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Organizational culture and knowledge sharing: design of incentives and business processes

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Abstract

Purpose: We present and study an analytical model of knowledge management (KM) in which employees' fit with a firm's organizational culture improves with their sharing and learning of the firm's common organizational practices.
Design/methodology/approach: Incentive rewards motivate knowledge workers to share their knowledge and contribute to a firm's central knowledge base. We develop a model in which the firm's cultural fit changes with the sequence of KM-based business processes including sharing, learning, evaluation, and production, and then analytically investigate the design of knowledge sharing rewards as well as the business process sequence to shape a firm's organizational cultural fit and maximize its profit.
Findings: The best sequence of KM processes is solved in the following order: *A* (Announcement), *E* (Evaluation), *S* (Sharing), *L* (Learning), and *P* (Production). The sharing reward for knowledge workers is analytically derived accordingly, which increases with the level of knowledge management systems (KMS) and decreases with the probability of a worker staying in the firm, the probability of a culturally unfit worker being identified by the firm, and the probability of a worker being culturally fit on the labor market. The optimal volume of knowledge base is also investigated with respect to these factors.
Originality/value: Applying a novel analytical approach, we model and study KM processes and their relationships with organizational culture and incentives. Our research provides valuable insights for managers to implement KM practices.

Key words: business process; incentives; information technology; knowledge management; knowledge sharing; organizational culture.

1. Introduction

Knowledge may be interpreted from a process perspective, which emphasizes knowledge management (KM) as the management of knowledge flows and the corresponding iterative and interactive processes of creation, storage, transfer, and application of knowledge. During KM processes, information technology plays a crucial role in growing and managing organizational knowledge. For instance, information technology helps establish communities of practice (Baird and Henderson 2001, Pan et al. 2015) and supports the development of effective knowledge markets within organizations (Davenport and Prusak 1998, Zhang and Jasimuddin 2012). The digital economy has brought KM many new opportunities by refining its processes with the emerging technologies. For instance, the recent development of social software enables knowledge workers to easily collaborate and exchange information and knowledge (Hemsleya and Masona 2013). Cloud-based technologies allow organizations to capture, store, and retrieve valuable information and knowledge with low costs. XML-based data structures and web services facilitate knowledge codification and extraction within organizations. These latest technologies have significantly extended the landscape of traditional KM and simplified the ways for knowledge workers to participate in organizations' KM initiatives.

However, technology is only one of the many factors affecting the performance of KM initiatives. Many other factors also play important roles in KM activities such as learning capacity (Simonin 1999, Peltokorpi 2016), perceivable organizational support (Wayne, Shore, and Liden 1997, Kim, Eisenberger, and Baik 2016), innovative working behavior (Janssen 2000, Tu and Lu 2013), social status (Thomas-Hunt, Ogden, and Neale 2003, Beck, Pahlke, and Seebach 2014), value of knowledge (Cummings 2004, Pacharapha and Ractham 2012), and participation inequality and conversational interactivity (Kuk 2006, Lai and Chen 2014). Among all the factors, a supporting organizational culture is crucial to motivate knowledge workers to contribute their knowledge in an organization (Davenport and Prusak 1998, Jarvenpaa and Staples 2000, Jasimuddin and Zhang 2013). Organization culture is often considered as “a system of shared values and norms that define appropriate attitudes and behaviors for its members (Tushman and O‘Reilly 2002)”, which may facilitate or inhibit some of the KM processes. For instance, a culture suffering from knowledge hoarding, apprehension about failures, and the “Not-invented-here” syndromes inhibits knowsledge sharing and capture (Michailova and Husted 2001). Incentives that motivate KM efforts and activities can help relieve such syndromes, leading to a KM-friendly culture (Szulanski 1996, Chang and Lin 2015); therefore, organizations need to offer incentives to motivate workers’ participation in KM processes.

Although prior research in KM has pointed out the essential role of organizational culture, incentives, and information technology, very few studies have incorporated the dimension of business processes into a combined framework of organizational culture and KM. Our study addresses this gap by exploring an analytical model of KM in which employees’ fit with a firm’s organizational culture improves with their sharing and learning of the firm’s common organizational practices.

Specifically, we study the following questions in this research. First, how can incentives be designed to motivate knowledge sharing so that organizational culture can be improved and organizational benefits maximized? Second, what is the best sequence of KM-based business processes including sharing, learning, evaluation, and production? Third, what is the inter-relationship among organizational culture, incentives, and business processes in enabling knowledge sharing and learning and achieving best organizational benefit? Fourth, under the best sequence of KM processes and optimally designed reward for knowledge sharing, how does the firm’s knowledge base change with some of the crucial factors in the workforce?

To address the above research questions, the paper uses a novel approach to analytically incorporate the major KM processes into the production setting of a firm. In our framework, we consider that incentive rewards motivate knowledge workers to share their knowledge and contribute to a firm's central knowledge base. In addition, the firm's cultural fit changes with the order of executing the KM processes including sharing, learning, evaluation, and production. Therefore, the firm's decision problem is to choose the best KM process sequence and design the knowledge sharing reward accordingly so as to promote the firm's organizational cultural fit and maximize its profit.

The rest of the paper proceeds as follows. Next section reviews related literature. The third section presents our model of KM and organization culture. The fourth section details our analysis. The last section concludes the paper.

2. Related Literature

This section reviews prior literature with a focus on three streams of KM research: (1) KM and organizational culture, (2) obstacles and incentives for knowledge sharing, and (3) the processes of KM, and then highlights the contribution of our research.

Many studies have examined the inter-relationships between organizational culture and KM. For instance, Park, Ribiere, and Schulte (2004) summarize the culture-based organizational attributes that can facilitate knowledge sharing and the implementation of KM technology. Lemken, Kahler, and Rittenbruch (2000) suggest that a culture that promotes knowledge sharing help organizations remain competitive and adaptive to changing environments. Donate and Guadmillas (2010) argue that organizational cultures have disparate effects for firms implementing different KM initiatives to store and transfer internal knowledge. Alavi, Kayworth, and Leidner (2006) explore the influence of organizational cultures on how KM technologies are used. In a related study, Leidner, Alavi, and Kayworth

(2006) investigate how organizational cultures affect two KM approaches (organizing communities and KM processes) and propose that culture-based knowledge initiatives may result in different outcomes. Jasimuddin and Zhang (2013) recommend the use of a symbiosis strategy to simplify knowledge replication within a company and inhibit the imitation of its competitors. However, prior research in this stream has not explicitly included and studied the role of incentives in KM in association with organizational cultures.

Incentive is considered as an important element in facilitating knowledge sharing and learning (Argote, McEvily, and Reagans 2003, Ba, Stallaert, and Whinston 2001) due to three types of obstacles (individual/personal, organizational, and technological) for knowledge sharing (Riege 2005) with examples such as apprehension about failures (Hutchings and Michailova 2004), knowledge base compatibility (Ho and Ganesan 2013), cost of imitation and its inherent fuzziness (Cao and Xiang 2012), cross-cultural barriers (Ray 2014), and knowledge hoarding (Welschen, Todorova, and Mills 2012). Recent research continues to explore the role of incentives in knowledge management within organizations. For instance, Lee and Ahn (2007) analyze the design of a knowledge sharing reward system and compare the effects between an individual-based and a group-based reward system. Lam and Lambermont-Ford (2010) find that knowledge sharing may be encouraged through normative motivation in combination with hedonic motivation in the format of extrinsic incentives. Hung, Durcikovab, Lai, and Lin (2011) study the effects of both intrinsic and extrinsic motivation on knowledge sharing and show that reputation feedback supports successful knowledge sharing in a knowledge management system (KMS). Hu and Randel (2014) investigate two mechanisms facilitating knowledge sharing: social capital and extrinsic incentives, which are related to tacit and explicit knowledge sharing. Sundaresan and Zhang (2016) explore the combined role of incentives and information systems in knowledge sharing and learning in organizations. However, none of these studies have incorporated the dimension of KM processes in their frameworks.

The third stream of research considers KM as a series of processes and explores the ways to effectively manage and take advantage of these processes. For example, analyzing qualitative data using the grounded theory approach, Mishra and Bhaskar (2011) identify four themes of KM process: knowledge creation, knowledge sharing, knowledge upgrade, and knowledge retention and propose two concepts: knowledge enablers and knowledge inhibitors. Marra, Ho, and Edwards (2012) summarize the main approaches of KM processes and detect a strong positive impact of KM processes on organizational performance. To analyze the role of KM for innovation in organizations, Xu, et al. (2010) propose a model that integrates the macro processes of KM and then uses a hierarchical model to propel the process of continuous innovation. However, these studies have not incorporated the issues of incentives into the framework of KM processes.

In summary, prior research has not explicitly studied the design of incentives and the process of KM against the backdrop of organizational culture. We investigate these important issues in our research through extending the model of organizational culture fit by Carrillo and Gromb (1999), which has been recently applied in studying various aspects of KM issues such as personal knowledge management (Zhang, 2009), social software strategy (Zhang, 2012), and information security awareness (Lyu and Zhang, 2015). In particular, we model incentives and information technology as the facilitator of KM-related business processes in a firm. Hence, the firm seeks the best design of incentives and business processes to leverage its internal knowledge assets to increase organizational cultural fit so as to maximize its organizational benefit.

3. Model

In this section, we present an analytical model of KM and organizational culture. We first outline the business setting of our model and then show the organizational decision problem.

We consider a model in which a firm chooses the best design of incentives and business processes to complement its existing KMS to facilitate knowledge sharing and learning within organizations to maximize its organizational profit. The major component of the KMS is a centralized knowledge base that stores organizational information and knowledge. We use T to denote the level of KMS supporting knowledge sharing and learning. When the firm's KMS for knowledge sharing is more advanced, it will be easier for workers to codify and contribute their knowledge to the knowledge base as well as learn and align themselves with the firm's organizational culture.

We next describe the business setting of the model, in which the firm operates for a single period with several stages. We normalize the total number of workers in the firm to be one. At the beginning, there are τ_0 percent of the workers who are aligned ("fit") with the firm's current organization culture, which is the same as those on the job market. We define the firm's organizational culture fit as the proportion of the culturally fit workers in the organization. Thus, the firm's cultural fit at the beginning is τ_0. Within the entire period, workers generate an output P_H when they fit the culture and $P_L = P_H - D$ otherwise. All the workers (both the fit and unfit) will get a fixed wage payment w in each period. We assume that the output produced by each worker is always greater than the wage payment (i.e., $P_L > w$). To model the dynamic changes in the pool of workers, we consider that each worker may voluntarily leave the firm with the probability λ. In addition, the firm evaluates workers; with the probability γ, those who are not fit will be identified and replaced with new hires from the labor market.

The firm announces a linear knowledge-sharing reward r to motivate the knowledge contribution from culturally fit workers. The incentive rewards a worker's contribution to the knowledge base based on the amount of knowledge k_s shared by the worker and is applicable to all workers. The central knowledge base stores the valuable knowledge that can potentially improve the cultural fit of workers. Applying the concept proposed by Jasimuddin and Zhang (2013) in their model, we use $p_1(V,T)$ to represent KMPQ (KM performance quotient), the proportion of culturally unfit workers who learn and align themselves to the firm's current culture, in which $p_1(V,T)$ concavely increases in both V and T, implying that (1) when the volume of the knowledge base increases, more useful knowledge can facilitate workers' learning to help them become culturally fit, and (2) when the level T of the KMS is higher, workers will find it easier to search the knowledge base and obtain their desired knowledge. Note that the volume V of the knowledge base in KMPQ varies, depending on when the cultural unfit workers will learn from the knowledge base and become aligned with the organizational culture.

$C(k_s, T)$	worker's cost of sharing knowledge
Δ	difference of revenues between culturally fit and unfit workers
τ_0	probability of a worker being fit with the firm's culture on the labor market
τ_1	organizational cultural fit at the end of the period
τ_P^a	the number of culturally fit workers before they engage in productions when the activity sequence a is chosen from S
τ_S^a	the number of culturally fit workers available to contribute their knowledge to the central knowledge base when a is selected
γ	probability of a worker being identified as unfit and replaced
λ	probability of a worker staying in the firm
p_1	probability of a cultural unfit worker being transformed into a culturally fit worker
V_0	volume of knowledge base at the beginning of the period
V_1	volume of knowledge base at the end of the period
w	fixed wage payment for workers in each period
P_L	output from culturally unfit workers
P_H	output from culturally fit workers
π	the firm's total payoff
π_i	the payoff of a culturally-fit worker
r	the sharing reward
T	level of KMS

Table 1. Summary of Notation

During the process of knowledge sharing and learning, the total payoff that a culturally fit knowledge worker can obtain from knowledge sharing in each period will be

$$\pi_i = r \cdot k_s - C(k_s, T). \quad (1)$$

We assume that only culturally fit workers have the useful knowledge to share that improves the organizational culture. Knowledge shared by culturally unfit workers will not be rewarded as it does not help improve the organizational culture fit.

Based on the illustration of the business setting, we summarize the following KM processes in each period:

1. Announcement (A) — The firm announces its reward policy for knowledge sharing as well as its plan for activity sequence for the entire period.
2. Sharing (S) — Culturally fit workers document and share their knowledge to the knowledge base.
3. Learning (L) — Workers who are culturally unfit learn from the knowledge base to align themselves with the current organizational culture.
4. Production (P) — All workers engage in productions and generate outputs accordingly.
5. Evaluation (E) — The firm evaluates workers, trying to identify and replacing culturally unfit workers. All workers may voluntarily quit the firm. The diminished workforce is replenished from the current job market.

	Process Sequence						Process Sequence				
Options	1	2	3	4	5	Options	1	2	3	4	5
1	A	S	L	P	E	13	A	P	S	L	E
2	A	S	L	E	P	14	A	P	S	E	L
3	A	S	P	L	E	15	A	P	L	S	E
4	A	S	P	E	L	16	A	P	L	E	S

5	A	S	E	L	P	17	A	P	E	S	L
6	A	S	E	P	L	18	A	P	E	L	S
7	A	L	S	P	E	19	A	E	S	L	P
8	A	L	S	E	P	20	A	E	S	P	L
9	A	L	P	S	E	21	A	E	L	S	P
10	A	L	P	E	S	22	A	E	L	P	S
11	A	L	E	S	P	23	A	E	P	S	L
12	A	L	E	P	S	24	A	E	P	L	S

Table 2. The complete set S of process sequences

Among these processes, the process A will remain as the first one to start, whereas the firm can choose to rearrange the order of the other four processes. Table 2 summarizes all the available process sequences. These last four processes can be mapped to the traditional KM processes; the process S focuses on knowledge capture and codification, the process L represents the transfer of knowledge, the process E denotes the assessment of knowledge quality, and the process P symbolizes the application of knowledge.

To summarize, the firm's decision problem $[DP]$ is to choose the best KM process sequence a and the linear sharing reward r to maximize its total payoff. We use S to denote the complete set of activity sequence that the firm can choose (shown in Table 2), V_0 to symbolize the beginning volume of the knowledge base, τ_P^a to represent the number of culturally fit workers before they engage in productions when the activity sequence a is chosen from S, and τ_S^a to stand for the number of culturally fit workers available to contribute their knowledge to the central knowledge base when a is selected, so the volume of the knowledge base at the end of the entire period is

$$V_1 = V_0 + k_s \cdot \tau_S^a, \tag{2}$$

and the firm's problem $[DP]$ can be modeled as

$$\max_{a,r} \pi = P_L - w + \tau_P^a \cdot \Delta - \tau_S^a \cdot r \cdot k_s^*, \tag{3}$$

subject to

$$k_s^* = \underset{k_s}{argmax}\, \pi_i \tag{4}$$

$$\pi_i \geq 0 \tag{5}$$

$$a \in S, \tag{6}$$

where Constraint (4) is the incentive-compatibility constraint and Constraint (5) is the individual-rationality constraint. All the notations can be found in Table 1.

4. Analysis and Discussion

This section details the analytical results of our model and their managerial insights. Beginning with exploring an individual worker's optimal decision on knowledge sharing, we then analyze the firm's organizational culture fit at three different stages, the best design of KM process sequence and sharing reward, and the volume of the central knowledge base for the optimal process sequence and reward.

We first investigate the optimal decision made by an individual knowledge worker. The following lemma demonstrates an individual worker's optimal amount of knowledge to share and how it changes with the level of the KMS and the reward for knowledge sharing.

Lemma 1. *A worker chooses the amount of knowledge* k_s^* *to share such that*

$$r = \partial C(k_s^*, T)/\partial k_s,$$

where k_s^* *increases with the level of KMS and the amount of reward for knowledge sharing.*

Proof. Please see Appendix A. ■

As the building block to further analyze the firm's decision problem, Lemma 1 specifies the optimal amount of knowledge that will be shared by each knowledge worker given the level T of the KMS and the sharing reward r from the firm. Intuitively, when the firm provides a higher level of IT support and offers more reward for knowledge sharing, workers will share more knowledge. Next, we study how the firm should determine the best KM process sequence and the incentive reward for knowledge sharing so as to achieve its maximal payoff.

1. Organizational cultural fit

We investigate the firm's organizational cultural fit at three different stages: before process S, before process P, and at the end of the entire period. As the objective function in problem $[DP]$ shows, the firm needs to offer sharing rewards to culturally fit workers to motive them to share knowledge to the central knowledge base and the culturally fit workers will be able to generate an output at a higher level; therefore, we are interested in the firm's cultural fit (the number of culturally fit workers) before process S and P for a chosen process sequence a. In addition, we will also study how the firm's cultural fit changes at the end of the entire period for different process sequences.

We use the first option of process sequences as an example to illustrate the firm's culturally fit at three stages and then extend our analysis to all the options of process sequences in Table 2. The first option of process sequences in Table 2 demonstrates the following order of processes: A, S, L, P, E. The percentage of culturally fit workers who are able to contribute to the knowledge base is equal to the organizational cultural fit at the beginning of the entire period, which is $\tau_S^{a=1} = \tau_0$ and the firm's cultural fit before the process P is $\tau_P^{a=1} = \tau_0 + (1-\tau_0) \cdot p_1$ as the cultural unfit workers will be able to align themselves with the current culture through learning. At the end of the entire period, when the process L is before E, the organization's cultural fit is

$$\begin{aligned}\tau_1^{a=1} &= \tau_1^{LE}\\ &= [\tau_0+(1-\tau_0)p_1]\cdot\lambda+\{(1-\tau_0)(1-p_1)(1-\lambda)+(1-\tau_0)(1-p_1)\cdot\lambda\cdot\gamma\\ &\quad+[\tau_0+(1-\tau_0)p_1]\cdot(1-\lambda)\}\cdot\tau_0\\ &= \lambda\cdot(1-p_1)\cdot(1-\gamma\cdot\tau_0)\cdot\tau_0+[1-\lambda+\lambda\cdot\gamma\cdot(1-p_1)]\cdot\tau_0+\lambda\cdot p_1,\end{aligned}$$

where p_1 is the KMPQ that parameterized with V_1 and T. The term $[\tau_0+(1-\tau_0)p_1]\cdot\lambda$ stands for the number of culturally fit workers who continue to remain in the firm, including those cultural unfit workers that have been converted into fit ones, the term $(1-\tau_0)(1-p_1)(1-\lambda)$ denotes the number of workers who remain as cultural unfit and eventually quit the firm, the term $(1-\tau_0)(1-p_1)\cdot\lambda\cdot\gamma$ represents the number of culturally unfit workers who want to stay in the firm, but have to leave because of being identified as culturally unfit, and the last term $[\tau_0+(1-\tau_0)p_1]\cdot(1-\lambda)$ corresponds to the number of the culturally fit workers who quit the firm. Those workers who leave the firm, either voluntarily or involuntarily, will be replenished from the labor market with the probability τ_0 of being culturally congruent with the current culture.

When the process S is executed after L, cultural unfit workers will learn from the knowledge base with an original volume V_0 before the contribution from culturally fit workers. Therefore, the KMPQ is now $p_1' = p_1'(V_0,T)$, so the firm's cultural fit may also be different for all the three stages. For instance, when $a=7$,

$$\begin{aligned}\tau_S^{a=7} &= \tau_0+(1-\tau_0)\cdot p_1',\\ \tau_P^{a=7} &= \tau_0+(1-\tau_0)\cdot p_1',\\ \tau_1^{a=7} &= \tau_1^{LE'} = \tau_0+(1-\tau_0)\cdot p_1'\\ &= \lambda\cdot(1-p_1')\cdot(1-\gamma\cdot\tau_0)\cdot\tau_0+[1-\lambda+\lambda\cdot\gamma\cdot(1-p_1')]\cdot\tau_0+\lambda\cdot p_1'.\end{aligned}$$

We next analyze the case when the process E is finished before L. The firm's cultural fit after E finishes and before other remaining processes for any process sequence is

$$\tau_1^E = \tau_0 \cdot \lambda + [\tau_0 \cdot (1-\lambda) + (1-\tau_0) \cdot (1-\lambda) + (1-\tau_0) \cdot \lambda \cdot \gamma] \cdot \tau_0$$
$$= \tau_0 \cdot \lambda + [1-\lambda + (1-\tau_0) \cdot \lambda \cdot \gamma] \cdot \tau_0$$
$$= [1 + \lambda \cdot \gamma \cdot (1-\tau_0)] \cdot \tau_0,$$

and under this case when the process S is completed before L, the cultural fit at the end of the entire period is

$$\tau_1^{EL} = \tau_1^E + (1-\tau_1^E) \cdot p_1$$
$$= p_1 + (1-p_1) \cdot [1 + \lambda \cdot \gamma \cdot (1-\tau_0)] \cdot \tau_0.$$

Alternatively, when the process S finishes after L under this case, the final cultural fit will be

$$\tau_1^{EL'} = p_1' + (1-p_1') \cdot [1 + \lambda \cdot \gamma \cdot (1-\tau_0)] \cdot \tau_0,$$

where $p_1' = p_1'(V_0, T)$. The following proposition compares the firm's cultural fit at the end of the period when E executes before L and that when E finishes after L.

	The Cultural Fit		
Options	Before S: τ_S^a	Before P: τ_P^a	At the end: τ_1^a
1	τ_0	$\tau_0 + (1-\tau_0) \cdot p_1$	τ_1^{LE}
2	τ_0	τ_1^{LE}	τ_1^{LE}
3	τ_0	τ_0	τ_1^{LE}
4	τ_0	τ_0	τ_1^{EL}
5	τ_0	τ_1^{EL}	τ_1^{EL}
6	τ_0	τ_1^{E}	τ_1^{EL}
7	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$
8	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$	$\tau_1^{LE'}$
9	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$
10	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$
11	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$	$\tau_1^{LE'}$
12	$\tau_0 + (1-\tau_0) \cdot p_1'$	$\tau_1^{LE'}$	$\tau_1^{LE'}$
13	τ_0	τ_0	τ_1^{LE}
14	τ_0	τ_0	τ_1^{EL}
15	$\tau_0 + (1-\tau_0) \cdot p_1'$	τ_0	$\tau_1^{LE'}$

16	$\tau_1^{LE'}$	τ_0	$\tau_1^{LE'}$
17	τ_1^{E}	τ_0	τ_1^{EL}
18	$\tau_1^{EL'}$	τ_0	$\tau_1^{EL'}$
19	τ_1^{E}	τ_1^{EL}	τ_1^{EL}
20	τ_1^{E}	τ_1^{E}	τ_1^{EL}
21	$\tau_1^{EL'}$	$\tau_1^{EL'}$	$\tau_1^{EL'}$
22	$\tau_1^{EL'}$	$\tau_1^{EL'}$	$\tau_1^{EL'}$
23	τ_1^{E}	τ_1^{E}	τ_1^{EL}
24	τ_1^{E}	τ_1^{EL}	$\tau_1^{EL'}$

Table 3. The cultural fit for different process sequences

Proposition 2. *The firm's cultural fit at the end of the entire period is higher when the process E is executed before L than that when E starts after L finishes.*

Proof. Please see Appendix B. ■

Proposition 2 shows that the firm can increase the total percentage of cultural fit workers at the end of the entire period by evaluating workers before they engage in learning activities from the central knowledge base. By executing the evaluation process first, the firm allows workers to choose whether they will continue to work for it and cultural unfit workers will be substituted from the workforce if they are identified. When the firm completes the evaluation process before its workers' training and learning, it can stabilize its organizational culture as workers who are culturally unfit and later converted into fit ones through training and learning will all continue to stay in the firm.

We continue to investigate how the firm's cultural fit at the end of the entire period changes with the major parameters in the model. Next proposition summarizes our findings.

Proposition 3. *The firm's cultural fit τ_1 at the end of the entire period increases with p_1*

(or $p_1^{'}$*),* λ*, and* γ*.*

Proof. Please see Appendix C. ■

Proposition 3 shows that the firm's cultural fit τ_1 at the end of the entire period increases with the KMPQ, the proportion p_1 (or $p_1^{'}$) of culturally unfit workers being transformed to culturally fit workers, the probability λ of workers staying in the firm, and the probability γ of the firm identifying a cultural unfit worker.

2. Best KM process sequence and sharing reward

Following our analysis about the firm's cultural fit at three stages, we next investigate the best KM process sequence the firm should choose to maximize its payoff.

When $p_1^{'} = p_1^{'}(V_0, T)$ is based on V_0, $p_1^{'}$ is not related to the sharing amount k_s. Therefore, when the learning is based on the original volume V_0 of the knowledge base, the firm will not benefit from the knowledge sharing activities for its production process. In other words, when the learning process L takes place before the sharing process S, knowledge sharing will not benefit the production process P. Hence, the firm should not offer any sharing rewards in this situation.

For ease of analysis, we next focus on specific functional forms of the sharing cost and KMPQ function. Specifically, we consider a sharing cost function as $c(k_s, T) = \delta \cdot k_s^2 / T$, where δ is the sharing cost coefficient. In addition, we assume that $p_1(V_1, T) = \mu \cdot V_1 \cdot T$. Based on these functional forms, the following proposition shows the best process sequence for the firm.

Proposition 4. *When* $c(k_s, T) = \delta \cdot k_s^2 / T$ *and* $p_1(V_1, T) = \mu \cdot V_1 \cdot T$*, the best process* *sequence is* $a = 19$ *from Table 2, i.e., the firm will achieve a highest payoff when all the processes are executed in the following order:* A, E, S, L, P.

Proof. Please see Appendix D. ■

Proposition 4 is related to our discussion for Proposition 2, where we show that it is better for the firm to execute process E before L to improve its overall cultural fit. In addition, Proposition D implies that the firm will be better off by completing the process S before L; otherwise, culturally unfit workers will not benefit from the knowledge shared by culturally fit workers to the central knowledge base, which will eventually result in fewer culturally fit workers. The production process should be the last one to finish after workers have completed the sharing and learning activities.

Following upon the best KM process sequence, we next analyze the optimal sharing reward for workers. The following proposition derives the closed form of the optimal sharing reward based on our assumed functional forms of sharing cost and KMPQ functions.

Proposition 5. *Based on the best process sequence (* A, E, S, L, P*), when* $c(k_s, T) = \delta \cdot k_s^2 / T$ *and* $p_1(V_1, T) = \mu \cdot V_1 \cdot T$*, the optimal sharing reward* r^* *can be derived as*

$$r^* = [1 - \tau_0 - \lambda \cdot \gamma \cdot (1 - \tau_0) \cdot \tau_0] \cdot \mu \cdot \frac{T}{2} \cdot \Delta,$$

which decreases with λ, γ*, and* τ_0*, and increases with* T.

Proof. Please see Appendix E. ■

Proposition 5 shows the optimal design of the sharing reward for the best KM process sequence (A, E, S, L, P) and how it changes with several important factors.

Proposition 5 suggests that the firm can reduce its sharing reward when more workers will remain in the firm, the initial cultural fit is higher, and it is more likely to identify culturally unfit workers. Interestingly, the firm should increase the amount of sharing reward when the level of KMS is higher to support sharing and learning, which is mainly due to the fact that the KMPQ p_1 and the volume of the knowledge base both increase in T. When the level of the KMS is higher, the firm would like to take advantage of the better system by offering a higher reward to motivating workers to contribute more knowledge to the system.

Next, we discuss how the process sequence and sharing reward affect the firm's central knowledge base. Based on the best process sequence and the optimal sharing reward from Proposition 4 and 5, the firm's volume of knowledge base at the end of the entire period is

$$V_1 = V_0 + (1-\tau_1^E)\cdot\tau_1^E\cdot\mu\cdot\Delta\cdot\frac{T^2}{4\delta},$$

which exhibits some special properties summarized in the following proposition.

Proposition 6. *Based on the best KM process sequence (A, E, S, L, P), when* $c(k_s,T)=\delta\cdot k_s^2/T$ *and* $p_1(V_1,T)=\mu\cdot V_1\cdot T$, *the optimal volume of the knowledge base always increases with* T, *but increases with* λ *and* γ *when* $\tau_1^E<1/2$, *and decreases with* λ *and* γ *when* $\tau_1^E>1/2$.

Proof. Please see Appendix F. ■

Proposition 6 demonstrates how the firm's optimal volume of knowledge base changes with the major parameters in our model. Specifically, the optimal volume of knowledge base always increases with the level of the KMS supporting knowledge sharing and learning. In addition, when more than half of the workforce is able to contribute to the knowledge base, the optimal volume of the knowledge base will decrease with the probability of workers staying in the firm, the likelihood of identifying a culturally unfit worker, and the initial organizational cultural fit. However, when less than half of the workers are culturally fit before the firm executes the sharing process, the optimal volume of the knowledge base will increase with these three parameters (λ, γ, τ_0).

Finally, we summarize the major results that we have derived from our model and presented in the previous propositions. Table 4 synthesizes the analytical model with respect to its objective function, decision variables, and constraints as well as the derived results from the following four aspects: organizational cultural fit, process sequence, sharing reward, and the volume of KMS.

Model	
Objective function	The firm's total payoff
Decision variables	A specific sequence of processes, knowledge-sharing reward
Constraints	Individual compatibility constraint Individual rationality constraint Process constraint
Results	
Organizational cultural fit	• The firm's cultural fit at the end of the entire period is higher when the process of evaluation is executed before learning than that when evaluation starts after learning finishes. • The firm's cultural fit at the end of the entire period increases with KMPQ, the probability of workers staying in the firm, and the probability of a culturally unfit workers being identified and replaced.
Process sequence	The firm will achieve a highest payoff when all the processes are executed in the following order: A, E, S, L, P.
Sharing reward	The optimal sharing reward decreases with the probability of workers staying in the firm, the probability of a culturally unfit workers being identified and replaced, and the initial organizational cultural fit, and increases with the level of KMS.
Volume of KMS	• The optimal volume of knowledge base increases with the level of the KMS. • When more than half of the workers are culturally fit, the optimal volume of the knowledge base will decrease with the probability of workers staying in the firm, the probability of identifying and replacing a cultural unfit worker, and the initial organizational cultural fit. • When less than half of the workers are culturally fit, the optimal volume of the knowledge base will increase with

	the probability of workers staying in the firm, the probability of identifying and replacing a cultural unfit worker, and the initial organizational cultural fit.

Table 4: Summary of Model and Results

5. Conclusion

In this paper, we present a formal analytical KM model capturing the interactions between IT, incentives, and organizational culture from a process perspective, and develop valuable insights for practitioners to effectively manage knowledge assets.

Prior studies have investigated the critical role of IT, incentives, and organization culture in facilitating specific aspects of KM, but they have not considered the joint interactions among these three elements in combination with the role of business processes for knowledge management. We incorporate their inter-relationships in our model and investigate the best design of KM business process sequence and knowledge sharing reward. Specifically, our research makes the following contribution to the current literature.

First, we model four major business processes related to KM activities and analyze how the order of these processes affect the firm's cultural fit at different stages. The four processes in our framework including sharing (*S*), learning (*L*), evaluation (*E*), and production (*P*). The sharing process focuses on knowledge capture and codification, learning process represents the transfer of knowledge, evaluation process denotes the assessment of knowledge quality, and production process symbolizes the application of knowledge. Our analysis indicates that different orders of these KM processes result in different organizational cultural fit for workers to engage in knowledge sharing and productions. When the evaluation process is executed before learning process, there will be more culturally fit workers at the end of the period.

Second, we analytically derive the best sequence of KM process and the sharing reward for knowledge workers. Our results show that the firm can achieve its maximal payoff by pursuing the following order of KM processes: A, E, S, L, P, and designing its sharing reward accordingly. We show that the optimal sharing reward increases with the likelihood of workers staying in the firm, the probability of the firm identifying a culturally unfit workers, and its initial organizational cultural fit. In particular, we find that a higher level of KMS requires the firm to supplement it with a higher sharing reward for workers.

Third, we study the knowledge base under the best design of the KM process sequence and sharing reward. We demonstrate that the optimal volume of the knowledge base increases with the level of the KMS. However, only when there are less than half of culturally fit workers in the firm will the optimal volume of the knowledge base increase with the probability of workers staying in the firm and that of the firm identifying a culturally unfit worker. If more than half of the workers are culturally fit, the optimal volume of the knowledge base will decrease with these two probabilities.

Despite the above contribution of our paper, we have to acknowledge that our results are based on some assumptions, which may not be very generic. For instance, we assume that the culturally fit workers will all share the same amount of knowledge to the knowledge base. More realistically, workers' knowledge levels are heterogeneous and thus may result in different amounts and types of knowledge being shared. We also use specific functional forms in deriving some of the analytical results for convenience. It would have been more convincing if the results are based on the general forms of functions. In addition, it is not a realistic practice assumed by our model that culturally unfit workers identified by the firm will be fired. Future research may extend some of these limitations to generate more meaningful results and insights. For instance, it will be worthwhile to explore the best practices to deal with culturally unfit workers in different organizational settings. Finally, our analytical model results are only explored at the theoretical level; it would be interesting to put them into practice to collect empirical evidence to further corroborate their usefulness.

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Appendix

A. Proof of Lemma 1

Proof. An individual knowledge worker chooses the best amount k_s^* of knowledge to share to maximize her payoff shown in Equation (1). Hence, the first order condition of Equation (1) shows that

$$r = \partial C(k_s, T)/\partial k_s.$$

When the level of IT infrastructure increases, the cost of sharing knowledge decreases, so does $\partial c(k_s, T)/\partial k_s$. Therefore, the optimal amount k_s^* of knowledge shared increases. When there is more reward for sharing the same amount of knowledge, r increases. Therefore, k_s^* increases as well. ■

B. Proof of Proposition 2

Proof. The difference between τ_1^{EL} and τ_1^{LE} is

$$\tau_1^{EL} - \tau_1^{LE} = p_1 \cdot (1-\lambda) \cdot (1-\tau_0) + \lambda \cdot \gamma \cdot \tau_0 \cdot \tau_0 \cdot (1-\lambda) \cdot (1-p_1) > 0.$$

Therefore, the firm's cultural fit is higher if the process of E is executed before L. ■

C. Proof of Proposition 3

Proof. Depending a specific chose process sequence a, the firm's final cultural fit can be τ_1^{LE}, $\tau_1^{LE'}$, τ_1^{EL}, or $\tau_1^{EL'}$. The first-order derivative of τ_1^{EL}, (or $\tau_1^{EL'}$) with respect to p_1 (or

$p_1^{'}$), λ, and γ are all positive.

In addition, the first-order derivative of τ_1^{LE} (or $\tau_1^{LE'}$) with respect to p_1 (or $p_1^{'}$) is

$$\frac{\partial \tau_1^{LE}}{\partial p_1} = \frac{\partial \tau_1^{LE'}}{\partial p_1^{'}} = \lambda \cdot (1-\tau_0) \cdot (1-\gamma \cdot \tau_0) > 0,$$

the first-order derivative of τ_1^{LE} (or $\tau_1^{LE'}$) with respect to λ is

$$\frac{\partial \tau_1^{LE}}{\partial \lambda} = (1-\tau_0) \cdot [p_1 + (1-p_1) \cdot \gamma \cdot \tau_0] > 0,$$
$$\frac{\partial \tau_1^{LE'}}{\partial \lambda} = (1-\tau_0) \cdot [p_1^{'} + (1-p_1^{'}) \cdot \gamma \cdot \tau_0] > 0,$$

and the first-order derivative of τ_1^{LE} (or $\tau_1^{LE'}$) with respect to γ is

$$\frac{\partial \tau_1^{LE}}{\partial \gamma} = \lambda \cdot (1-\tau_0) \cdot (1-p_1) > 0,$$
$$\frac{\partial \tau_1^{LE'}}{\partial \gamma} = \lambda \cdot (1-\tau_0) \cdot (1-p_1^{'}) > 0,$$

which concludes the proof of the proposition. ■

D. Proof of Proposition 4

Proof. When $c(k_s, T) = \delta \cdot k_s^2/T$ and $p_1(V_1, T) = \mu \cdot V_1 \cdot T$, the first-order condition of an individual's payoff of knowledge sharing in Equation (1) yields that the best amount of knowledge shared by each individual is $k_s^* = r \cdot T/2\delta$, where an individual's net payoff is $r/2$. Therefore, replacing k_s with the best sharing amount k_s^* from knowledge workers, we can obtain $p_1(V_1, T) = \mu \cdot T \cdot (V_0 + r \cdot T \cdot \tau_S^a/2\delta)$. Thus, the firm's total payoff can be represented as

$$\pi = P_L - w + \tau_P^a \cdot \Delta - \tau_S^a \cdot \frac{r^2 \cdot T}{2\delta}.$$

For all the process sequences in which τ_P^a does not depend on r, the highest payoff the firm can achieve is when $\tau_P^a = \tau_1^{LE'}$, where $p_1^{'} = \mu \cdot T \cdot V_0$. This payoff is still less than what the firm can obtain when τ_P^a depends on r, for instance, when $\tau_P^a = \tau_1^{LE}$.

We next compare the firm's payoff for all the process sequences that change with r. The top three candidates of process sequences are $a = 2,5,$ and 19. The firm's payoff functions for these three sequences are

$$\pi^{a=2} = P_L - w + [(\lambda\gamma\tau_0(1-\tau_0)+\tau_0)+(\lambda-\lambda\tau_0(1-\gamma\tau_0)-\lambda\gamma)\mu T(V_0+\frac{rT\tau_0}{2\delta})]\cdot\Delta$$
$$-\tau_0\cdot\frac{r^2\cdot T}{2\delta},$$
$$\pi^{a=5} = P_L - w + [\tau_1^E + (1-\tau_1^E)\mu T(V_0+\frac{rT\tau_0}{2\delta})]\cdot\Delta - \tau_0\cdot\frac{r^2\cdot T}{2\delta}, \text{and}$$
$$\pi^{a=19} = P_L - w + [\tau_1^E + (1-\tau_1^E)\mu T(V_0+\frac{rT\tau_1^E}{2\delta})]\cdot\Delta - \tau_1^E\cdot\frac{r^2\cdot T}{2\delta}.$$

We map the above three functions to

$$\pi^{a=2} = -\alpha_2\cdot r^2 + \beta_2\cdot r + \gamma_2,$$
$$\pi^{a=5} = -\alpha_5\cdot r^2 + \beta_5\cdot r + \gamma_5, \text{and}$$
$$\pi^{a=19} = -\alpha_{19}\cdot r^2 + \beta_{19}\cdot r + \gamma_{19},$$

where $\gamma_{19} = \gamma_5 > \gamma_2$, $\beta_5 > \beta_2$, $\alpha_5 = \alpha_2$, $\beta_{19} > \beta_5$, $\alpha_{19} > \alpha_5$, and

$$\frac{\alpha_{19}}{\alpha_5} = \frac{\beta_{19}}{\beta_5} = \frac{\tau_1^E}{\tau_0}.$$

As we know, the firm achieves its highest payoff for these three process sequences as

$$\pi^{*a=2} = \frac{\beta_2^2}{4\alpha_2} + \gamma_2,$$
$$\pi^{*a=5} = \frac{\beta_5^2}{4\alpha_5} + \gamma_5, \text{and}$$
$$\pi^{*a=19} = \frac{\beta_{19}^2}{4\alpha_{19}} + \gamma_{19}.$$

Therefore, $a = 19$ from Table 2 is the best process sequence for the firm to maximize its total payoff. ■

E. Proof of Proposition 5

Proof. The firm's achieves its maximal payoff when $a = 19$, which is

$$\pi^{a=19} = P_L - w + [\tau_1^E + (1-\tau_1^E)\mu T(V_0 + \frac{rT\tau_1^E}{2\delta})] \cdot \Delta - \tau_1^E \cdot \frac{r^2 \cdot T}{2\delta}.$$

The first-order condition of $\pi^{a=19}$ with respect to r yields that

$$r = (1-\tau_1^E) \cdot \mu \cdot \frac{T}{2} \cdot \Delta$$
$$= [1 - \tau_0 - \lambda \cdot \gamma \cdot (1-\tau_0) \cdot \tau_0] \cdot \mu \cdot \frac{T}{2} \cdot \Delta.$$

The first-order derivative of r^* with respect to τ_0 is

$$\frac{\partial r^*}{\partial \tau_0} = -1 - \lambda \cdot \gamma + 2\lambda \cdot \gamma \cdot \tau_0$$
$$= -(1-\lambda \cdot \gamma \cdot \tau_0) - \lambda \cdot \gamma \cdot (1-\tau_0) < 0.$$

Therefore, when $\tau_0 > (1+\lambda \cdot \gamma)/2\lambda \cdot \gamma$, r^* decreases with τ_0. ■

F. Proof of Proposition 6

Proof. When the firm chooses the best process sequence (A, E, S, L, P) and sharing reward r^*,

$$V_1^* = V_0 + \frac{r^* T \tau_1^E}{2\delta}$$
$$= V_0 + (1-\tau_1^E) \cdot \tau_1^E \cdot \mu \cdot \Delta \cdot \frac{T^2}{4\delta}.$$

The first-order derivative of τ_1^E with respect to τ_0 is

$$\frac{\partial \tau_1^E}{\partial \tau_0} = 1 + \lambda \cdot \gamma \cdot (1-\tau_0) - \lambda \cdot \gamma \cdot \tau_0 > 0.$$

The first-order derivative of τ_1^E with respect to λ is

$$\frac{\partial \tau_1^E}{\partial \lambda} = \gamma \cdot (1-\tau_0)\cdot \tau_0 > 0.$$

The first-order derivative of τ_1^E with respect to γ is

$$\frac{\partial \tau_1^E}{\partial \gamma} = \lambda \cdot (1-\tau_0)\cdot \tau_0 > 0.$$

When $\tau_1^E < 1/2$, V_1^* increases with λ, γ, and τ_0. When $\tau_1^E > 1/2$, V_1^* decreases with λ, γ, and τ_0. ■