A Simulation-Based Exploration into The Effectiveness of IT-Enabled Knowledge Management Initiatives

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Abstract
Organizations are increasingly adopting Knowledge Management Systems (KMS) to effectively manage knowledge within the organization and realize firm and operational level benefits. However, many KMS implementations fail to yield desired outcomes due to the lack of understanding of the antecedent of successful knowledge management. Prior studies have established that organizational cultural values are one of the key enablers of knowledge management. We develop a computational model of organizational knowledge processes and employ simulations to examine the impact of KMS in different organizational cultural settings. We find that cultural values that govern the employees' predisposition towards seeking knowledge from others have a greater influence on KMS effectiveness than those that govern the employees' attitudes towards sharing their knowledge with others. We also find that organizations with cultures that foster high levels knowledge sharing behaviors can expect performance gains if KMS implementations incorporate knowledge seeking activities into the employees' work processes.

Keywords:
Knowledge Management, Knowledge Management Systems, Knowledge Sharing, Organizational Culture

Introduction

As organizations realize that the knowledge residing among their employees is one of their most valuable resources and that their competitiveness hinges on effective management of these intellectual resources, Knowledge Management (KM) has rapidly become an integral business function [1]. The basic idea behind managing knowledge is quite intuitive. Knowledge management is a systemic and organizationally specified process for acquiring, organizing and communicating knowledge of employees so that other employees may make use of it to be more effective and productive in their work [1]. However, like many management practices, knowledge management has proven to be more difficult to implement in practice and many KM initiatives result in less than desirable outcomes [7]. Organizations are still struggling to understand how best to implement effective KM as there is little theory available to explain when such efforts will lead to success or failures [18].

In an effort to better understand when and why KM initiatives fail (or succeed), this study investigates the relationship between organizational culture and the effectiveness of IT-enabled KM initiatives. More specifically, we focus on the cultural characteristics that govern organizational knowledge sharing behaviors and examine their impact on the effectiveness of KMS in terms of organizational performance. This study seeks to answer two main research questions:

1. How is a KMS' effectiveness, in its ability to have a positive impact on organizational performance, influenced by organizational culture?
2. Which cultural characteristics have the most significant influence, and how can they be leveraged in order to create the most value for the organization?

The remainder of the paper is organized as follows. In the next section, we develop a formal model of organizational knowledge work processes. We then outline the experimental methodology of our simulation study. The simulation results are presented and we conclude the paper with a discussion of implications.

Model of Organizational Knowledge Processes

Carley's [4] model of organizational learning is used as the basis for our model of organizational knowledge processes. Carley's model is a useful starting point for modeling KM processes as it effectively captures performance at the organizational level as an outcome of knowledge utilization at the individual level. We extend this model to incorporate explicit KM processes such as knowledge storage and transfer. Knowledge storage is incorporated by modeling a KMS that acts as a central repository of knowledge; and knowledge transfer by allowing organizational members to learn from and share their knowledge with others.

Organization, Groups and Knowledge Specialization

The organization is conceptualized as an information processor that operates in an environment that supplies it with problems (or tasks) for which it must formulate a response (i.e., make decisions). Organizational performance in such an environment can be conceptualized as the ability to make correct decisions across a sequence of decision-making periods [4].

We model the organization as a collection of G groups (or teams) each with m individuals, who possess a common domain specialization (unique to the group), and are responsible for solving problems that are (mostly) related to this specialization. This is similar to organizations being structured as specialized functional departments (e.g.,

procurement, production, marketing/sales etc.) – although organizations operate in a holistic environment, each functional department develops its own specialized strategic responses. While knowledge specialization leads to efficiencies in knowledge creation, acquisition and retention [8], it also creates a disconnect between the specialists [17] and problems with knowledge division and coordination [12]. Therefore, the introduction of groups with knowledge specializations into the model of organizational learning creates an environment that is conducive to the efficient creation of knowledge within specializations, and creates requirements for the transfer of knowledge across specializations.

Problems that organizations face are modeled as N bit strings where each bit may take a binary value of 0 or 1 representing the existence (1) or absence (0) of a particular strategic dimension [4]. Consequently, N represents environmental complexity – as N increases, the likelihood of encountering an identical problem in consecutive decision periods decreases exponentially.[1] The group must determine which pattern of 1's and 0's corresponds to a *yes* or *no* answer. Since each group receives a problem of complexity N and has m members, each member is assigned a subproblem of size $n = N/m$. Individuals make a *yes* or *no* recommendation for their assigned subproblem and the final group-level decision is determined by a majority vote.

Individual Decision Process

Individuals are modeled as imperfect statisticians who adjust their expectations for decision outcomes based on experience [4]. Individuals learn by retaining past experiences as knowledge stored in their memory [20]. The individual's memory is modeled as a cumulative record of the subproblems the individual has received and the corresponding feedback (i.e., correct decision for the group's entire problem). The memory comprises of two counters for each subproblem pattern, which store the number of times the correct decision was *yes* or *no*. Individuals learn by incrementing the appropriate counter for the current subproblem based on the correct decision that is discovered through feedback received at the end of each decision-making period.

Individuals' memories are susceptible to decay. This cognitive limitation is incorporated as time based forgetting [2], which is modeled by restricting the quantity of information that can be retained by an individual at any given point of time. Thus, only the cumulative record of the subproblems for the past τ time periods is retained in the individual's memory.

In addition to their own past experiences, individuals can also access and use knowledge residing elsewhere in the organization (e.g., experiences of colleagues, knowledge artifacts stored in knowledge repositories etc.). The search for knowledge begins locally and proceeds to more distant sources of knowledge if the initial search fails to generate a satisficing outcome [5]. In other words, individuals are biased towards knowledge sources that are closest to them [15], and will only resort to external sources only if they are unable to make a principled recommendation based on their past experiences. More formally, when an organization member is faced with a subproblem, the following procedure is followed to make a decision:

1. Identify the yes and no counts for the subproblem; if the yes count is greater than no count, return yes as the recommendation; otherwise, return no;
2. If the yes and no counts are equal (or both are zero), seek an alternative source of knowledge;
3. If search does not yield a recommendation, return either a yes or no decision with equal likelihood (i.e., improvise / guess).

This process of making a decision based on the individuals' own memory is termed *Internal Search*. If Internal Search fails to yield a decision, the individual can employ knowledge possessed by others in the organization. This process is termed *Local Search* and entails the following: (i) Identify an organizational member who possesses the required knowledge; (ii) If a knowledge colleague is identified, employ her knowledge 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, *improvise* the decision (i.e., step (3) above).

The social relationships between individuals are an important aspect of interpersonal knowledge exchange [13]. 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 [5], as individuals tend to share knowledge within close knit networks [19]. Therefore, the scope of *Local Search* is limited to other members in the individual's own group.

The knowledge seeking and sharing process during Local Search is influenced by the organization's knowledge sharing culture. An individual seeks knowledge within his/her group with probability b_i. If this individual seeks knowledge and is able to identify a group member who has the required knowledge, the group member shares this knowledge with the probability s_i. The probabilities b_i and s_i represent the propensity of an individual to seek (or *b*uy) and share (or *s*ell) knowledge through *i*nterpersonal interactions. If the group member is willing to share his/her knowledge, this knowledge in employed to make the decision. The decision process described above is our Base Case Model.

The Knowledge Management System (KMS)

KMS generally differ with respect to the types of processes emphasized by the KM strategy (i.e., personalization vs. codification) and the information technology (IT) used to facilitate knowledge management efforts (e.g., discussion forum vs. document repository) [9]. Despite the variety of flavors of KMS implementations, we simplify our analyses by incorporating a generic KMS as a centralized knowledge repository that stores codified knowledge of organizational members, and can be used as an additional source of

[1] So with this model formulation, there are 2^N possible distinct problem types that a group may face.

knowledge in the organizational members' decision-making process. We assume that the KMS is technologically efficient, consistent and reliable: (a) All knowledge contributed to the knowledge repository is codified accurately and completely, and (b) The knowledge extracted from the knowledge repository is precise, complete and accurately reflects the search criteria.

The KMS is modeled similarly to individuals' memories, in that it retains a cumulative record of the subproblems and the corresponding correct decisions. Since the knowledge repository is persistent, it is not constrained by the cognitive limitations of memory decay and so can permanently retain all knowledge contributed to it. In other words, there is no forgetting. The KMS acquires and stores new knowledge, when members contribute to the knowledge repository (i.e., by codifying and adding newly acquired experiences) at the end of each period. Individuals contribute to the KMS with probability s_a in each time period.

Consequently, the KMS is merely another source of knowledge available to the organizational members in addition to individuals' own memories and those of colleagues. The KMS is incorporated into the individuals' decision making process in the following manner. The querying, retrieving and utilization of knowledge from the KMS to make a decision for a subproblem is termed *Lookup*. When individuals perform a Lookup, the knowledge exchange is one sided as the behaviors of the knowledge seller does not directly affect the current knowledge exchange. If the required knowledge exists in the KMS, the recipient can extract it without the consent of the contributor(s) of that knowledge. Under the KMS Model, if the Local Search fails, the individual looks for the required knowledge in the KMS with the probability b_a and uses this knowledge to make the decision if it exists in the knowledge repository. The individual is forced to improvise a decision for the subproblem, only if all three knowledge sources fail to yield a decision.

Organizational Culture

Organizational culture constitutes shared beliefs, ideologies and the norms that influence the actions of the organization's members [3]. We adopt the integration perspective of organizational culture that recognizes organizational culture as a homogenous collection of values that act as an integrative mechanism or social/normative glue that holds a potentially diverse group of organizational members together [14].

An organization's knowledge sharing behaviors are an important component of organizational culture. In other words, the cultural values of the organization govern its members' willingness to seek (or buy) and share (or sell) knowledge within the organization. There are various factors that influence individuals' motivations to share their knowledge, including knowledge ownership [21] and the expectation of certain personal benefits [16] and social rewards such as reputation and status [10].

In our model, members of the organization share knowledge through interpersonal interactions and indirectly using knowledge artifacts stored in the KMS. The probability b_i represents an individual's willingness (or propensity) to seek (or *b*uy) knowledge from a group member through *i*nterpersonal interactions, while the probability b_a represents his willingness to seek (or *b*uy) knowledge *a*nonymously from the KMS. High knowledge buying propensities reflect willingness of individuals to proactively seek knowledge from external sources, and their receptiveness to new ideas and suggestions. On the other hand, the "Not Invented Here" syndrome is representative of low knowledge buying propensities, and reflects reluctance to reuse external knowledge [11]. Likewise, the probability s_i represents an individual's willingness to share (or *s*ell) his/her knowledge with a colleague through *i*nterpersonal interactions, while s_a represents an individual's willingness to contribute to the KMS. For example, low knowledge selling propensities are representative of "knowledge hoarding" practices [6]. The organizational culture, therefore, determines these knowledge buying and selling propensities of the individuals and is represented by the vector $[b_i, s_i, b_a, s_a]$. The four culture parameters are modeled as probabilities and are random variables drawn from the interval [0, 1].

Methods

In our model, an organization is characterized by its structure (number of groups G, and number of organizational members m) and its culture (which is represented by the knowledge sharing propensity of the organizational members). While keeping the structure fixed (G=3 and m=9), we vary environmental complexity (N) and the organization's knowledge sharing culture ($[b_i, s_i, b_a, s_a]$). We examine three levels of complexity: Low, Medium and High, with $N(n)$ = 27(3), 45(5) and 63(7), respectively. Of the possible 2^n subproblems, each group is randomly assigned approximately 1/3 of the subproblems as the specialization set and each specialization set is independent (i.e., no subproblem can belong to the specialization set of more than one group). We also examine three levels of each of the knowledge buying and selling propensities: Low, Medium and High, with probability = 0.2, 0.5 and 0.8, respectively. We limit the size of the individual memory (τ) to 100 time periods. When complexity is low (n = 3), individuals have the capacity to retain their past experiences for all 2^n possible subproblem. However, when complexity is higher (n = 5 or 7), their memory is unable to retain past experiences for all the possible subproblems. We conduct the simulations using a full factorial design of $3(b_i) \times 3(s_i) \times 3(N) = 27$ for the Base case and $3(b_i) \times 3(s_i) \times 3(b_a) \times 3(s_a) \times 3(N) = 243$ for the KMS case for a total of 270 organizational configurations. To generate insights into the effectiveness of KMS, we compare performance with or without the KMS (i.e., Base Case vs. KMS) under different configurations of buying and selling propensities.

For each organizational configuration, we measure performance across 2500 time periods. The performance of the organization at time t is computed as the average percentage of correct decisions made over the time period [t-20, t]. We use three performance measures to reflect the

organization's performance at three different points in time (i.e., initial, mid-term and end, with t = 500, 1000 and 2500, respectively). Measures at different times help us appreciate the dynamic impacts of the KMS implementations, as short-term performance gains may not necessarily extend to similar increases in the long-term, and vice versa. All results are based on 400 runs for each organizational configuration.

We also monitor and capture the individual decision processes as the actions members take in each period (i.e., internal search, local search, KMS lookup and improvisation). These actions reflect the knowledge source that was used by the individual to make the decision. By analyzing these actions, we may further investigate why the KMS implementation was effective (or ineffective).

Results

KMS Implementation

The KMS implementation has a significant and positive impact on the organization's performance; however this impact is greater in the short-term than in the long run. In other words, the presence of the KMS results in an increase in short-term performance, but this increase is difficult to sustain over the long run (see Figure 1), especially when environmental complexity is high (N = 63). The degree to which the short-term performance is improved due to the KMS implementation is determined by the knowledge sharing propensities of the organization's members. These results imply that the KMS implementation leads to rapid diffusion of knowledge within the organization to improve decision-making, but does not lead to a comparable long-run increase in knowledge acquisition.

The KMS implementation allows organizational members to perform *Lookup* in addition to *Local Search* when the *Internal Search* fails. Therefore, we examine the influence of both the anonymous and interpersonal knowledge sharing propensities on the organization's performance. The anonymous knowledge buying propensities (b_a) has a significant and positive impact on performance in both the long-term and short-term, while interpersonal knowledge buying and selling propensities (b_i and s_i) do not have a significant impact on performance. However, the impact of anonymous knowledge buying propensity (b_a) decreases with time (β_{ba} ~ 0.0497 at t=500, β_{ba} = 0.0377 at t=1000, β_{ba} = 0.0182 at t=2500[2]). Since the influence of the KMS implementation itself decreases with time, the influence of the organizations' members' propensities to use the KMS also decrease with time.

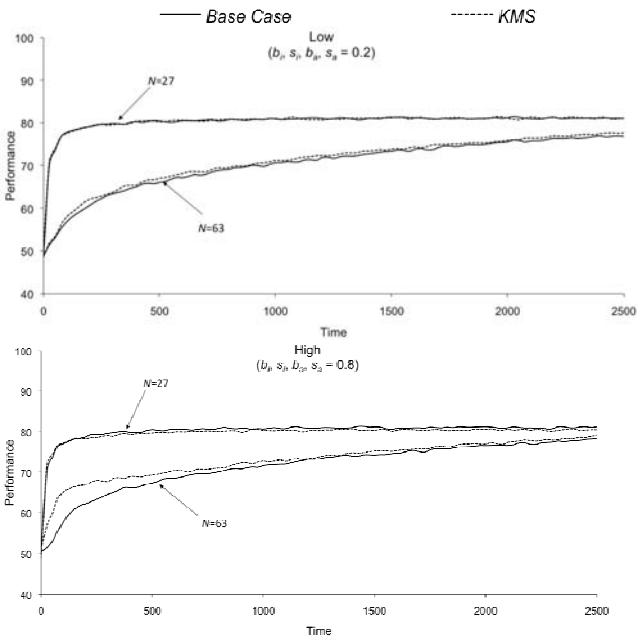

Figure 1 – Performance: Base Case vs. KMS Model

The organization's members' propensity to share knowledge has a positive and significant impact on the amount of *Local Search* that occurs within the organization. Since a *Lookup* occurs only when *Local Search* fails, the interpersonal propensities (b_i and s_i) have a stronger influence than the anonymous propensities (b_a and s_a). On the other hand, the interpersonal knowledge buying and selling propensities (b_i and s_i) have a significant and negative impact on the amount of *Lookup* that occurs (β_{bi} < -0.2 and β_{si} < -0.06), while the anonymous buying propensity (b_a) has a significant positive impact (β_{ba} > 0.35) and the anonymous selling propensity (s_a) does not have a significant impact on the amount of *Lookup*. These findings suggest that organization members access the knowledge repository only when the propensity for knowledge exchange through interpersonal interactions is low, which leads to failed *Local Search*. We also find that the impact of the knowledge sharing propensities on the proportion of *Lookup* and *Local Search* decreases with time, indicating that individuals rely more on their own knowledge as they gain experience over time.

KMS Implementation with Process Change

The two major implications of the above findings are that (1) organizational members rely primarily on their own past experience, even though superior knowledge may be available elsewhere in the organization, and (2) the organization's performance may be suboptimal due to the satisficing nature of the individuals' decision making process. The presence of the KMS implementation has a positive influence the organization's performance in the short-term, which can be attributed to the higher levels of the KMS usage (in terms of the proportion of *Lookup*). Therefore, similar performance increases can be expected if these knowledge sharing behaviors are sustained over time and individuals rely on knowledge sources other than their

[2] Henceforth, βs represent regression coefficients of knowledge sharing propensities when regressed on performance (and later on knowledge actions) after controlling for problem complexity.

own memories even if they have experience, albeit limited. Consequently, we modified the KMS implementation model to integrate the knowledge repository more closely into the individual's decision-making process. In the new KMS model, which we call the KMS Rational Model, individuals evaluate the knowledge existing in the three sources available to them (namely, their own memories, their group members' memories and the knowledge repository), and choose the source with superior knowledge to aid them with their decision. In each period, an individual evaluates the *confidence* of the knowledge pertaining to the assigned subproblem from the three knowledge sources. Here, confidence is computed as the sum of the yes and no counts associated with each subproblem. This measure indicates the experience with the subproblem and can be used to rank the knowledge sources. We use experience with a subproblem as an indicator of the quality of knowledge, as higher experience levels result in more accurate computation of the expectation for the final decision. The individual then uses the knowledge from the source with the highest confidence to create an expectation for the decision for the assigned subproblem. In what follows, we compare the new KMS Rational Model with the original KMS Model, which we now call the KMS Standard Model, to differentiate between the two KM processes.

Under the KMS Rational Model, the diffusion of knowledge within the organization takes place more slowly when compared to the KMS Standard Model, resulting in lower organizational performance in the short-term. However, in the long run, the KMS Rational Model leads to higher levels of organizational performance, as the accuracy and the reliability of knowledge is taken into consideration while making decisions (see Figure 2).

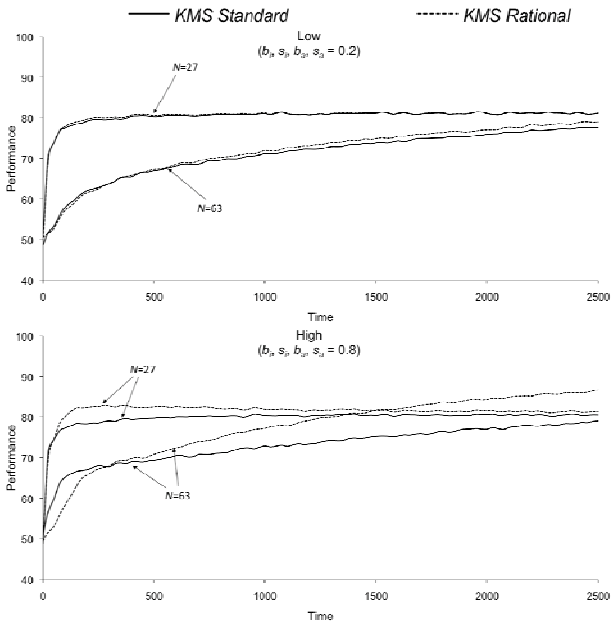

Figure 2 – Performance: KMS Standard vs. KMS Rational

The implementation of the KMS Rational Model has a positive impact of the organization's performance. However, this impact is moderated by the knowledge buying and selling propensities of the organization's members. We find that the knowledge buying propensities (b_i and b_a) have significant positive impacts on the short-term and long-term performance of the organization ($\beta_{bi} \sim 0.03$, $\beta_{ba} \sim 0.19$ for all time periods). The interpersonal selling propensity (s_i) has a significant impact only on the short-term performance, though this impact is negative ($\beta_{si} = -0.024$, $p<0.001$ at time t=500, and $\beta_{si} = -0.012$, $p<0.05$ at time t=1000), while the anonymous selling propensity (s_a) has a positive and significant impact only on the short-term organizational performance ($\beta_{sa} = -0.012$, $p<0.05$ at time t=500). These results imply that under the KMS Rational Model, the organization members rely on the knowledge repository more than under the KMS Standard Model. Furthermore, organizations with high knowledge buying propensities (b_i and b_a) and high anonymous knowledge selling propensities (s_a) can benefit (in terms of long-term performance) more from the implantation of the KMS Rational Model than organizations with lower knowledge sharing propensities.

The interpersonal knowledge sharing propensities (b_i and s_i) have a significant negative impact on the proportion of *Lookup* that occurs under the KMS Standard Model. Under the KMS Rational model, the interpersonal knowledge selling propensities (s_i) exhibits a similar influence ($\beta_{si} = -0.087$ at time t=500), though the interpersonal knowledge buying propensity (b_i) exhibits a positive influence ($_{\beta bi} = 0.095$ at time t=500). The anonymous knowledge sharing propensities (b_a and s_a), on the other hand, have a much larger impact on the proportion of *Lookup* under the KMS Rational Model than they do on the KMS Standard Model ($\beta_{ba} > 0.85$, $\beta_{sa} \sim 0.01$ for all time periods). Under both the KMS Standard and Rational Models, we find that the interpersonal knowledge selling propensities (b_i and s_i) have a positive and significant impact on the proportion of *Local Search* ($\beta_{bi} > 0.9$, $\beta_{si} > 0.34$ for all time periods). However, unlike under the KMS Standard while the anonymous knowledge sharing propensities (b_a and s_a) have significant negative impacts on the proportion of *Local Search* under the KMS Rational Model ($\beta_{ba} < -0.13$, $\beta_{sa} < -0.002$ for all time periods).

The implications of these findings are that under the KMS Rational Model, the knowledge buying propensities have a greater influence on the proportion of decisions that are made based on knowledge transfers (from both group members and the knowledge repository). Since the individuals evaluate the confidence of the various knowledge sources prior to making their decision, they use the most reliable knowledge source that is available to them, thus deviating from satisficing decision-making. These behaviors lead to a greater proportion of both *Local Search* and *Lookup* within the organization, especially when the knowledge buying propensities (b_i and b_a) are high.

Conclusion and Discussion

This study investigates the relationship between KMS effectiveness in different organizational cultural contexts that influence knowledge sharing behaviors. Our results indicate that the KMS has a positive impact on the

short-term performance, while long-term performance improvements are difficult to sustain. The complexity of the knowledge that the organization operates in has a detrimental impact on its performance in the absence of a KMS. However the improvement in short-term performance in such environments experienced due to the existence of KMS is more significant, than it is in environments with low knowledge complexity. On closer inspection of the KMS usage behaviors of the organization's members, we find that while the initial usage is high, over time the KMS falls into disuse even when its contents are consistently being augmented. On the other hand, when a KMS is implemented in conjunction with policies that motivate the organizational members to evaluate the reliability and quality of the knowledge sources available to them (as opposed to accessing the closest knowledge source), we find that while there isn't a significant improvement in the short-term performance, the long-term performance is significantly higher. Furthermore, the KMS usage is also consistently high over time.

The implications of these results are that in spite of increases in short-term performance and KMS usage, the existence of a KMS does not necessarily lead to long-term performance increases. Therefore, when KMS implementations are introduced into the organization, the novelty of the system and sudden increase in the visibility and availability of organizational knowledge may lead to encouraging increases in performance. However, these performance increases are not necessarily sustainable in the long-term unless efficient usage of the KMS is embedded into the organization's workflow. Investment in KMS implementations may not yield the desired returns after the initial novelty of the system wears off, unless the KMS initiative includes guidelines, incentives and policy changes that encourage organizational members to embed KMS usage into their workflow.

Our analysis on organizational culture and the knowledge sharing behaviors of the organization members reveals that the cultural values that govern organization members' willingness to seek knowledge from other sources have a more significant impact on the how knowledge is exchanged within the organization than the members' willingness to share their knowledge with others. These impacts hold in the case of both the interpersonal knowledge exchanges as well as indirect knowledge transfer through codified artifacts. Furthermore, these knowledge sharing predispositions have similar impacts on the organizational performance. We also find that organizations with cultures that are conducive to high levels of knowledge seeking and knowledge exchange experience the largest improvements in short-term performances due to KMS implementations. Such cultures also stand to experience the greatest gains when the KMS is implemented in conjunction with policy changes.

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