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ABSTRACT

Knowledge sharing is crucial to the success of knowledge management systems. Information technologies and incentives are important to effectively manage knowledge assets in organizations. In this paper, we study the *joint* role of incentives and information technologies in enabling knowledge sharing and learning. We investigate two organizational knowledge-transfer policies: *mandatory learning* and *voluntary learning*. We demonstrate the role of linear incentive structures from three aspects: truthful report of knowledge levels, *knowledge sharing/learning alignment*, and *full-knowledge transfer*. We establish the necessary IT level to facilitate *complete-knowledge enablement* and provide guidance for a firm to choose an appropriate knowledge-transfer policy with respect to its IT level.

Keywords

Knowledge sharing, incentives, information technologies, knowledge management.

INTRODUCTION

Managing knowledge assets to maintain a healthy *Knowledge Quotient*™ [1] is assuming greater importance for organizations that rely on knowledge workers and extensive flow of information and ideas in the eBusiness arena (Hansen, Nohria, and Tierney 1999). Knowledge and knowledge management (KM) can be explained from different perspectives. In this paper, we understand knowledge from the process perspective and interpret knowledge management as a process of applying expertise including *creation*, *codification*, *storage*, *transfer*, and *application* of knowledge (Alavi and Leidner 2001).

A variety of information technologies support knowledge management by facilitating its processes. Generally, there are three perspectives on the role of information technologies in supporting knowledge management. From the support and guidance perspective, successful IT application should provide both supportive and guiding information to enable knowledge management. For example, database system basically provides support information, but can be enhanced to be the repository of guidance. Enterprise information portals can be used to offer both supportive and guidance information to obtain various benefits (Wilson, 1999). From the process-oriented perspective, information technologies function to streamline knowledge management processes. For example, data mining techniques enhance knowledge creation, knowledge repositories codify and store knowledge, knowledge directories and enterprise portals enable the accurate transmission of knowledge, and workflow systems and indexing techniques are used in applications of knowledge (Alavi et al., 2001). Lastly, information technologies support the "tacit-explicit model" (Nonaka and Takeuchi 1995) with its essential role in knowledge conversion and transmission. For example, document management tools are widely applied in explicit-to-explicit knowledge transfer, collaboration technologies support a tacit-to-explicit knowledge conversion, knowledge discovery tools help the explicit-to-tacit conversion of knowledge, and the support of peer-to-peer networks can be tacit-to-tacit or tacit-to-explicit (Lindvall, Rus, and Sinha 2002).

Advances in information technology have greatly facilitated knowledge capture and sharing. However, technology by itself is insufficient, since people are the central element in creating and sharing knowledge. Therefore, a well-designed incentive system is indispensable for organizations to successfully diffuse knowledge (Ba, Stallaert, and Whinston 2001b, Argote, McEvily, and Reagans 2003). Many companies, in particular, knowledge-based learning organizations, make learning mandatory to promote internal knowledge culture. Typically, employees are required to learn to acquire necessary

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[1] The Penn State Research Foundation, 2003.

skills for their jobs. For example, at O'Hagan, Smith & Amundsen LLC, certification of basic IT skills is mandatory for everyone, from the top partners to the lowest-paid clerical worker. Employees have to go through training and pass a series of certification tests to fulfill their basic job requirements (King 2002). Insurance company USAA in San Antonio also requires similar training for its employees (Goff 2001). In contrast, direct reward for knowledge sharing is also applied by other leading companies. For example, Siemens measures and rewards individuals for participation in ShareNet. Contributors earn rewards based on the quality and reusability of their contributions assessed through peer rating. Hewlett-Packard Consulting rewards and recognizes employees whose knowledge mastery best exemplifies the balance of innovation and significantly contributes in promoting knowledge culture (APQC 2001).

Recent years have seen a growth of academic research in knowledge management, including the impacts of information systems and incentive mechanisms on knowledge sharing (e.g., Barua, Lee, and Whinston 1995, Davenport and Prusak 1998, Baird and Henderson 2001, Ba, Stallaert, and Whinston 2001a). A well-established body of research also exists on incentives in economics literature (Grossman and Hart 1983, Groves 1973, Holmstrom 1979, Holmstrom 1982, Marshak and Radner 1972, Spence 1973). However, incentives that explicitly induce workers' knowledge-sharing behaviors and their synergetic interaction with information systems, which are the focus of this paper, have not been fully studied yet.

Our research addresses this gap. We embed the knowledge sharing and learning process within a team context in which information technology and incentives are major drivers of knowledge transfer. Based on business practices, we study the *joint* role of incentives and information technologies in facilitating knowledge sharing and learning within firms. In addition to traditional incentives to induce workers' best efforts, we also study the role of incentive policies in motivating workers to share and learn knowledge and explore the linkage between these two sets of incentive structures. We explicitly model rewards and costs for knowledge sharing and learning, capture characteristics of information technologies in facilitating knowledge transfer, and investigate the complementarity between incentive schemes and information technologies.

The rest of the paper is organized as follows. Next section outlines our model. The following section presents our preliminary results and the final section summarizes the paper.

MODEL

We first outline the model setting in which workers exchange information and transfer knowledge through a knowledge management system and then we describe the mathematical model. We present a framework of knowledge transfer within organizations via a knowledge management system (KMS) (e.g., Lotus Discovery Server from IBM[2]), which is used to maintain a knowledge directory and facilitate knowledge sharing and learning among knowledge workers (Figure 1). Specifically, the organization controls the knowledge server, monitoring and coordinating the KM processes such as registration, update, notification, and search. The KMS provides the "hard" support for knowledge transfer in the organization. It helps to create a knowledge directory for the organization to identify potential knowledge providers and knowledge seekers and facilitates the transfer of knowledge.

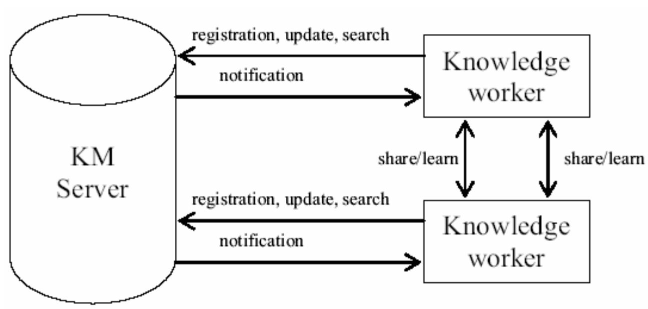

Figure 1. A framework of knowledge transfer

However, incentives are indispensable for the organization to get an accurate knowledge directory and streamline the transfer of knowledge (Ba et al. 2001b, Argote et al. 2003). Next, we describe our analytical model to investigate the important role of incentives in providing the "soft" support for knowledge transfer.

[2] Source: http://www.lotus.com/products/discserver.nsf.

We consider n knowledge workers functioning as a team in a firm to complete a project. These workers belong to one of two types with either *high* or *low* knowledge level. Each worker i ($i=1,2$) has a certain knowledge level k_i (we assume $k_1>k_2$) that affects his ability to understand and work with the other member to generate a team output x. The output x is a concavely increasing in all the workers' effort levels e_i, and $x=(e_1,e_2,\theta)$, where the parameter θ reflects the stochasticity of the team output.

We map the whole knowledge transfer process into the following three stages. In the first stage, the firm announces an incentive policy for rewarding knowledge sharing and learning and a sharing rule to motivate the best efforts of workers. The incentive policies $R_s(k_i^s,\tau_i)$ and $R_l(k_i^l,\tau_i)$ reward knowledge sharing and learning based on the observed sharing or learning amount (k_i^s or k_i^l) and a worker's reported knowledge level τ_i. The sharing rule $s_i(x,\tau)$ allocates the team's total output x to each individual in a specific way based on the observed final output x and their reported knowledge levels τ. In the second stage, each individual i reports her knowledge level τ_i to the firm. In the third stage, each individual exerts effort, shares knowledge or learns, completes the project, and gets an allocation according to the contract and knowledge-sharing or learning reward if applicable.

Each risk-neutral knowledge worker has to choose a non-observable effort level $e_i \in E_i=[0,\infty)$, keeping in mind the sharing rule designed by the firm. The cost C_i for exerting effort decreases with respect to an individual's knowledge level and convexly increases with his effort level. Additionally, workers determine how much knowledge k_i^s to share and how much k_i^l to learn. A worker's cost of sharing knowledge C_i^s convexly increases with respect to his sharing amount k_i^s and decreases with his knowledge level k_i. Similarly, we assume that the cost of learning C_i^l convexly increases with his learning amount k_i^l and decreases with his knowledge level k_i. These two assumptions imply that a worker with a higher knowledge level incurs less sharing and learning costs for sharing or learning the same amount of knowledge. Finally, we assume that both the sharing and learning costs are parameterized by the level T of information technology employed in the KMS by the firm. The more advanced (a higher T) the KMS, the lower the sharing and learning costs.

In summary, the firm tries to apply the rewarding policies $R_s(k_i^s,\tau_i)$ and $R_l(k_i^l,\tau_i)$ to motivate workers to share knowledge and learn, and design sharing rules $s_i(x,\tau)$ for all possible output x to maximize its expected final output. Formally, we define the firm's problem *[P]* as

$$\max_{s_i,R_s,R_l} \quad E[\pi]=E\{x-\sum_{i=1}^{2}s_i(x,\tau)-\sum_{i=1}^{2}[R_s(k_i^s,\tau_i)+R_l(k_i^l,\tau_i)]\},$$

subject to

$$(e_i^*,\tau_i^*,(k_i^s)^*,(k_i^l)^*)\in \underset{(e_i,\tau_i,k_i^s,k_i^l)}{argmax} \quad E[\pi_i], \qquad [1]$$

$$E[\pi_i]\geq 0, \qquad [2]$$

where $\pi_i=s_i(x,\tau)-C_i(e_i,k_i)-C_i^s(k_i^s,k_i,T)-C_i^l(k_i^l,k_i,T)+R_s(k_i^s,\tau_i)+R_l(k_i^l,\tau_i)$ and Equations [1] and [2] are the workers' incentive-compatibility and individual-rationality constraints. Based on business practices, we investigate two commonly adopted knowledge-transfer policies: *mandatory learning* (ML) and *voluntary learning* (VL), both rewarding knowledge sharing $R_s(k_i^s,\tau_i)$ or learning $R_l(k_i^l,\tau_i)$ (if necessary) based on the amount of knowledge being shared k_i^s or learned k_i^l and the reported knowledge level τ_i. However, in the first case, workers are mandated to learn whenever other workers share knowledge useful to them, i.e., $k_i^l=k_j^s, \forall i,j=1,2\ \&\ i\neq j$, while, in the second case, workers can independently choose how much to learn, i.e., $k_i^l\leq k_j^s, \forall i,j=1,2\ \&\ i\neq j$.

We next define three desirable knowledge-transfer characteristics that we will use in the following analysis.

Knowledge-sharing/learning alignment: individuals acting independently are induced to share/learn the same amount of knowledge as desired by the firm.

Full-knowledge transfer: the knowledge shared by the higher-knowledge worker is fully absorbed by the lower-knowledge worker.

Complete-knowledge enablement: the higher-knowledge worker shares the knowledge completely so that the lower knowledge worker may reach her knowledge level.

ANALYSIS AND DISCUSSION

In this section, we present our preliminary results and insights. Due to space constraints, we describe our major findings and omit all the mathematical proofs.

We first show that the firm gets the same profits for both policies (ML&VL). The reason is that the firm always requires that the sharing amount to be the same as the learning amount. Hence, there is no difference as to the firm's optimal profit for two policies. Because the payment to each worker including rewards can be expressed as the difference between a worker's expected payoff and his total costs, workers' individual-rationality constraints are always satisfied if the firm can design a contract such that each worker's expected payoff is zero if his knowledge level is zero. Based on this characterization, we demonstrate that the optimal effort levels and the amount to share or learn for the workers can be obtained. Then, the next problem is to induce workers to exert the same efforts and share or learn the same amount as desired by the firm. We demonstrate that a simple payment structure, linear in output x, and a simple sharing and learning structure, linear in the amount being shared and learned, are optimal under some broad conditions. We study the role of the linear payment and reward structures from three aspects: inducing workers to truthfully report their knowledge levels, achieving knowledge-sharing/learning alignment, and enabling full-knowledge transfer.

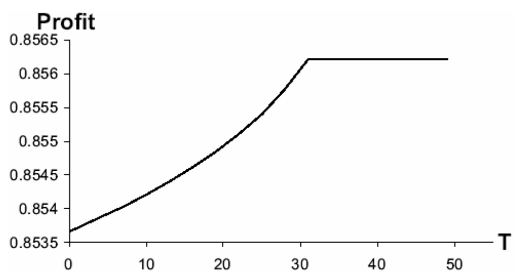

Figure 2. The firm's expect profit vs. IT level *T*

We next turn to examine the role of information systems in facilitating knowledge transfer. We show that when the level of information technology T increases, the firm's profit increases as well (Figure 2) and there exits a threshold T^C (as shown in Figure 3) beyond which complete-knowledge enablement is achieved, leading to a high-performance team. We also investigate the relationship between the level of information systems and the adoption of different knowledge-transfer policies. In Figure 3, we show the knowledge-transfer policies (ML&VL) that can be implemented for different level of information systems. When the level of information systems is high enough ($T \geq T^C$) to facilitate complete-knowledge enablement, VL policy can be adopted. In contrast, when the level of information systems is within the threshold T^C, firms have to use ML policy to mandate workers to learn so that truthful report of knowledge levels, knowledge-sharing/learning alignment, and full-knowledge transfer can be achieved.

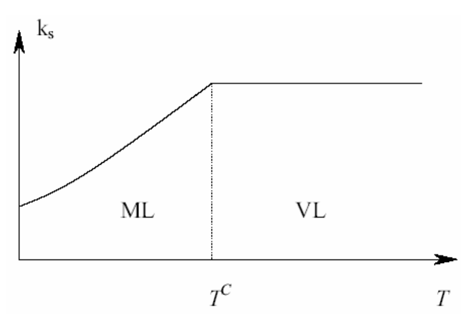

Figure 3. A firm's IT level *T* with different policies

SUMMARY

In this paper, we study the impact of information technologies and incentives on knowledge sharing and learning in organizations. We demonstrate how to design an appropriate incentive system to induce workers to share knowledge and learn and exert best efforts. We also analyze the necessary information technology level for a firm to achieve complete-knowledge enablement. We are currently exploring the design of knowledge-sharing incentives in conjunction with IT investment. We would like to fully investigate the tradeoff between incentives and information technologies in facilitating knowledge sharing and learning.

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