KMS are of greater value to organizations operating in environments of high knowledge complexity. In such organizations, the KMS usage is more critical and the knowledge seeking and sharing propensities play a more important role in determining if and how the KMS impacts organizational performance.

We also discover that individuals rely primarily on their own experience and expertise, even though superior and more accurate knowledge is available elsewhere in the organization. We develop an alternate KMS implementation where the organization's employees are more rational in their search for knowledge and are not limited by satisficing outcomes (i.e., proceeding to distant sources of knowledge only when the local sources fail to yield the required knowledge). Under this alternate KMS implementation, the employees' usage of the KMS increases significantly and organizations universally experience substantial performance gains. Once again, we find that the impact of the KMS on performance is more significant when the knowledge complexity is high, and that the influence of the knowledge seeking propensities on KMS effectiveness is greater than that of the knowledge sharing propensities. Interestingly we find that the performance gains increase with the employees' knowledge seeking and sharing propensities. Organizations whose employees display high levels of knowledge buying and selling propensities experience the greatest performance gains due to higher levels of KMS usage. Therefore, organizations can expect substantially greater performance gains from the KMS implementation if they embed KM processes into the organization's work routines in an effective manner.

These findings have a number of implications of both practitioners and academics. As discussed previously, the majority of prior studies on intra-organization knowledge exchange have focused on the motivations for knowledge sharing, particularly from the knowledge sellers' perspective. This study contributes to this rich body of work on knowledge exchange as we distinguish between knowledge seeking (i.e., buying) and sharing (i.e., selling) propensities and find that the knowledge seeking propensities have a greater impact on organizational learning and KMS effectiveness than the knowledge sharing propensities. This result leads to a number of interesting avenues for future research.

In order to better understand the antecedents and impediments to KMS success, our findings suggest that future research should address the knowledge seeking propensities and behaviors of employees. In the context of knowledge sharing propensities and behaviors, prior studies have identified the intrinsic and extrinsic motivations for sharing knowledge (Osterloh and Frey 2000). In a similar vein, others have identified a variety of factors (e.g., organizational climate, interpersonal relationships (Szulanski 1996) and absorptive capacity (Cohen and Levinthal 1989)) that govern the efficiency of knowledge exchange within the organization. We believe that a similar line of inquiry in the context of knowledge seeking within the organization may offer valuable insights on how the effective use of KMS can be promoted with the organization. By investigating the antecedents of "good" knowledge seeking behaviors in the context of KMS, we will be able to develop new insights for both theory and practice on how KM initiatives can create value for the organization.

In the IS literature knowledge transfer has been studied in the context of IT. This phenomenon has been investigated in a variety of settings, including traditional (e.g., Pan and Scarbrough 1998) and distributed organizations (Bock et al. 2005) as well as in online communities (Lee and Cole 2003). Once again, these studies have concentrated on the motivations of the knowledge sharer (e.g.,Wasko and Faraj 2005). In addition to investigating the motivations and behaviors of knowledge seekers in the context of IT, we propose that future studies also address how these knowledge seeking propensities vary for different media. The employees' preferred medium for knowledge exchange (e.g., face-to-face, synchronous communication, asynchronous communication or knowledge artifacts) is another factor that determines the effectiveness of the KMS in a particular organization. Therefore, we recommend that future studies examine the relationships between knowledge buying propensities for different media in order to provide interesting insights on how to determine the appropriate KM strategy for an organization. In our study we do not differentiate between the propensities for buying knowledge through interpersonal interactions and through the KMS. However, these propensities may be quite different (Massey and Montoya-Weiss 2006) and the interaction between these propensities (for both knowledge buying and selling) may have important and interesting implications. For example, an organization where the predisposition for interpersonal knowledge exchange is high may benefit from a KM initiative that is able to effectively exploit these propensities (e.g., personalization strategy) than a KM initiative that necessitates the institution of new behaviors (e.g., codification strategy).

From a managerial perspective, the implications of these finding are that before investing in KMS, the employees' attitudes towards knowledge sharing and seeking need to be gauged in order to predict if the KMS will yield the desired results. For example, if the employees in the organization are open to sharing their expertise but prefer to work independently and are disinclined to accept advice or knowledge from others, investments in KMS will yield poor returns. Managers in these organizations must take steps to induce appropriate knowledge sharing and seeking behaviors as part of the KM initiative prior to the actual implementation of the KMS. These "good" knowledge sharing and seeking behaviors can be induced in a number of ways. For example, British Petroleum (BP) use peer pressure to ensure that their employees seek advice and learn from others (Hansen 2002). Alternatively, Casciaro and Lobo (2005) suggest these behaviors can be induced by hiring individuals who are easy to collaborate with and have a natural inclination to ask for help (Hansen 2002).

The implications for IS theory and practice are that organizational characteristics such as culture and climate need to be given due consideration when designing and developing IS such as KMS that cannot be directly embedded into the work processes of the organization. Unfortunately, current system design methodologies do not provide frameworks that facilitate the prediction of IS outcomes in different organizational settings. Our simple model demonstrates how a single KMS implementation yields drastically different outcomes in different organizational settings. Similar tools or methodologies may be used to predict the intermittent and long-term outcomes of a specific IS implementation in a particular organization, taking into consideration its culture, structure and environment.

When the KMS is implemented in conjunction with knowledge practices that encourage individuals to employ the most appropriate knowledge source for each problem (as opposed to using external sources only when absolutely necessary), we find that both KMS usage and subsequent decision making performance increase. Nonaka (1991) argued that continuous knowledge processes were necessary for organizational knowledge creation. Our results suggest that these continuous knowledge processes are also necessary for the effective application of this knowledge. For example, the KMSR Model is an instance of a normative routine that yields significantly higher performance gains with the same KMS implementation. To this effect, Davenport et al. (2008) recently suggested that KM processes should be integrated with the organization's learning processes and Paul (2003) asserts that organizations "must bake knowledge collection and dissemination into people's everyday jobs". Since knowledge workers are already under severe time pressures, the reuse and application of organizational knowledge can be increased by integrating the KMS into information systems that they already use. Thus knowledge seeking behaviors can be induced by reducing the effort that individuals need to expend (for example, accessing another system etc.). Similarly, in order to increase contribution to the KMS, in order to reduce the required effort, dedicated KM co-coordinators can be employed to updated and maintain the KMS (Paul 2003).

This study is an exploratory study of the relationship between the organization's knowledge culture and KMS effectiveness. The simulation model developed in this study is a novel tool that captures the processes of an organization in a knowledge economy. Moreover, it allows us to measure organizational performance as an emergent outcome of its knowledge creation and sharing abilities. However, as is the case with all model abstractions, it based on a number of assumptions. For instance, the organizations' environments are modeled as static environments, wherein the characteristics of the problems/subproblems do not change over time. In this setting the employees engage in primarily what Argyris and Schoen (1978) defined as single-loop learning. KMS support and facilitate single-loop learning at the organizational level (Stein and Vladimir 1995). In contrast, double-loop learning entails creative and exploratory thinking and learning (Argyris and Schoen 1978) and can either be impeded or aided by the KMS (Stein and Vladimir 1995). Therefore, we believe that an interesting extension to this study would be to establish the impact of KMS on organizational performance related to creativity and innovation driven knowledge work, and to investigate how the organization's knowledge culture affects this relationship. Other extensions of our model may include the investigation of the effectiveness of KMS in different organizational structures (e.g., autonomous, hierarchical, flat or distributed). Carley (1992) and Walsh and Ungson (1991) found that organizational knowledge is retained, to a certain extent, in the organizations' structure and processes. It would be interesting to understand how KMS could effectively disseminate this knowledge within the organization. Our model does not consider personnel turnover, however it is an important aspect of KM that must be included in future extensions of this study. Our model is based on certain assumptions regarding the quality of both interpersonal and IT-enabled knowledge transfer, in that knowledge exchange between individuals is complete and without any loss. Our findings, therefore, represent the ideal scenario while in reality the expected performance gains due to the KMS may be lower. We leave it for future research to empirically investigate the impacts of the knowledge sharing behaviors on both short-term and long-term performance.

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