

IMPACT OF KNOWLEDGE MANAGEMENT STRATEGY ON ORGANIZATIONAL LEARNING: A SIMULATION STUDY

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ABSTRACT

The main objective of this study is to examine how an organization can implement knowledge management strategies that are best suited to its structure, culture and knowledge needs. We employ March's (1991) model for organizational learning in the context of knowledge management and analyze the effectiveness of the codification and personalization strategies in different organizational settings. This paper develops insights into the effectiveness of knowledge management systems in different organizational environments and into the learning behaviors of individuals in the presence of these systems. The results indicate that KMS that codify the knowledge of only the superior performing organizational members are more effective than KMS that codify the knowledge of all the organizational members, though this discrepancy in performance decreases when the frequency of the codification process is low. Personalization strategies that enhance the ability of organizational members to locate other better performing individuals are found to be more effective in the long term than in the short term. However, when such personalization strategies are implemented in conjunction with codification strategies, the combined impact is not beneficial in the long term.

Keywords:

Knowledge Management, Organizational Learning, Simulations

1. Background and Motivation

Today's competitive business environment requires firms to develop innovative products and services on faster cycle times. This has led to a gradual replacement of capital and labor intensive firms by *knowledge* intensive firms (Starbuck, 1992). The knowledge based view of the firm conceptualizes knowledge as a strategic asset that creates competitive advantage (Ashworth, Mukhohpadhyay and Argote, 2004; Kogut and Zander, 1992). The knowledge creation capabilities of a firm also have a significant impact on the level of new product development and services (Smith, Collins and Clark, 2005). Consequently organizations are increasingly adopting knowledge management systems (**KMS**) to effectively manage knowledge within the organization (Davenport and Prusak, 1998).

However, it is the harsh reality that many knowledge management initiatives result in less than desirable outcomes (Fahey and Prusak, 1998; McDermott, 1999). Organizations are still struggling to understand how best to implement effective KMS. While organizations within the same industry may have similar knowledge needs, the success of a KMS implementation within an organization largely depends on how well it fits in with the organization's culture and environment and how effective it is in capturing the knowledge that is essential to the organization's operations. Existing research has addressed various issues pertaining to knowledge management, including the taxonomies of knowledge (e.g., Nonaka, 1994), the purpose and function of KMS, and the relationship between information technology (IT) and KMS (e.g., Massey and Montoya-Weiss, 2006; Pentland, 1995; Robertson, Swan and Newell, 1996). While these studies address vital issues pertaining to the functions and implementation of KMS (Holzner and Marx, 1979; Pentland, 1995), the effectiveness of a KMS in a particular environment in optimizing these functions of the KMS calls for deeper investigation. Our lack of understanding of the relationship between the characteristics of a KMS and the organization's

knowledge culture and external environment contributes to the varying levels of the success of knowledge management strategies employed in different organizational settings. For example, Dresdner Kleinwort Wasserstein has in recent years adopted emerging technologies such as Wikis and blogs (McAfee and Sjomann, 2006a, , 2006b) as a means for employees to transfer knowledge and collaborate. NASA JPL implemented innovative ways to capture the knowledge of retiring personnel using audio-video technologies (Leonard and Kiron, 2002). Such implementations of KMS, while being innovative, have often failed to perform as desired.

Organizations can realize performance benefits in the competitive marketplace by leveraging its ability to learn (Senge, 1990; Slocum and McGill, 1994). The learning culture within an organization at the individual level and at organizational level determines its ability to learn. Therefore a successful knowledge management strategy would be one that is best suited to the learning culture within the organization and that enhances its ability to learn in both the long term and the short term. In addition to the organization's learning culture, the nature of the organization's knowledge requirements is another important factor that has to be considered. The knowledge requirements vary from organization to organization, and hence a KMS that is extremely effective for one organization may not be suited for another organization, even if they have similar learning cultures. The purpose of this research is to understand the interactions between an organization's knowledge management strategy, its learning culture and environment as well as its knowledge needs.

In this research, we extend the model of organizational learning developed by March (1991) and Miller et al. (2006) to incorporate KMS that instantiate the two primary knowledge management strategies. These strategies are the codification and the personalization knowledge management strategies (Hansen, Nohria and Tierney, 1999). We incorporate these knowledge

management strategies into the Miller et al.'s (2006) extended model of organizational learning by instantiating knowledge management systems for these strategies and examine the performance in terms of knowledge acquisition at the organizational level and the individual level in the long term and short term for different organizational and environmental conditions. The results indicate that KMS that codify the knowledge of only the superior performing organizational members are more effective than KMS that codify the knowledge of all the organizational members, though this discrepancy in performance decreases when the frequency of the codification process is low. Personalization strategies that enhance the ability of organizational members to locate other better performing individuals are found to be more effective in the long term than in the short term. However, when such personalization strategies are implemented in conjunction with codification strategies, the combined impact is not beneficial in the long term.

The remainder of this paper is organized as follows. In section 2, we provide a brief overview of the model of organizational learning by March (1991) and Miller et al. (2006) and draw on existing literature to support our proposed extensions to incorporate KMS that implement the two knowledge management strategies. Section 3 describes the simulation methods used in this study. In section 4 we discuss the effectiveness of the different KMS in different organizational environmental conditions. Finally, in section 5 we conclude with a discussion of the results.

2. Literature Review and Model Development

2.1. Knowledge Management Strategies

Given that the primary functions of a knowledge management system (KMS) are to capture, store and retrieve, transfer and apply knowledge within the organization (Alavi and Leidner, 2001; Holzner and Marx, 1979; Pentland, 1995), and the value of the KMS is realized through the efficiency with which knowledge can be transferred and applied by an organization's

employees, the effectiveness of KMS are directly dependent on what knowledge is captured and stored. By optimizing these processes so that the knowledge that is captured will provide the most value to the organization (Chen and Edgington, 2005), the effectiveness of the other functions (i.e., store, retrieve, transfer and apply knowledge) can be improved.

Knowledge can be classified as codifiable *explicit* knowledge and non-codifiable *tacit* knowledge (Polanyi, 1966). Explicit knowledge is formal and systematic in nature and can therefore be easily codified, communicated and shared. Tacit knowledge, on the other hand, is highly personal and has both technical and cognitive dimensions which are consequently difficult to articulate, communicate and share (Nonaka, 1994).

Effective knowledge management is an issue that is faced by a growing number of organizations. In order to promote the capturing and sharing of knowledge, strategies for knowledge management are implemented in various forms (Davenport and Prusak, 1998). Knowledge management strategies can generally be categorized into two major types – personalization strategies and codification strategies (Hansen et al., 1999). Codification is the process by which individuals codifying explicit knowledge and storing it in a knowledge repository, where it can be accessed, applied and reused effectively by all members of the organization. The codification strategy is used in organizational environments that encourage the reuse of knowledge artifacts and require coordination and communication amongst large groups of people. In contrast, personalization knowledge strategies provide means of identifying individuals who possess the knowledge and provide a medium for communicating the knowledge directly (i.e., interpersonally) rather than storing it. These strategies are typically employed by organizations where members work in small teams and encourage the exchange of ideas, innovation and creative thinking through one-on-one interactions.

The purpose of this study is not to compare the two knowledge management strategies, but compare the effectiveness of KMS that instantiate both the personalization and codification strategies in different forms. A KMS that embodies the codification strategy alone creates an environment where knowledge is transferred between individuals exclusively by means of a knowledge repository and in the absence of interpersonal communication. Furthermore, codification strategies implemented in isolation exclude the transfer of tacit knowledge. While March (1991) examines this scenario in great detail, Miller et al. (2006) highlight the importance of interpersonal knowledge transfer. Personalization strategies implemented alone, on the other hand, rely exclusively on interpersonal communication between members of the organization as a means of knowledge transfer. In the absence of formal knowledge repositories, the organizational memory exists only in the individual memories of the members of the organization. Such a scenario leads to a reduction in organizational knowledge in the presence of employee turnover (Carley, 1992). While the impact of personnel turnover is outside the scope of this study, we recognize the consequences of the absence of formal knowledge repositories as a result of implementing personalization strategies in isolation. Therefore, in this study we examine KMS that incorporate both codification and personalization strategies.

The above discussion introduces the two types of knowledge management strategies and their purposes. In the following discussion, we describe the relationship between organizational learning and KMS that instantiate these two strategies, and develop a model that describes this relationship. This model is based on Miller et al.'s (2006) model of organizational learning, which is in turn an extension of March's (1991) model.

2.2. A Model of Organizational Learning and Knowledge Management

March's (1991) framework models an organization's knowledge needs as the *environment* that the organization is in. The primary characteristic of this environment is its inherent

complexity, which is modeled as the number of distinct beliefs that can completely describe the environment. As the number of beliefs increases, so does the complexity of the knowledge. The nature of the knowledge needs of an organization can further be characterized by its tacitness or explicitness in addition to its complexity. Miller et al.'s (2006) extension of this model adds the dimension of tacitness of the knowledge needs of the organization in addition to its complexity as a factor for evaluating learning within an organization. The tacitness of the knowledge is modeled as the proportion of beliefs that are non-codifiable and can be transferred through interpersonal interactions alone. The nature of the knowledge needs of an organization (in terms of the tacitness and explicitness) is an important consideration for implementing KMS since they handle the two types of knowledge in very different ways. For example, different codification strategies are used to manage codifiable knowledge, while personalization strategies are used to manage both explicit and tacit knowledge.

In addition to the individual's personal store of knowledge, the organization as an entity also retains knowledge in the form of knowledge repositories or an *organizational code*.¹ An organization code reflects the beliefs and practices that are embedded within the organization (i.e., organizational routines), and is continuously (or periodically) updated with the best practices and ideas that emerge from the members of the organization (Cohen and Levinthal, 1990). In the context of a KMS, the organizational code represents the knowledge that is acquired and stored in the knowledge repositories. While individuals possess both tacit and explicit knowledge, the organization code only stores codifiable or explicit knowledge, while individuals. Therefore, the transfer of explicit knowledge occurs through the capture, storage and retrieval functions of the KMS (in the form of the organization code), whereas the primary

¹ For the remainder of this paper, the terms knowledge repository and organizational code will be used interchangeably.

function of the KMS for the transfer of tacit knowledge is to augment the process of knowledge sharing amongst the individual members. The roles of these functions of the KMS in terms of organizational learning are discussed in more detail below.

In this framework, knowledge transfer or learning takes place in three forms, namely individual learning, interpersonal learning and learning by the organization code (Massey and Montoya-Weiss, 2006) (see Figure 1). It is well established in the literature, that at the individual level, organization members augment their knowledge by independently learning from the organization code (e.g., Easterby-Smith, Crossan and Nicolini, 2000; Walsh and Ungson, 1991). March (1991) and Miller et al. (2006) interpret this as “the socialization of the individual members into organizational norms”. In the context of KMS, “learning from the code” translates to the retrieval and absorption of knowledge by the individual members of the organization from the knowledge repositories, and is limited to explicit knowledge only, as discussed above.

“Learning by the code”, in March’s (1991) model reflects the absorption of the organization members’ knowledge by the organizational code over time. In other words, knowledge is transferred from the individuals to the organization code. In the context of a KMS, this form of knowledge transfer is analogous to the KMS’s function of capturing and storing explicit knowledge in repositories that can be accessed by all the members of organization.

The final form of knowledge transfer is interpersonal learning. Individuals learn from each other through interpersonal exchanges. While only explicit knowledge can be transferred by learning from and by the code, interpersonal learning transfers both explicit and tacit knowledge. The social relationships between individuals is an important aspect of interpersonal learning (Levinthal and March, 1993) as individuals tend to share knowledge within close knit networks (Robertson et al., 1996) where face to face communications are critical to knowledge transfer

(Orlikowski, 2002). There exists an inherent bias towards searching locally and learning from proximate neighbors rather than searching in an extended network and learning from a distant individual (Cyert and March, 1963; Granovetter, 1973). In Miller et al. (2006), individuals first search within their local neighborhood for an individual to learn from (Lave and Wenger, 1991). If the local search fails to locate a better performer, the individual performs an organization wide (or distant) search to locate a better performing member to learn from.

KMS augment interpersonal learning by increasing the visibility of the location of knowledge or the individual(s) who possess the knowledge within the organization (Andreu and Ciborra, 1996; Offsey, 1997). They also incorporate interpersonal communication technologies that aid or enhance interpersonal learning and knowledge transfer. Conventionally, the size of the local networks has been found to have a more significant impact on the interpersonal knowledge transfer than the scope of the distant searches (Inkpen and Dinur, 1998). However, local networks can also be effectively expanded to more weakly connected larger networks and expose individuals to new ideas (Robertson et al., 1996) using interpersonal communication technologies such as e-mail, message boards etc. (Robey, Boudreau and Rose, 2000; Yates, Orlikowski and Okamura, 1999).

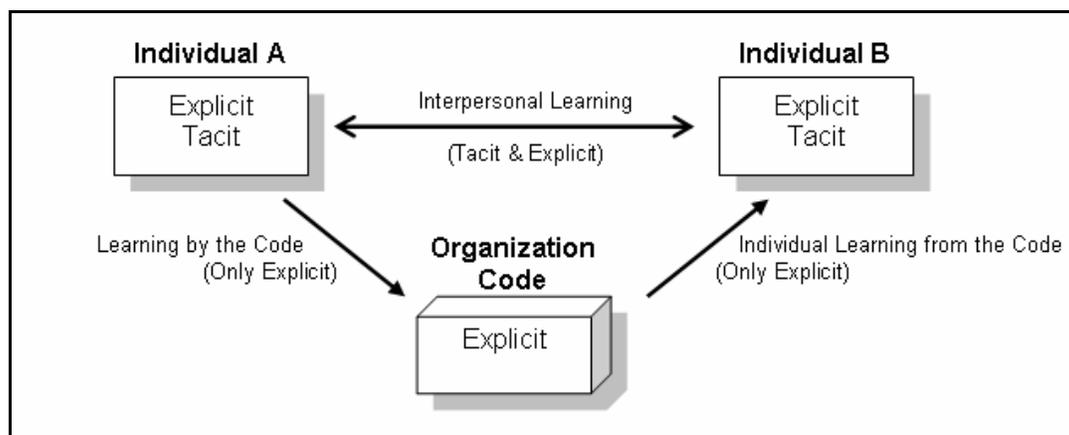


Figure 1: Knowledge Transfer within the Organization

In the above discussion we have outline how KMS can be integrated into the framework of organizational learning and knowledge transfer. In the following section, we describe this relationship in further detail and formally define the different parameters of the model.

2.3. A Formal Model of Organizational Learning

The knowledge needs of an organization in March's (1991) framework are modeled as an m -dimensional vector of independent beliefs. This vector represents the environment or the *justified true beliefs* (Nonaka, 1994). Each element of this vector can take the value of 1 or -1 , and is independent of the individual organization members' beliefs.² The environment's complexity is measure by the value of m . Miller et al. (2006) incorporate the distinction between tacit and explicit knowledge into March's (1991) framework by introducing q or the tacitness ($0 \leq q \leq 1$) of the environment, where $q \times m$ dimensions of the environment are tacit and the remaining $(1-q) \times m$ dimensions are explicit.

An organization is comprised of n members, where n represents the size of the organization. The knowledge of each of the n organization members is also modeled as an m -dimensional vector. Each element of this vector may take a value of 1, -1 or 0, which may or may not match the corresponding value reflected in the environment. The organization code is also represented by an $(1-q) \times m$ -dimensional vector whose elements over time absorbs the dominant belief of the organization's members. The degree of match between the beliefs and the environment is an indicator of knowledge.³

In March's (1991) framework, the individuals learn from the organizational code by modifying each element of their m -dimensional beliefs to the corresponding belief of the code

² Conceptually, this modeling approach represents competing in a business environment as making m independent decisions.

³ As in Miller et al.'s (2006) model, we evaluate performance as the proportion of the correct beliefs. The net percentage of correct beliefs is computed as the number of beliefs that match reality minus the number of beliefs that do not match, divided by m . Using this method, the random initial beliefs perform near 0 on average.

with an independent probability of p_1 in each time period. The parameter p_1 , represents the strength of socialization into organizational norms (i.e., the probability that an individual will learn from the organizational code). Meanwhile, the organizational code also adjusts over time to reflect the dominant beliefs of the explicit dimensions held by its members. The code learns these dominant beliefs with an independent probability of p_2 , which represent the malleability of organizational norms to the practice of individuals (i.e., the probability that the organizational code will learn from the organization's members).

Interpersonal learning occurs when individuals are able to find another individual who perform better than themselves, either in their local strong-tie network (local search) or from a distant search within the weak-tie network. In Miller et al. (2006), the n individuals are positioned within a spatial grid in which each have four neighbors, which represent his or her local strong-tie network. On locating a better performing member within the local network, an individual updates the m -dimensions of his beliefs with the corresponding values of this better performing member with a probability of p_3 (i.e., the probability that a searcher will adopt the knowledge of a close neighbor – learning from local search). If the local search fails to locate a superior performer, the individual performs an organization wide search by randomly drawing four individuals and chooses the best performer within these four to learn from with a probability of p_4 (i.e., the probability that a searcher will adopt the knowledge of a non-neighbor – learning from distant search). When both these searches do not yield a better performing individual, then no learning takes place. Within this framework, the organization reaches equilibrium when all the members of the organization become homogenous in their beliefs, or in other words when no more learning can take place by either the individuals or by the code.

In the following section we describe in detail how KMS can be instantiated using the model described above.

2.4. Incorporating Knowledge Management Strategies and Systems

The number of dimensions (m) and the tacitness (q) of the organization's knowledge needs are exogenous parameters that cannot be controlled by the organization. The variables that describe the organization's learning culture include the individual learning rates p_1 , p_3 and p_4 . Codification strategies (Hansen et al., 1999) entail the effective capture of explicit knowledge into knowledge artifacts such as document repositories etc., (Daft and Lengel, 1984; Stein and Zwass, 1995). These strategies can be instantiated by KMS by manipulating the code learning rate (p_2), and the manner in which the code learns. While the individual learning rate (p_1) is a part of the organization's learning culture, it can also be manipulated by the design of the KMS in terms of the ease of searching and retrieving information. Personalization strategies (Hansen et al., 1999) are instantiated in KMS by the creation of personnel directories and knowledge networks (Hansen, 2002). The manner in which both these strategies are instantiated is outlined below.

Codification Strategies

Within the framework described above, codification strategies are instantiated in the KMS by manipulating the interactions between the individual members and the organization code. These interactions occur in the form of "learning by the code" (i.e., the manner in which the beliefs of the individuals are absorbed by the organization code) and "learning from the code" (i.e., the manner in which the individuals update their beliefs with those in the code). Therefore, the main variables of interest for the analysis of the codification strategies are the individual learning rate (p_1) and the code learning rate (p_2). The variable p_1 indicates how effective the KMS is in dissemination knowledge among individuals and is determined by both the intrinsic learning

capabilities of the individuals as well as the user-friendliness of the KMS and the individuals' familiarity with the KMS (Daft and Lengel, 1986). Similarly, the variable p_2 signifies how effective the KMS is in capturing the knowledge from the organization members. Higher values of p_2 indicate the KMS is more successful in capturing the knowledge in a form that can be effortlessly learned by individuals than lower values of p_2 .

Miller et al.(2006) incorporated the episodic nature of code learning into March's (1991) model, wherein the emergence and updating of organizational rules is episodic as opposed to continuous (March, Schulz and Zhou, 2000). In the context of KMS, the episodic updating of the code can be interpreted as the degree of integration of the KMS and the organization's workflow. When the KMS is tightly coupled with the day to day activities of the organization, the knowledge repositories are updated on a continuous basis with all documents and knowledge artifacts that are produced by members of the organization. In contrast, when the knowledge acquisition activities are removed from the day to day activities of the organization, the knowledge repositories are updated periodically by the members of the organization. To model the episodic nature of the code updates, Miller et al.(2006) introduced the parameter τ that reflects the frequency of learning by the code and individuals' learning from the code. In the context of a KMS, when τ is low (i.e., close to 1), the code learns concurrently with interpersonal learning (e.g., the code could be represented by the discussion forums through which the individuals interact with each other or code learning is embedded in the workflow), and when τ is high, the codification process a task that is periodically performed by the individuals or by a system administrator.

The codification strategies can be demonstrated by the identification of those individuals with whose beliefs the code is updated. Both March (1991) and Miller et al. (2006) assume that

the code learns only from the better-performing organization members, however, for some implementations of the codification strategy, the code absorbs the dominant belief held by all the members in the organization. For example, in the software development industry, in order to promote the recycling and reuse of programs and algorithms, large repositories are maintained in order to store the contribution of each member of the organization. When the organization code is updated with the dominant beliefs of the individuals whose knowledge levels are higher than code's, the code "learns from superior performers". On the other hand, when the organization code is updated with the dominant beliefs of all the members of the organization, the code "learns from all members".

We instantiate KMS that implement the codification strategies described above and compare their performance in terms of equilibrium code knowledge levels, while varying the complexity of the organization's knowledge needs (m) and the organizational learning culture (the four learning rates).

Personalization Strategies

Within the framework described above, personalization strategies are instantiated in the KMS by manipulating the interactions between the individual members of the organization. These interactions occur primarily through interpersonal communication between individuals and therefore, the variables of interest are the local and distant learning rates (p_3 and p_4 respectively). Gupta and Govindarajan's (2000) findings show that knowledge transfer between individuals (sender and recipient) depend on the perceived value of the sender's knowledge, the willingness of the sender to share his knowledge (Wasko and Faraj, 2005), the richness of the communication medium (Carlson and Zmud, 1999; Dennis and Kinney, 1998), the disposition and ability of the recipient to learn (Cross and Sproull, 2004). These behaviors are captured by the variables p_3 and p_4 .

Miller et al.'s (2006) model of interpersonal learning, as described in the previous section, constraints the size of the local networks and the distant searches to 4. As personalization strategies improve the visibility of individuals' capabilities and knowledge levels, the probability of locating an individual with superior knowledge is also increased. Since there is a bias towards searching locally and learning from proximate neighbors rather than through distant searches (Cyert and March, 1963; Granovetter, 1973), personalization strategies can be implemented in KMS by increasing the size of the distant searches.

We instantiate KMS that implement the personalization strategies by varying the size of the distant searches and compare their performance in terms of average equilibrium knowledge levels of the individuals, while varying the complexity of the organization's knowledge needs (m) and the organizational learning culture (the four learning rates). Unlike the codification strategies, personalization strategies impact the acquisition and dissemination of both explicit and tacit knowledge.

In the following section we describe how the two knowledge management strategies (codification and personalization) are instantiated in KMS using the model of organizational learning and analyze each of their strengths and weaknesses.

3. Methodology

Simulation methods will be the primary methodological vehicle for this research. There are several reasons why simulations methods are most suited to our current research. First, sharing of knowledge and interactions between members of an organization are inherently non-linear, and simulations have been found to be particularly relevant when the focal phenomenon is non-linear (Davis, Bingham and Eisenhardt, 2007). Secondly, simulations have been found to be effective in developing an understanding of how the effects of micro-level behavior (at the individual level) aggregate to macro-level dynamics (at the organization level) (Lomi and Larsen,

1996). In this paper, we are interested in studying how learning at the individual level under different circumstances impacts the long term and short term knowledge levels of the organization, therefore simulations are an appropriate research method. Finally, the data required for empirically comparing how different knowledge management strategies would perform in a particular environment or how a knowledge management strategy would perform in different environments, would entail numerous expensive and large scale experiments. In such situations, where it is challenging to collect time variant data at the individual and organizational levels for empirical analysis, simulations have been found to be an effectual substitute. (Davis et al., 2007; Zott, 2003).⁴

Matlab 7.2 was used for constructing the simulation models described above. The KMS that were implemented instantiated the codification and personalization strategies described in the previous section (and are summarized in Table 1). For each run of the simulations, we used different random seeds to generate the initial conditions. The default values for all the models were $n = 100$, $q = 0.5$, $m = 150$, and $p_1, p_2, p_3, p_4 = 0.5$. In order to examine the impact of the complexity (m) of the organizations' knowledge needs on the performance of a KMS, the simulations for each KMS were run for $m = 150, 300$ and 450 . In each time period, the values of the average tacit and explicit knowledge levels of the organization members and the explicit knowledge were stored.

KMS	Personalization Strategy		Codification Strategy	
	Size of Local Network	Size of Distant Searches	Code Updated By	τ
KMS 1	4	4	All Members	1, 5, 10
KMS 2	4	8	All Members	1, 5, 10
KMS 3	4	4	Superior Performers	1, 5, 10
KMS 4	4	8	Superior Performers	1, 5, 10

Table 1: Experimental Design

⁴ However, we acknowledge the limitations of simulation methods and stress that the purpose of this study is to generate theoretical hypotheses that can (and should) later be tested empirically.

In our model, equilibrium is reached when there is no change in the knowledge level (which are calculated as the performance described in the previous section) of the code or the individuals for an extended period of time ($t = 15$). The outcome variables stored in each time period $t = 1 \dots T$ ($T = 400$) include the knowledge level of the organizational code, and the average levels of tacit and explicit knowledge levels of all the organizational members. The following results are based on the averages of the outcome variables for 100 runs for KMS.

4. Simulation Results

Our simulation models for each of the knowledge management strategies displayed the characteristics of organizational learning described in the results of March (1991) and Miller et al. (2006). When the complexity of knowledge is low, knowledge is accumulated at a faster rate and the knowledge levels at equilibrium are higher than when the complexity of knowledge is high. As explained by Miller et al. (2006), when the complexity of knowledge is high, there are a larger number of elements to learn, and consequently more effort is required to absorb the knowledge at the individual and the group level. There also exists a relationship between the number of organizational members (n) and the complexity of the knowledge (m). When n is close to m , the diversity in the beliefs is higher and the number of interactions between the individuals are also higher, thus leading to higher levels of equilibrium knowledge. When the difference between n and m is high, the lack of diversity in the beliefs of the individuals leads to faster dissemination of the dominant beliefs (both correct and incorrect) and consequently lower knowledge levels at equilibrium. In the following discussion we analyze the performance of the different knowledge management strategies in more detail. Figure 2 and 3 represents the equilibrium knowledge level of the organization code for the four KMS described in Table 1, while varying the frequency of code updates (τ) and complexity of the knowledge needs (m) along with the code learning rate (p_2) and individual learning rate (p_1) respectively, while Figure

4 represents the time to equilibrium for the same. Figure 5 shows the equilibrium knowledge levels of the organization code and the individual members of the organization, while varying the interpersonal learning rate (p_3), while Figure 6 shows the time it takes to reach equilibrium for the average explicit and tacit knowledge levels of the individuals.

4.1. Codification Strategies

Codification strategies can be instantiated by appropriately calibrating the parameters associated with the capture of explicit knowledge by the KMS, the frequency of code updates (τ) and the set of individuals (all organization members or superior performing members) from whom the code learns. In the following analysis, we compare the performance of the codification strategies described above (Table 1), and examine the impact of the different implementations on the knowledge level of the code and the explicit knowledge of the individuals. Since tacit knowledge is not transferred via the code, it is not relevant to the following discussion.

Learn From Superiors and Learn From All

March's (1991) results indicate that the long term knowledge levels of the organization depend on the how long heterogeneity in the beliefs of the organization members can be sustained. In other words, the longer it takes to reach equilibrium, the higher are the equilibrium knowledge levels. Our results demonstrate that this relationship is moderated by the set of individuals that the code learns from as well as the frequency of the code updates (see Figure 2 and 3). We find that the 'learning from superior performers' strategy always outperforms the 'learning from all members' strategy for different values of τ and m in terms of both the long term and short term equilibrium knowledge levels of the organizational code and the individual members even though both strategies reach equilibrium at similar times (see Figure 4). Therefore,

the set of organizational members who are involved in updating the code has a significant impact on the knowledge acquired by the organization. While new technologies may reduce the costs of storage and consequently allow all the members to contribute to the knowledge repositories, in the long term it is more beneficial to employ a filtering mechanism to control what information is stored in these knowledge repositories. Since there is a uniform impact on both the knowledge in the repositories as well as the individuals' personal knowledge, the set of individuals who contribute to the knowledge repositories not only affects the knowledge acquisition function of the KMS, but also the dissemination functions.

Proposition 1: Selective contribution to knowledge repositories leads to superior performance of the KMS in the long term and short term.

Frequency of Code Updates (τ)

We observe that slower code updates (i.e., higher τ) lead to consistently higher levels of equilibrium code knowledge (and the average equilibrium explicit knowledge of the individuals) in the long term, while frequent code updates (i.e., lower τ) leads to higher levels of same in the short term (see Figure 4(a)). The organization code contributes to the rapid dissemination of beliefs that may or may not be correct and therefore impedes the dissemination of correct beliefs, especially when the members learn rapidly from the code. By decreasing the frequency of code updates, the members of the organization learn more frequently from each other than from the code. Consequently with each update the organization code absorbs a higher number of correct beliefs, and these correct beliefs are then absorbed rapidly by the organization members.

Proposition 2: The periodic updating of knowledge repositories leads to superior performance of the KMS in the long term, while frequent updating leads to superior performance of the KMS in the short term.

Figure 2(a) Equilibrium Code Knowledge – Varying Frequency of Updates (τ)

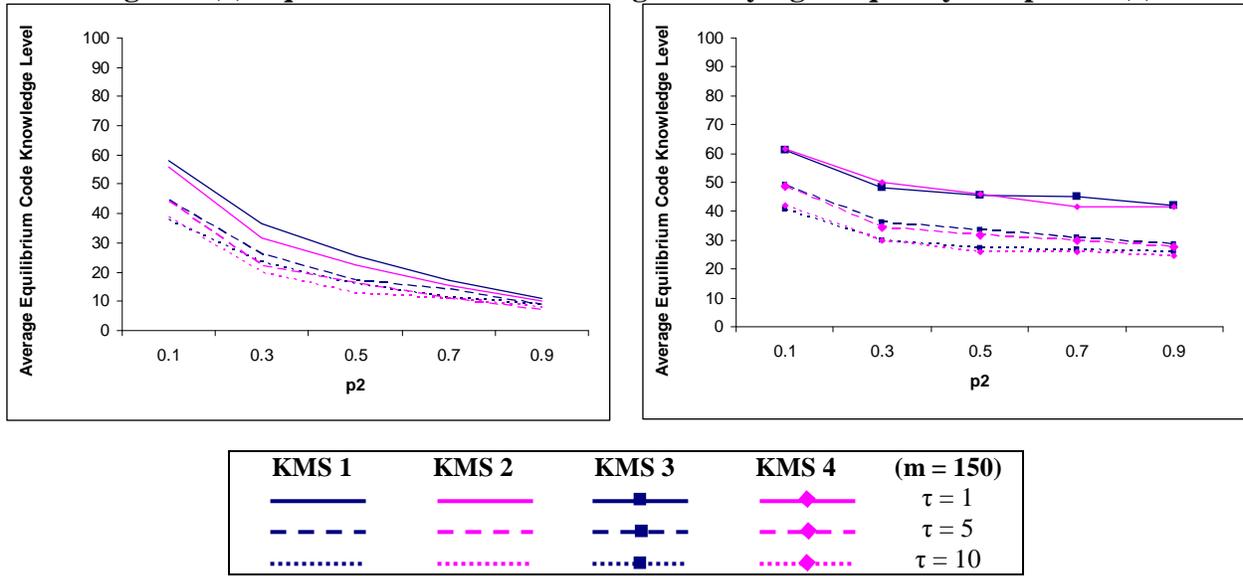
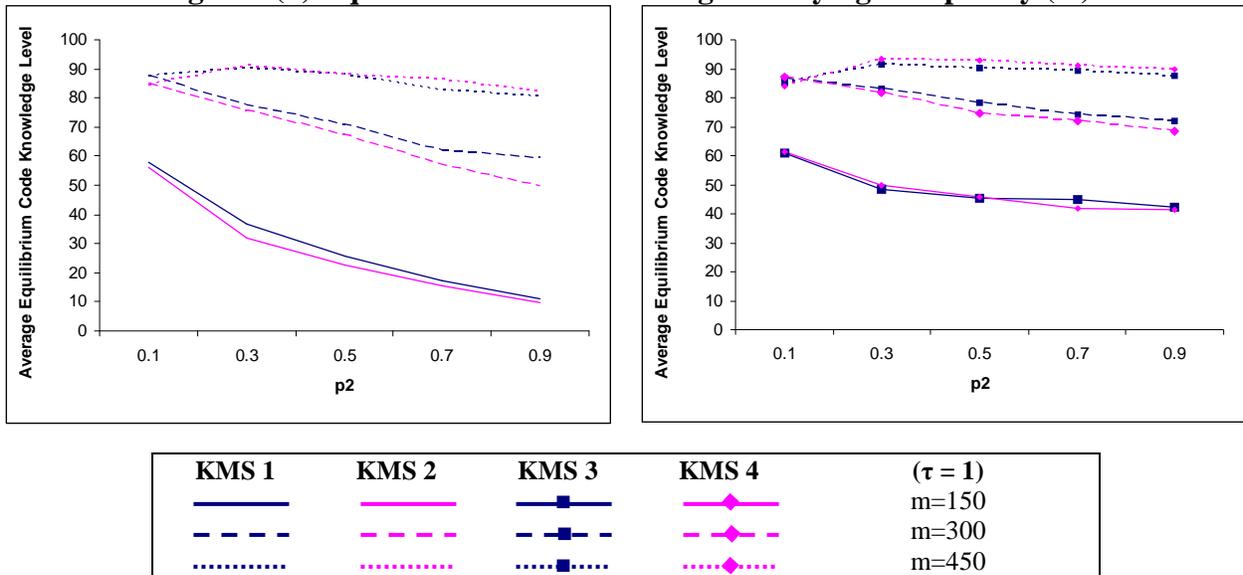


Figure 2(b) Equilibrium Code Knowledge – Varying Complexity (m)



We also observe that when τ is high, the difference in the performance of the two strategies decreases (see Figure 2 and 3). In other words, when the frequency of code updates is low, the impact of who updates the code on equilibrium knowledge level is less. Since a lower code update frequency implies more reliance on interpersonal learning, the correct beliefs are disseminated faster among the members of the organization before the code is updated.

Therefore, the dominant belief of the superior performing members is likely to be the similar to the dominant belief of all the members and consequently it is immaterial from whom the code learns.

Proposition 3: The periodic updating of knowledge repositories can substitute the need for selective contribution to the same and achieve similar performance levels of the KMS.

Figure 3(a) Equilibrium Code Knowledge – Varying Frequency of Updates (τ)

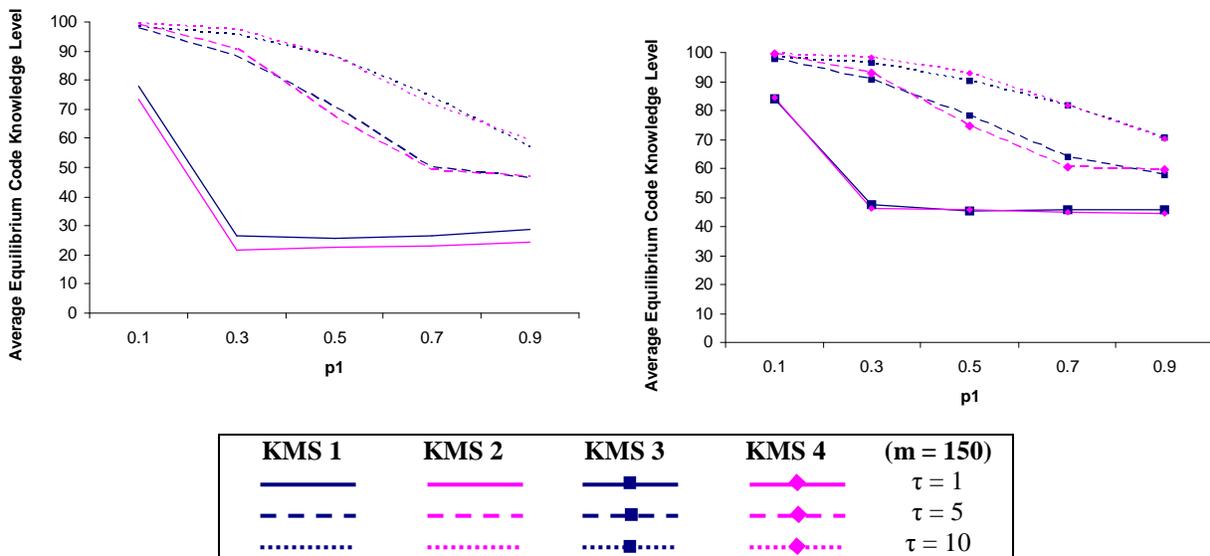


Figure 3(b) Equilibrium Code Knowledge – Varying Complexity (m)

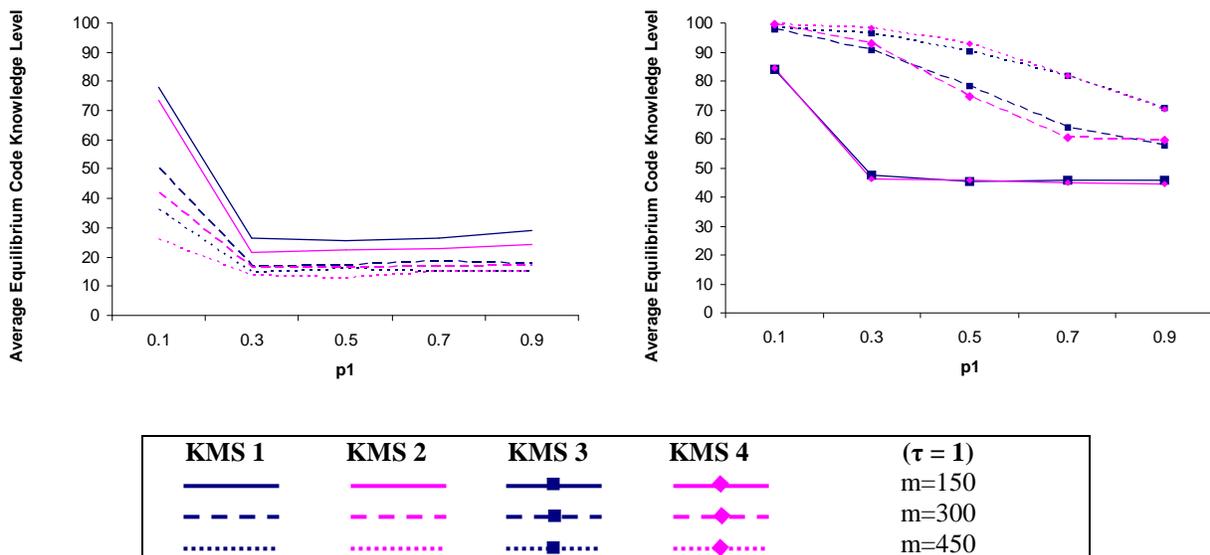


Figure 4(a) Code Knowledge Levels – Varying Frequency of Updates (τ)

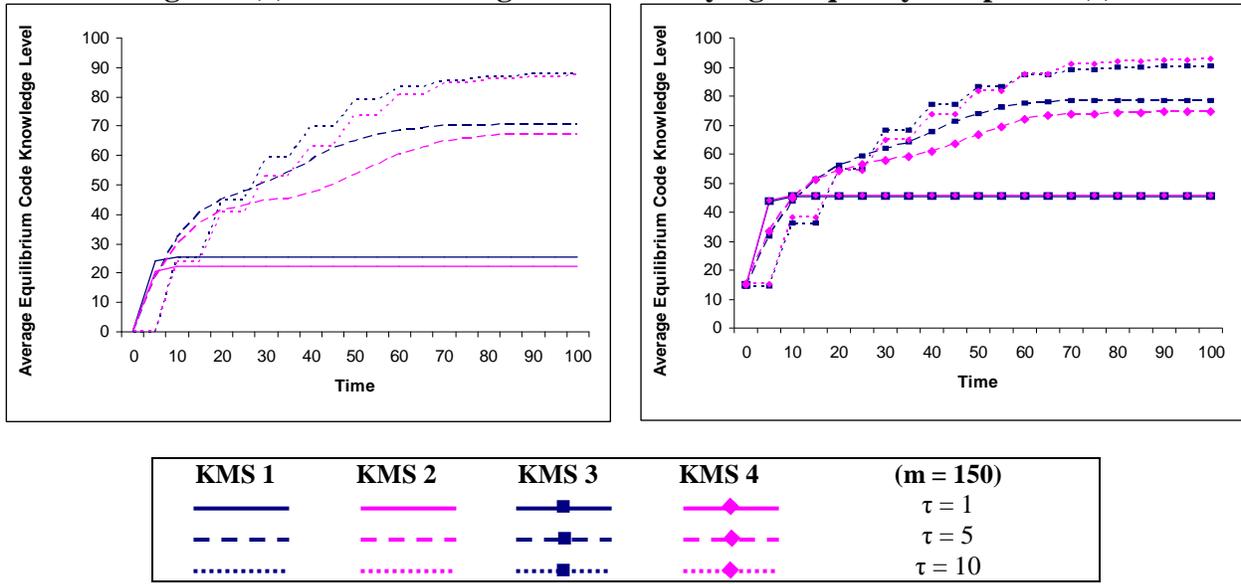
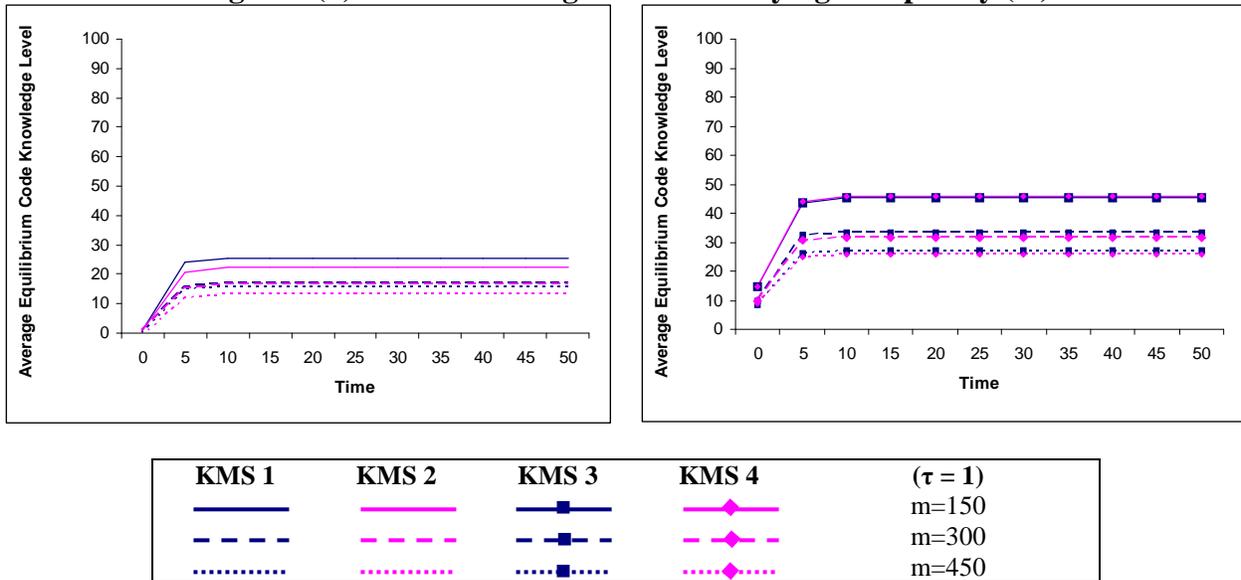


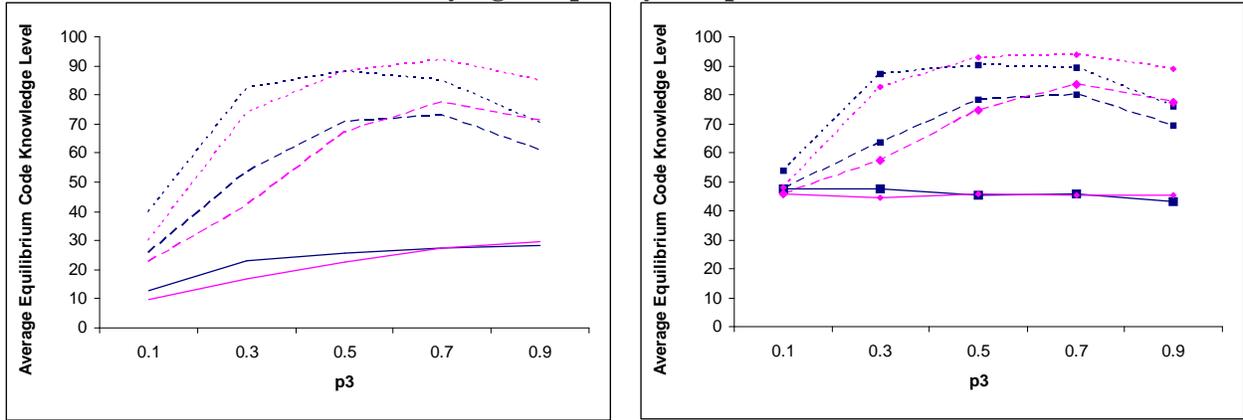
Figure 4(b) Code Knowledge Levels – Varying Complexity (m)



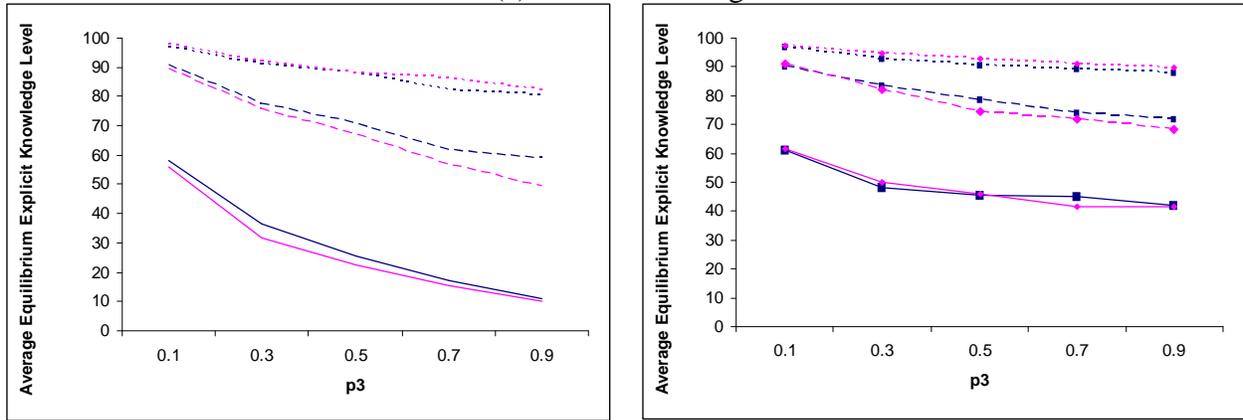
Learning Rates

When comparing the codification strategies with respect to the individual learning rate (p_1) and code learning rate (p_2), we observe that the performance of the ‘learning from all members’ strategy is lower than the performance of the ‘learning from superior performers’ strategy (see Figure 2 and 3) when the learning rates are high.

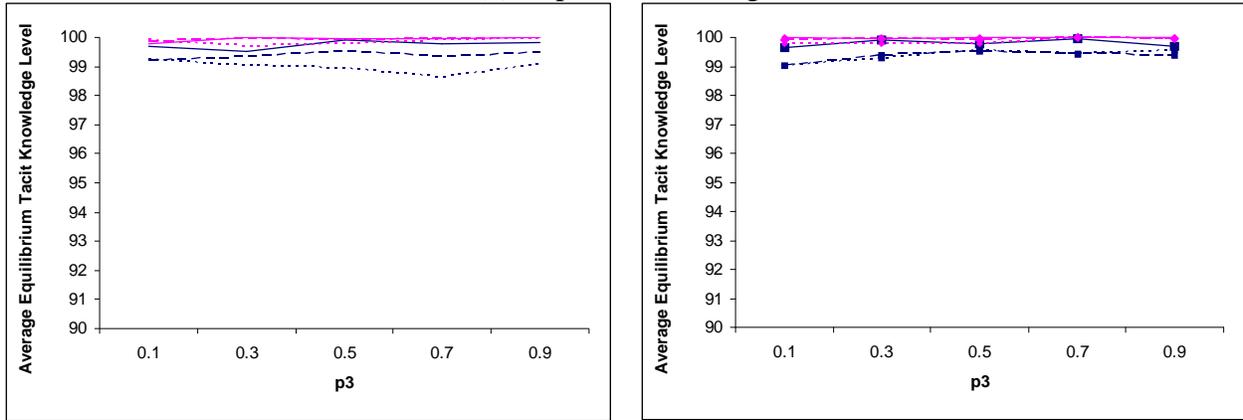
**Figure 5: Equilibrium Knowledge Levels and Interpersonal Learning
(Varying Frequency of Updates (τ))**



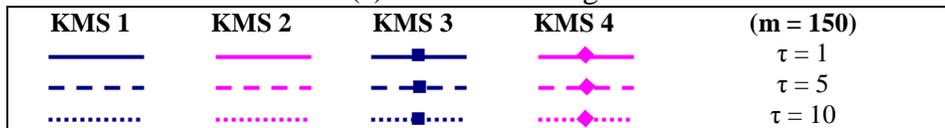
(a) Code Knowledge



(b) Explicit Knowledge



(c) Tacit Knowledge



When the code learning is efficient in absorbing the beliefs of all the members of the organization and they in turn learn efficiently from the code, a greater number of incorrect beliefs disseminate at a faster rate than when it learns efficiently from the superior performing members only. These results are consistent with March's (1991) findings. When the code updates are frequent (i.e. τ is low), the individual learning rate (p_1) does not have a significant impact on the equilibrium knowledge levels of the code, however when the code updates are frequent, we observe that the individual learning rate has a detrimental impact on the equilibrium knowledge levels of the code and the individuals themselves.

As mentioned previously, when the code updates are less frequent (i.e., τ is high), the code is updated with knowledge of the individuals that has been augmented by interpersonal learning. Consequently, the interpersonal learning rates (p_3 and p_4) also affect the equilibrium knowledge levels in these situations. Miller et al.'s (2006) results show that intermediate levels of interpersonal learning rates lead to the highest levels of knowledge at equilibrium. We observe that while this is true for the organization code, the average explicit knowledge levels of the organization members at equilibrium are consistently lower when interpersonal learning rates are high, than when interpersonal learning rates are low. However, the average equilibrium levels of the individuals' explicit knowledge are consistently higher than equilibrium knowledge levels of the organization code. The separate relationship between interpersonal learning rates and the knowledge levels of the code and organization members also results in a difference in the equilibrium values of knowledge. The implications of these results are that as code update frequency increases, the individuals' learn more from interpersonal interactions than directly from the code. We also observe that when the code is updated by the all members of the

organization, the average equilibrium knowledge levels are more sensitive to the interpersonal learning rates, than when the code is updated by only the superior performing members.

Proposition 4: When the knowledge repositories are updated periodically, individuals' reliance on interpersonal communications for knowledge acquisition increases, consequently leading to higher knowledge levels at equilibrium when compared to that stored in the KMS.

4.2. Personalization Strategies

Personalization strategies are instantiated by varying the size of the distant searches. In the following analysis, we compare the performance of the codification strategies described above (Table 1), and examine the impact of the different implementations on the explicit and tacit knowledge level of the individuals. Tacit knowledge is communicated exclusively through interpersonal interactions between the individuals, while explicit knowledge is also communicated through the individuals' direct interaction with the organization code. Consequently, there exists a significant discrepancy between the levels of tacit and explicit knowledge levels of the organization members. As previously discussed, the knowledge repositories contribute to the rapid dissemination of both correct and incorrect beliefs, while interpersonal learning results in slower dissemination of correct beliefs as individuals learn from only those individuals who possess superior knowledge. Consequently, the tacit knowledge levels are always higher than explicit knowledge levels in the long term, while the converse is true in the short term.

Increased Size of Distant Searches

The increase in the size of the distant searches performed when an individual with superior knowledge is not found in the local network has different effects on the explicit and tacit

knowledge levels of the individuals. We observe that increasing the size of the distant searches results in low levels of both tacit and explicit knowledge in the short term (Figure 6). In the long term, the levels of tacit knowledge are consistently higher when the size of the distant searches is increased. The levels of explicit knowledge, on the other hand, remain comparatively lower when the code is updated frequently. As mentioned above, when the frequency of code updates is low, the interpersonal learning has a more significant effect on the explicit knowledge levels of the individuals than the organization code. Therefore, the personalization strategy employed in augmenting interpersonal communications also moderate this relationship. We observe that increasing the size of the distant searches results in the higher explicit knowledge levels in the long term when the code updates are less frequent (i.e., τ is high) (see Figure 4).

Proposition 5(a): Personalization strategies that improve the performance of distant searches lead to higher levels of average tacit knowledge within the organization in the long term, and lower levels of both tacit and explicit knowledge in the short term.

Proposition 5(b): When the KMS' codification strategy includes periodic updating of the code, personalization strategies that improve the performance of distant searches lead to higher levels of explicit knowledge in the long term.

We also observe that increasing the size of the distant searches makes the performance of the KMS (in terms of equilibrium tacit knowledge levels) less sensitive to the complexity of the knowledge needs of the organization. As the time taken to reach equilibrium is affected by the complexity of the knowledge, when the complexity is high the short term tacit knowledge levels are correspondingly low. The relationship between the level of explicit knowledge and the

complexity of the knowledge is however, primarily determined by the codification strategy employed by the KMS and not significantly affected by the personalization strategies.

Learning Rates

Since tacit knowledge is transferred exclusively through interpersonal interactions between the individuals, the levels of tacit knowledge in the short term and long term are not affected by either the individual learning rate (p_1) or the code learning rate (p_2). The relationship between the equilibrium tacit knowledge levels and interpersonal learning rates (p_3 and p_4) are fairly uniform, consistent and independent of the complexity of the organization's knowledge needs. The performance (in terms of equilibrium tacit levels) of personalization strategies that increase the size of the distant searches is less sensitive to both the local and distant interpersonal learning rates (p_3 and p_4 respectively). When the size of the distant searches is small, the levels of equilibrium tacit knowledge are highest for intermediate levels of the local interpersonal learning rate (see Figure 5). We observe that most interactions occur within the local networks; therefore the local interpersonal learning rate has a more significant impact on both types of the personalization strategies. When the focal member has the highest knowledge level within his or her local network, and he or she probably has superior knowledge compared to the majority of other individuals in the organization as well. Consequently, when the size of the distant search is small, the probability of locating an individual with superior knowledge than the focal member is low and therefore no learning takes place. When the size of the distant search is increased, this probability is also increased, and the probability that the focal member does not learn is decreased. Therefore, the distant interpersonal learning rate (p_4) has a more significant impact on knowledge transfer when the size of the distant search is increased, and subsequently balances the local interpersonal learning rate (p_3) resulting in consistent higher levels of equilibrium tacit knowledge.

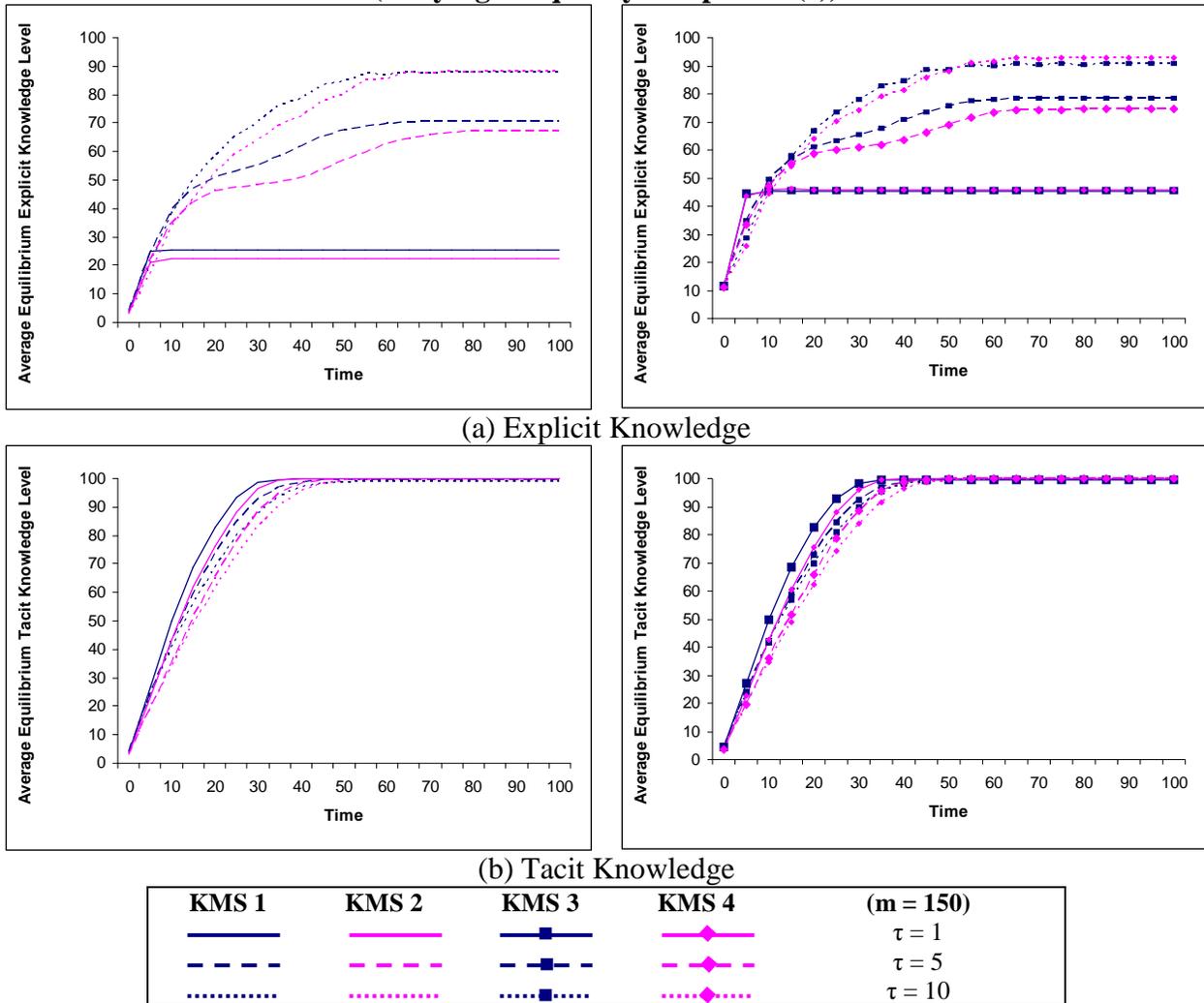
As mentioned in above, explicit knowledge is transferred through interpersonal communications and through the organization code. As noted in the analysis of the codification strategies, contribution of the organization code towards the dissemination of knowledge is more significant than that of interpersonal interactions. However, when the frequency of the code updates is low, interpersonal interactions do contribute to the equilibrium explicit knowledge levels of the individuals. Irrespective of the size of the distant searches, high interpersonal learning rates result in low levels of explicit knowledge at equilibrium, and vice versa (see Figure 5). Increasing the size of the distant searches, however, results in a more significant detrimental impact on the equilibrium knowledge levels of the individuals, especially when the code update frequency is low. In other words, when the organization code is updated periodically, high interpersonal learning rates result in lower equilibrium levels of explicit knowledge when the size of the distant searches are increased. As high interpersonal learning rates in conjunction with the increased size of distant searches, lead to rapid dissemination of knowledge (including both correct and incorrect beliefs), the acquisition and subsequent uniform dissemination of this knowledge by the code results in proliferation of homogenous beliefs at an increased pace. This ultimately results in lower levels of explicit knowledge at equilibrium.

Therefore, when knowledge transfer occurs without the interference of a central knowledge repository, increasing the size of distant searches leads to higher levels of knowledge at equilibrium, independent of the interpersonal learning rates. However, in the presence of a central knowledge repository, both high interpersonal learning rates and increased size of distant searches contribute to the rapid dissemination of inferior knowledge and consequently low levels of knowledge at equilibrium.

Proposition 6(a): Personalization strategies that increase the performance of distant searches result in higher levels of tacit knowledge at equilibrium, irrespective of the interpersonal learning rates.

Proposition 6(b): High interpersonal learning rates degrade the performance of personalization strategies in terms of explicit knowledge levels at equilibrium. This deterioration is more significant when the performance of distant searches is increased.

Figure 6: Average Knowledge Levels of Individual Members (Varying Frequency of Updates (τ))



5. Discussion and Conclusion

In this paper we use the model of organizational learning developed by March (1991) and Miller et al. (2006) to study the effectiveness of knowledge management systems in different organizational environments and knowledge needs. We first interpret the model of organizational learning in the context of knowledge management systems and extend the model to instantiate the codification and personalization knowledge management strategies. We then analyze the impact of these knowledge management strategies in different organizational environments. Our results indicate that while implementing filtering mechanisms that codify the knowledge of only the best performing individuals lead to the most effective knowledge acquisition in the long term, similar levels of knowledge can be attained by providing incentives to the organizational members to self filter, implementing intelligent search programs, rating systems etc., and decreasing the frequency of code updates at much lower costs.

When we look at the role of knowledge management systems in interpersonal learning, we find that knowledge management systems that improve the performance of distant searches result in higher knowledge levels at equilibrium. However, this is true primarily for tacit knowledge which is transferred exclusively through interpersonal communications. The long term acquisition of explicit knowledge deteriorates as a consequence of the interaction effects of the codification strategy employed by the KMS and the personalization strategies that improve distant searches. These results indicate that when implemented in isolation, personalization strategies improve the performance of interpersonal interactions in terms of long term knowledge acquisition; however, when employed in conjunction with codification strategies their effectiveness diminishes.

The results of this paper are limited by certain assumptions made by the model. The focus of this study has been on the transfer and sharing of knowledge, which is primarily static in nature

and does not evolve over time. The model incorporates the transfer of explicit and tacit knowledge between members of the organization, and the transfer of explicit knowledge between knowledge repositories and individuals. While the model focuses does not overtly capture the knowledge creation capabilities of organization or the interaction between the explicit and tacit elements of the knowledge (Nonaka, 1994), these results are relevant to the dynamic aspects of knowledge creation as well since the static knowledge acquisition capabilities of an organization are indicative of its dynamic knowledge creation capabilities (Smith et al., 2005).

In this paper in addition to developing insights into effectiveness of knowledge management systems in different organizational environments we also develop insights into the learning behaviors of individuals in the presence of various knowledge management systems. Further extensions of this study would be including employee turnover and organizational growth in the model as well as instability in the organization's knowledge needs in terms of the complexity and the changes in the 'absolute truth' over time. Both March (1991) and Miller et al. (2006) model employee turnover as the random replacement of an individual with an individual with randomly assigned beliefs. This model of employee turnover can also be extended to incorporate different recruiting policies (such as recruiting fresh graduates with no beliefs or individuals with experience whose beliefs close match the 'absolute truth') and study the impact of these policies on the long term knowledge levels of the organization.

The heterogeneity among individual learning rates is an area that calls for further exploration. We assume that the learning rates of all individuals in the organization are uniform and part of the organizational culture. While this assumption is not restrictive and does not mitigate the implications of our results, an interesting extension of these studies would be to examine the impact of heterogeneity of learning rates on the knowledge sharing behavior of individuals.

Another possible extension of these studies would be to study the relationship between the knowledge sharing behaviors and the ties between individuals within the organization in a social network context.

The model employed in this study is restricted to a flat organizational structure; extensions of this study could incorporate various organization structures to gain further insights into the effectiveness of different knowledge management strategies. In this study, the knowledge repository is the only form of organizational memory and is capable of storing only codifiable knowledge. Carley's (1992) study found that in organizations with hierarchical structures, the organizations' structure itself simulated organizational memory and retained knowledge even in the presence of employee turnover. Since in our model, tacit knowledge exists only in the individuals' memory, the incorporation of different organizational structures may lead to additional insights into the effectiveness of the personalization strategies.

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