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Inter-Organizational Knowledge Development in IT Outsourcing

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ABSTRACT

To examine the effects of inter-organizational activities on knowledge development in IT outsourcing projects, we develop a research framework based on a knowledge-based view of organizations. Using this framework, we model the process of knowledge development and utilize simulation to generate various scenarios with different levels of inter-organizational activities. We evaluate the development of overall knowledge capabilities in those scenarios. The results indicate that knowledge development is a highly dynamic process, specifically in the inter-organizational settings. Even a marginal change in the level of inter-organizational activities can have significant effects on the abilities of the client and the outsourcing vendor to develop knowledge capabilities required for the project.

Keywords: IT Outsourcing; Knowledge Management; Simulation

INTRODUCTION

Organizations are increasingly outsourcing their information technology (IT) operations and systems development. Most IT outsourcing cases involve the transfer of not only IT assets and personnel but also knowledge assets and decision-making control (Choudhury and Sabherwal 2003; Elitzur and Wensley 2002). Therefore, understanding the process of exchanging the existing knowledge and creating new knowledge between the client and vendor during an IT outsourcing project is important. It can lead to more effective development of knowledge capabilities required for the project and greater project success (Elitzur and Wensley 2002; Lee and Kim 2005; Willcocks et al. 2004; Willcocks and Kern 1998).

In an IT outsourcing project, the vendor and client have their unique sets of knowledge. When these knowledge sets are complimentary to each other, they can provide significant benefits to the project. However, that requires understanding: What type of business and technology knowledge is needed for the project? Who, the vendor or the client, has that knowledge? Which part of that knowledge is tacit and which part is explicit? How do the vendor and client exchange this knowledge and use it to develop new knowledge? What are the factors, specifically organizational activities and structure, which may influence this knowledge exchange and creation process?

To address these research questions, we analyze the composition of knowledge in IT outsourcing projects. We decompose the knowledge development process and identify the most important inter-organizational activities that influence the efficiency of each of its components. We, then, build simulation studies to create and manipulate different business scenarios and examine the impact of these factors under those scenarios. The use of simulation to represent organizational settings and processes is popular, because it enforces internal consistency of the theory and uncovers theory's intuitively unobvious assumptions (Repenning 2002; Sastry 1997).

THEORETICAL BACKGROUND

In recent years, a knowledge-based view has emerged as an extension of the resource-based view, as knowledge assets possessed by a firm are considered critical resources (Conner 1991; Grant 1996). The knowledge-based view assumes that organizational efficiency and competence are consequences of the possession and use of unique knowledge. Using the knowledge-based view, Nonaka (1993) describes a three-layer framework for knowledge exchange and creation in organizations: Project-team layer, business-system layer, and knowledge-base layer. Members of the project team collaborate

to exchange and create project-related knowledge in the project-team layer under the overarching vision and objectives of the project. They then move down to the knowledge-base layer to document, re-categorize and re-contextualize the newly acquired knowledge. Finally, they return to their business-system layer, where they apply the knowledge relevant for their own business activities. The ability to move swiftly from one layer to another determines the organizational capability for knowledge creation. We use this theoretical framework to analyze knowledge in inter-organizational relationships such as IT outsourcing.

In information systems development process, knowledge is mainly composed of technical knowledge and business knowledge (Rus and Lindvall 2002). Technical knowledge refers to the knowledge about system design, programming, and development processes; while business knowledge refers to the knowledge about the intended user's business processes, business rules, and requirement for the new system. In IT outsourcing projects, business knowledge mainly comes from the client's experience in business issues and technical knowledge from vendors' experience in technical issues (Willcocks et al. 2004). The success of IT outsourcing is determined by the fit between total project knowledge requirements for both technical and business knowledge and the knowledge capabilities of the client and vendor (Willcocks et al. 2004). Tiwana (2003) empirically demonstrates that the knowledge overlap in both technical and business knowledge area across the client and vendor is very important in IT outsourcing. This means that we cannot assume that technical knowledge would come only from the vendor and business knowledge would come only from the client. Both the vendor and client may have specific sets of technical and business knowledge, which may even overlap. The effectiveness of the exchange of these knowledge sets and the creation of additional project-specific knowledge would determine the knowledge capabilities and eventually the outcome of the IT outsourcing project (Lee and Kim 2005). In addition, knowledge in two forms: explicit and tacit knowledge (Nonaka 1994). Explicit knowledge can be codified and transmitted in formal language. Software codes and standard operating procedures are examples of explicit knowledge. Tacit knowledge is abstract and rooted in action, communication and involvement in a specific context. Knowing how to normalize a database or how to design an IS are examples of tacit knowledge.

Nonaka (1994) proposed four modes of knowledge exchange and creation. The process of sharing tacit knowledge is called socialization. The process of integrating explicit knowledge is called combination. The process of converting tacit knowledge to explicit knowledge is called externalization. The process of converting explicit knowledge to tacit knowledge is called internalization. The first two processes refine and augment the original knowledge base in the same form. The last two processes contribute by creating a new form of knowledge. In IT outsourcing projects, these processes occur at inter-organizational level between the client and vendor.

RESEARCH FRAMEWORK

Based on the theoretical background discussed in the previous section, we develop a research framework (Figure 1) that outlines the four knowledge exchange and creation processes in inter-organizational settings and articulates activities—communication, coordination, organization culture, and documentation—that may influence these processes. Previous studies have indicated that external and internal environments influence knowledge processes (Hall 1997). Organizations adjust their structures, activities and resource allocations to fit their knowledge capabilities with the environment they face. How those adjustments may take place in IT outsourcing and their effects are discussed below.

Socialization and Communication

Nonaka (1994) refers to socialization as a process of sharing implicit experiences and creating tacit knowledge such as shared mental models and technical skill. In this tacit knowledge exchange process, different media offer different capabilities to exchange knowledge. Media richness theory (Daft and Lengel 1986) proposes a prescriptive model to achieve a fit between information processing requirement and communication channel to increase organizational effectiveness (Markus 1994). Daft and Lengel (1986) described the amount of information can facilitate the reduction of uncertainty and the structural mechanism can reduce equivocality. In many IT outsourcing cases, the client and vendor are geographically separated and various communications channels provide the basis for exchanging information. They type of media used can play an important role in this knowledge exchange process. Selection fit media is not only considering the congruently match for knowledge requirement but also the feasibility to increase the efficiency and effects.

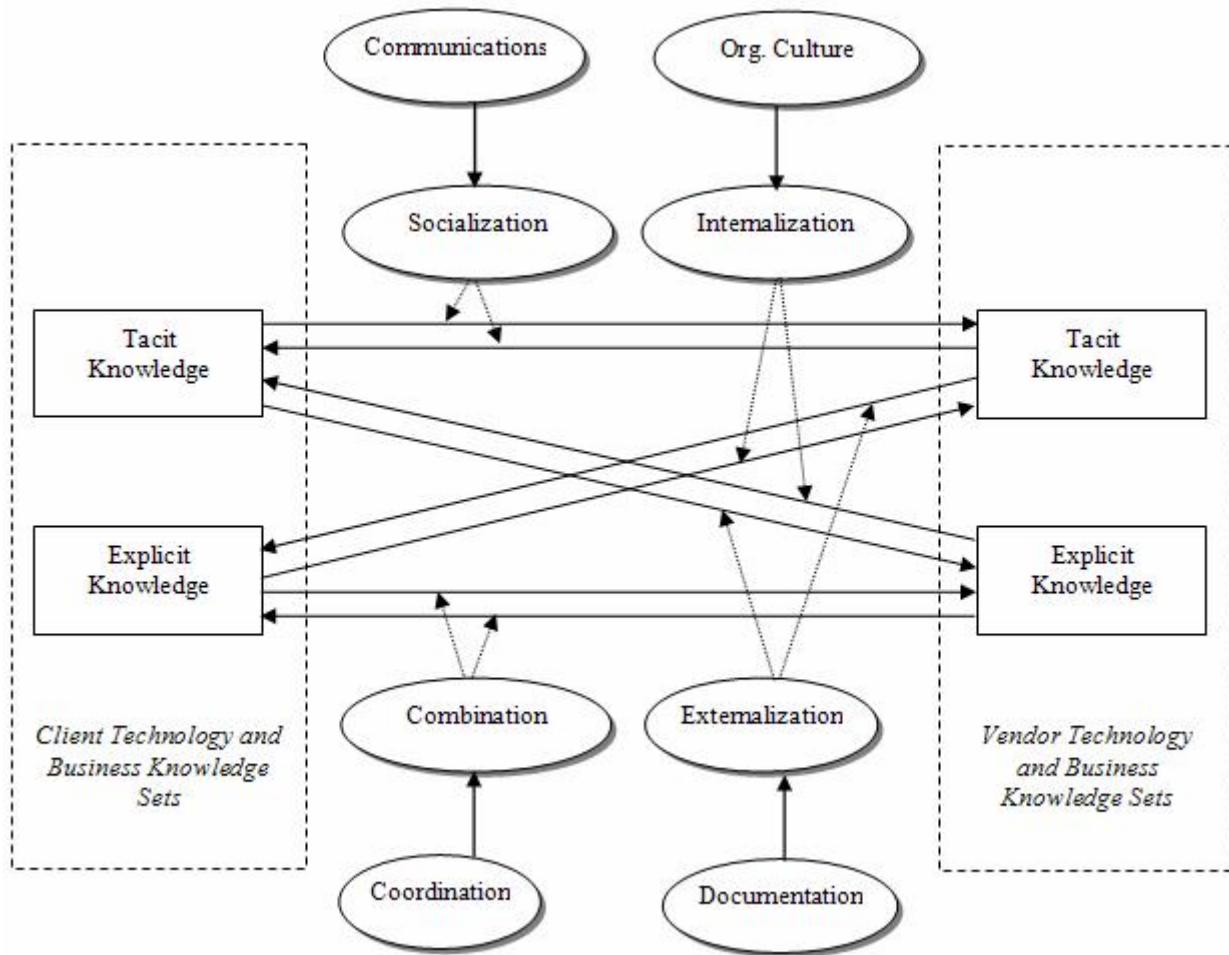


Figure 1: Research Framework

Externalization and Documentation

For tacit knowledge to become explicit knowledge, creation of documents, manual, and oral stories are very helpful (Nonaka and Konno 1993). It could help sort and collect individual knowledge, as knowledge is seen in very personal terms. As a consequence, it increases the access to knowledge in organization and reduces knowledge loss. In inter-organizational situations like IT outsourcing, knowledge documentation follows existing models or systems shared by the two organizations. Such collective documentation process will not only facilitate the emergence of a shared mental model, but also help inquiry and knowledge generation in future through synthesis. Knowledge gaps across the vendor and client organizations can be partly filled by externalization through documentation. The standard and sufficient documents which both vendor and user can accurately understand and access will help develop strong knowledge capabilities.

Combination and Coordination

Combination is the process of sorting, adding, comparing, combining, and categorizing explicit knowledge from various sources; in IT outsourcing, from the client and vendor. To effectively integrate various sources of knowledge in two organizations, coordination between them is necessary (Hall 1997). The level of coordination defines the degree to which the two organizations will cooperate. In IT outsourcing, coordination represents the cooperation between the client and vendor. Faraj and Sproull (2000) empirically illustrated that knowledge coordination was different from administrative coordination in IS software development projects. For vertical coordination, the structure is clearly pre-defined in the outsourcing contract. Depending on the structure of the contract, either the client or the vendor dominates the coordination process. Vertical coordination will guarantee effective exchange of knowledge. For horizontal coordination, the structure is rather it is loose and emergent. Hierarchical barriers are avoided to encourage better coordination among peers in both organizations. This

facilitates the knowledge exchange process at various levels within an IT outsourcing project. It is critical when knowledge required for the outsourcing is not clearly-defined and neither side has upper hand.

Internalization and Organizational Culture

Internalization means converting writings or other articulation of language into tacit knowledge. Here, the fundamental issues are related with individuals' mental models, beliefs, and cognitive assumptions (Nonaka and Konno 1993). Metaphors, analogies, and models act as bridges between objective knowledge and intuitive understanding (Nonaka 1994). Organizational or corporate culture includes "the values and beliefs expressed in artifacts, symbols and practices as well as organizational language, traditions, myths, rituals, and stories" (Zakaria et al. 2004, p.19). Organizational culture also refers to a value system of risk, reward, warmth, and support (James and Jones 1979). Organizational culture and climate, thus, provides the background for drawing metaphors, analogies, and models necessary for internalization and shape individuals' mental models, beliefs, and cognitive assumptions (Janz and Prasarnphanich 2003). In IT outsourcing, the degree of fit between organizational cultures of the client and vendor firms will determine the level of internalization of explicit knowledge gained from the other side.

KNOWLEDGE DEVELOPMENT PROCESS MODEL

Based on the discussion and research framework developed in the previous sections, we develop a process model that consists of two types of knowledge relevant for IT outsourcing: Business knowledge and technical knowledge. The total project-related knowledge can be represented as a weighted summation of these two types. The vendor and client have their own sets of tacit and explicit knowledge for each of business and technical knowledge. During IT outsourcing, they interact synergistically to exchange and create new knowledge. Therefore, we put this logical description as follows:

$$\begin{aligned} \text{Business Knowledge} &= \text{Tacit Business knowledge} + \text{Explicit Business Knowledge} \\ \text{Technical Knowledge} &= \text{Tacit Technical Knowledge} + \text{Explicit Technical Knowledge} \\ \text{Project-Related Knowledge} &= W_B (\text{weight}) * \text{Business Knowledge} \\ &\quad + W_H (\text{weight}) * \text{Technical Knowledge} \end{aligned}$$

Modeling Business Knowledge Exchange and Creation

Knowledge creation is a dynamic process, so it produces cycles or feedback loops over a period of time (Nonaka 1994). Time relates to the rate at which the knowledge is exchanged and new knowledge is created and the relative speed with which knowledge translation changes (Hall et al. 2001; Hu et al. 1997). We use (t) to represent the cycling time effect. At the start of the project, $t = 0$ (t_0) and at any later given point of time it is $t=T$. The detail index of parameters is given in Appendix A.

At the start of an IT outsourcing project, the vendor has some level of initial tacit business knowledge. We express it as $K_{V-t_0}^{BT}$. Now, as the project progresses, a part of the client's knowledge will start transferring to the vendor through one of the four knowledge exchange and creation processes. At the beginning of this process, the rate of transfer is small. However, as the two organizations' organizational activities synchronize the transfer rate will increase. Eventually, the translation rate will reach a maximum point and begin to stabilize. In the Nonaka's (1995) Spiral Development Model, organizational knowledge increases in amount and quality through a spiral shape, for which a sine function is well-suited. Therefore, we select a sine function to simulate this shifting of conversion rate over time.

During the IT outsourcing project, as discussed above, a part of the client's tacit business knowledge ($K_{F-t_0}^{BT}$) gets transferred to the vendor through the socialization process. The ratio at which this exchange takes place is α_B^{TT} . Thus, at any given point of time, the value of the client's tacit business knowledge gained by the vendor as new tacit knowledge can be expressed as:

$$\frac{\alpha_B^{TT} K_{F-t_0}^{BT}}{T} \int_0^t \sin\left(\frac{\pi}{T} t\right) \cdot dt \quad [1]$$

During the same time, a part of the client's explicit business knowledge ($K_{F-t_0}^{BE}$) will also transfer to the vendor through internalization process, in which understands explicit business rules and processes of the client firm. The ratio at which this transfer takes place is α_B^{ET} . This conversion, however, does not take place at the same rate as explicit knowledge exchange.

Given the complexity of conversion, there could be a delay, which can be represented as $\sin(\frac{\pi}{T} + \omega)$. Thus, at any given point of time, the value of the client's explicit business knowledge gained by the vendor as new tacit knowledge is:

$$\frac{\alpha_B^{ET} K_{F-t0}^{BE}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega\right) t \cdot dt \quad [2]$$

Thus, overall tacit business knowledge available with the vendor at any given point of time can be expressed as the sum of above individual components:

$$K_t^{BT} = K_{V-t0}^{BT} + \frac{\alpha_B^{TT} K_{F-t0}^{BT}}{T} \int_0^t \sin\left(\frac{\pi}{T}\right) t \cdot dt + \frac{\alpha_B^{ET} K_{F-t0}^{BE}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega\right) t \cdot dt \quad [3]$$

Similarly, at the start of the vendor has some level of initial explicit business knowledge. We express it as K_{V-t0}^{BE} . During the IT outsourcing project, a part of the client's explicit business knowledge (K_{F-t0}^{BE}) gets transferred to the vendor through the combination process. The ratio at which this exchange takes place is α_B^{EE} . Thus, at any given point of time, the value of the client's explicit business knowledge gained by the vendor as new explicit knowledge can be expressed as:

$$\frac{\alpha_B^{EE} K_{F-t0}^{BE}}{T} \int_0^t \sin\left(\frac{\pi}{T}\right) t \cdot dt \quad [4]$$

During the same time, a part of the client's tacit business knowledge (K_{F-t0}^{BT}) will also transfer to the vendor through externalization process, in which the vendor creates explicit documents or other forms of formal expressions such as operating processes or quality checks. The ratio at which this transfer takes place is α_B^{TE} . As discussed earlier, there could be some delay in this conversion process too. Thus, at any given point of time, the value of client's tacit business knowledge gained by the vendor as new explicit knowledge is:

$$\frac{\alpha_B^{TE} K_{F-t0}^{BT}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega\right) t \cdot dt \quad [5]$$

Thus, overall explicit business knowledge available with the vendor at any given point of time can be expressed as the sum of above individual components:

$$K_t^{BE} = K_{V-t0}^{BE} + \frac{\alpha_B^{EE} K_{F-t0}^{BE}}{T} \int_0^t \sin\left(\frac{\pi}{T}\right) t \cdot dt + \frac{\alpha_B^{TE} K_{F-t0}^{BT}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega\right) t \cdot dt \quad [6]$$

The identical knowledge exchange and creation for business knowledge takes place for the client. Thus, over a long period of time the client's and the vendor's knowledge sets related to the IT outsourcing project will converge and completely overlap. Since we are interested in the development of overall knowledge capabilities (the converged knowledge set) through the process of knowledge exchange and creation, we are not including the process from the client side in the simulation model to avoid double calculation of the knowledge. In the conversion process, we also assume that all parts of knowledge carry the same degree of importance, and each part impacts the whole system. In sum, all the knowledge takes part in the conversion process and shows influence during the whole process.

Modeling Technical Knowledge Exchange and Creation.

Here, our approach is the similar to that for business knowledge and develop the following models for tacit and explicit technical knowledge.

For tacit technical knowledge:

$$K_t^{HT} = K_{V-t0}^{HT} + \frac{\alpha_H^{TT} K_{F-t0}^{HT}}{T} \int_0^t \sin\left(\frac{\pi}{T}\right)t \bullet dt + \frac{\alpha_H^{ET} K_{F-t0}^{HE}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega 3\right)t \bullet dt \quad [7]$$

For explicit technical knowledge:

$$K_t^{HE} = K_{V-t0}^{HE} + \frac{\alpha_H^{EE} K_{F-t0}^{HE}}{T} \int_0^t \sin\left(\frac{\pi}{T}\right)t \bullet dt + \frac{\alpha_H^{TE} K_{F-t0}^{HT}}{T} \int_0^t \sin\left(\frac{\pi}{T} + \omega 4\right)t \bullet dt \quad [8]$$

Overall Model

As discussed earlier, organizational knowledge is the summation of weighted tacit and explicit knowledge. There is a debate about the amount of values for the weights for tacit and explicit knowledge in organizational knowledge (Nonaka 1994). To enable, the organizations to choose their own point of view on this debate, we use a general formulation for weights. The total project-oriented knowledge is expressed as:

$$K_G = W_B \cdot (W_B^T K_t^{BT} + W_{B1}^E K_t^{BE}) + W_H (W_H^T K_t^{HT} + W_H^E K_t^{HE}) \quad [9]$$

In the equation, W_B , W_H are the weight for overall business and technical knowledge. W_B^T and W_B^E are the weights for business tacit knowledge and business explicit knowledge. W_H^T and W_H^E are the weights for technical tacit knowledge and technical explicit knowledge.

RESULTS AND DISCUSSION

We use simulation as a research method to examine the effects of the four organizational factors on knowledge exchange and creation process between the vendor and client organizations. Simulation provides a controlled method to investigate a complex phenomenon, and studies the effects of alternative processes or situations on outcomes through manipulations of key influential factors. In the simulation, we developed six different cases by manipulating various factors in the model. For each case, we randomly generated 100 scenarios. We used MathLAB software to run the simulation for the total 600 scenarios. The simulation included three key variables: transfer rates, knowledge level, and time. The complete range of the transfer rates were standardized to vary from 0 to 1, where 0 being none and 1 being the optimal (not maximum as the higher values may provide diminishing returns). The initial value of knowledge was arbitrarily set at 4 and allowed it to vary without any limit. The time factor was also standardized to vary from 0 to 1, where 0 being the start of the project and 1 being the end of the project. All weights were set equally at 1, though they can be changed based on organizational situations.

Effects of an Individual Factor Manipulation

Our research model identifies four organizational factors affecting four inter-organizational knowledge exchange and creation processes. In the first two cases, we manipulate only one—communications—of the four factors; other three factors are stable. Communications affect the socialization process, in which tacit knowledge is transferred from one organization to the other organization. Socialization is represented by α_B^{TT} (transfer rate of tacit business knowledge) and α_H^{TT} (transfer rate of tacit technical knowledge). We chose the range of 0.6 to 0.9 for high level of communications and 0.1 to 0.4 for low level of communications. Other α s have the stable, middle value of 0.5. The result of the 200 sample simulations is given in Table 1.

Manipulation				The range of α_B^{TT} and α_H^{TT}	K_G Mean	K_G Std. Dev.	t-value	p-value
Case 1	High	Level	of	0.6-0.9 $\sigma = 0.15$	6.852	0.126	38.04	<.001
Case2	Low	Level	of	0.1-0.4 $\sigma = 0.15$	6.226	0.128		

Table 1: Results of One Factor Manipulation

The results indicate that there is significant difference in total knowledge generation when one factor is manipulated. Figure 2 shows the values of K_G for all observations for both Cases 1 and 2. The points are relatively less scattered indicating small amount of variation among different observations.

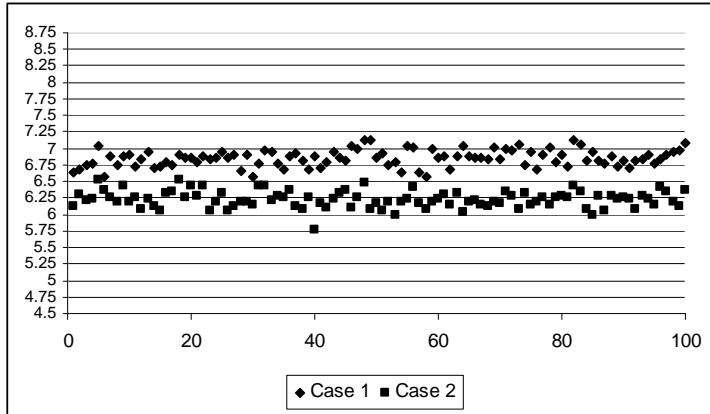


Figure 2: One Factor Manipulation - Case 1 & Case 2

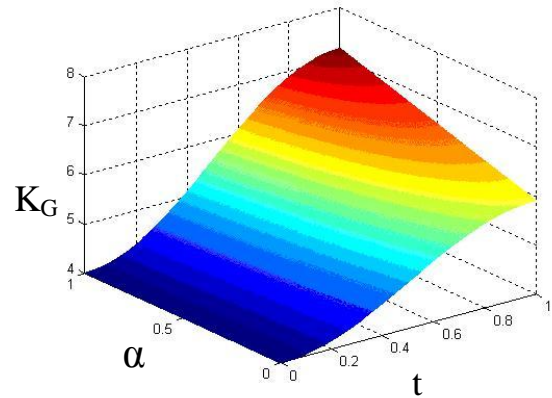


Figure 3: Simulation-One Factor

These cases provide a basic example of the simulation. A quantitative measurement of the effects of changes in the organizational performance with the adjustment of external or internal environment would help managers build a reliable management tool for predicting future operation. Given other conditions being equal, the efficiency is as important as causal relationship. In these scenarios, we manipulated only the level of communication for its impact on tacit knowledge transfer. Figure 3 shows, how such manipulation can affect the knowledge level over a period. If the level of socialization remains the same the over time, the knowledge graph will be two dimensional with time on one axis and knowledge level on other axis. However, if the level of socialization changes through improving/deteriorating communications between the client and vendor, the transfer rate would change over time and, eventually, the final knowledge level would also change as shown by the three-dimensional heat chart.

Effects of Two Factors Manipulation

In the Cases 3 and 4, we manipulated two factors and kept the other two factors stable. This manipulation represents exchange and creation of tacit knowledge, through the socialization and internalization processes, in which both tacit and explicit knowledge from one organization is transferred into the other organization as new tacit knowledge. This infusion of new project-related knowledge increases the knowledge capabilities of the receiving organization and may lead to the project success. Here, we manipulated four α s: two (α_B^{TT} and α_H^{TT}) related to socialization and two (α_B^{ET} and α_H^{ET}) related to internalization. Again, we chose the range of 0.6 to 0.9 for high levels of communications and organizational culture fit between the two organizations and 0.1 to 0.4 for the low levels. Again, the remaining four α s were kept at the stable, middle value of 0.5. The results of the 200 sample simulations are given in Table 2.

	Manipulation	The range of α_B^{ET} and α_H^{ET}	K_G Mean	K_G Std. Dev.	t-value	p-value
Case 3	High Levels of Media Richness and Org. Culture Fit	0.6-0.9 $\sigma = 0.15$	7.186	0.165	49.32	<.001
Case 4	Low Levels of Media Richness and Org. Culture Fit	0.1-0.4 $\sigma = 0.15$	5.925	0.191		

Table 2: Results of Two Factors Manipulation

The results indicate that there is significant difference in total knowledge generation when two factors are manipulated. Figure 3 shows the values of K_G for all observations for both Cases 3 and 4. The points are more scattered than those in Figure 2 suggesting that the variation in knowledge generation increases, while the average knowledge generated may be higher.

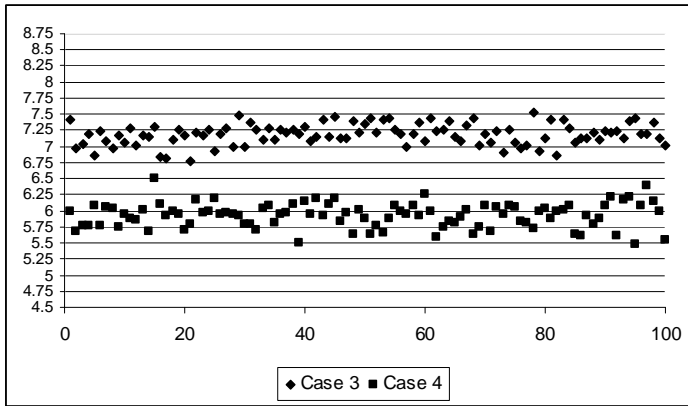


Figure 4: Two Factors Manipulation - Case 3 & Case 4

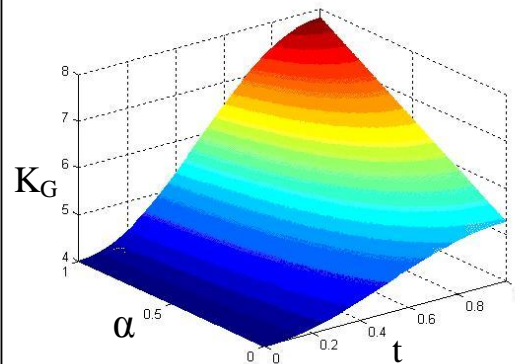


Figure 5: Simulation - Two Factors

These cases are a bit more intricate than the previous two as they involve simultaneous manipulation of two factors. They suggest that a manager can influence the exchange and creation of a specific form of knowledge by focusing on specific types of activities. However, sometimes, those activities are beyond the immediate control of the manager. In these cases, we manipulated the levels of communications and organizational cultural fit between the client and vendor. The simulations show that the level of tacit knowledge increases with the higher levels. The sub-context of communications and culture may have variations, but understanding their influence on knowledge transfer and creation processes and a specific form of knowledge may provide managers with a clear direction toward where he or she should allocate resources to achieve specific knowledge capability required for the project.

Effects of All Factors Manipulation

For the Cases 5 and 6, we manipulated all four factors. This enabled us to examine effects of these factors on all of the four knowledge exchange and creation processes, in which both tacit and explicit knowledge from one organization is transferred and converted into new tacit and explicit knowledge in the other organization. To enable this, we manipulated all eight α s in the simulation model. Here also, we chose the range of 0.6 to 0.9 for high levels of communications, organizational culture fit, combination, and coordination between the two organizations and 0.1 to 0.4 for the low levels. The results of the 200 sample simulations are given in Table 3.

Manipulation		The range of all α s	K_G Mean	K_G Std. Dev.	t-value	p-value
Case 5	High Levels on All Factors	0.6-0.9 $\sigma = 0.15$	7.826	0.299	57.33	<.001
Case 6	Low Levels on All Factors	0.1-0.4 $\sigma = 0.15$	5.258	0.296		

Table 3: Result of All Factor Manipulation

The results again indicate that there is significant difference in total knowledge generation when all four factors are manipulated simultaneously for their high levels versus their low levels. Figure 4 shows the values of K_G for all observations for both Cases 5 and 6. The points are much more scattered than those in Figure 2 and Figure 3 suggesting that the variation in knowledge generation increases significantly with manipulation of more factors.

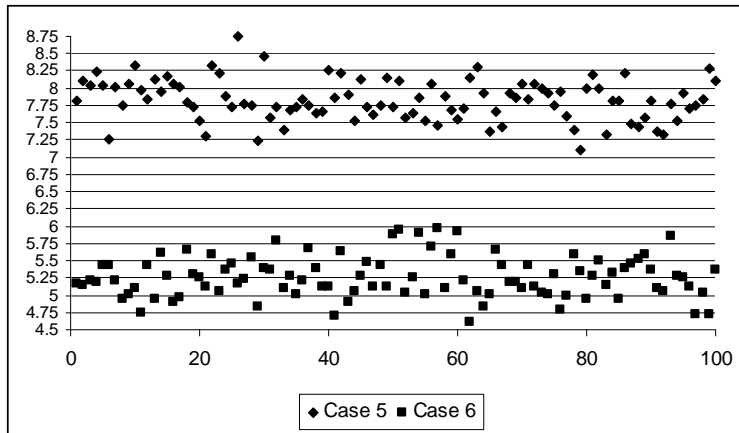


Figure 6: All Factors Manipulation - Case 5 & Case 6

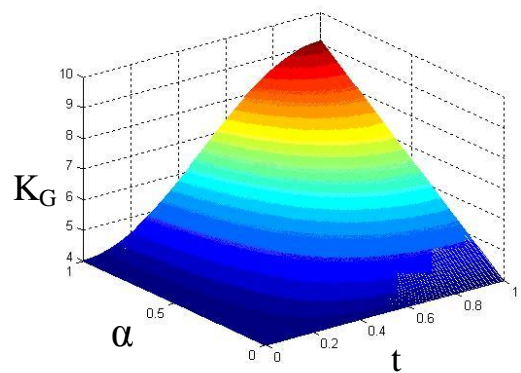


Figure 7: Simulation - All Factors

These cases are the most intricate, as they involve manipulation of all factors. The simulations show that the success of knowledge management could be achieved through two different ways. First, organizations could adjust their structures, adopt new technologies, build proactive firm culture, and specify strategies to influence the inter-organizational activities affecting knowledge management. This will increase the exchange and creation rate leading to higher level of knowledge. Second, organizations could use the dynamic nature of knowledge creation that leads to expanding the level of knowledge. They could build a knowledge-based layer in their organizations enabling the project participants to integrate organizational knowledge resources. Organizations operate in complex environment. These cases suggest that managers may need to adjust different composition of knowledge asset, strategy arrangement, and organizational structure to gain short-term and long-term knowledge advantage.

CONCLUSION

As IT outsourcing is becoming a strategic activity, the development of shared knowledge capabilities becomes critical for the success of increasingly rich and complex IT outsourcing relationships. In this paper, we examined how inter-organizational activities, specifically level of communication, organizational cultural fit, documentation, and coordination between the vendor and client, affect the knowledge exchange and creation process in IT outsourcing. We used the knowledge-based view to decompose this process and used simulations to generate various business scenarios to evaluate effects of various interorganizational activities on its components.

To reconcile the cost-tradeoff and necessity of knowledge exchange and creation in IT outsourcing projects, managers need an effective measurement and scientific forecasting tools to adjust their organizational activities. The process model presented in this paper provides a tool for managers to make effective decisions regarding resource allocations for those activities. They can fine-tune the model and set appropriate initial values of parameters based on their understanding about their own organizations, previous experience, historical data, and other quantitative and qualitative analysis about knowledge requirement in IT project.

The four inter-organizational activities used in this study serve as examples for activities having significant effects on inter-organizational knowledge management. Other activities may also have significant effects on knowledge creation and exchange processes. They may even interact with these activities and moderate their effects over time. A future work may explore this line of research and further improve the model.

Simulation is a useful modeling technique. However, like any other models, such as an architectural model, it is a basal representation of reality through mathematical relationships. It cannot completely represent the real world (Repenning 2002). Future studies could build on this work to examine the knowledge exchange and creation process in laboratory experiments with tightly-controlled manipulations but in a human-participant environment. Other research methods such as survey and longitudinal field study may also be employed to evaluate results across different research methods and extend our model.

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APPENDIX A

$K_{V-t_0}^{HT}$; $K_{V-t_0}^{HE}$; $K_{V-t_0}^{BE}$; $K_{V-t_0}^{BT}$: Initial tacit(T)/explicit(E) technical(H)/business(B) knowledge from vendor(V)

$K_{F-t_0}^{HT}$; $K_{F-t_0}^{HE}$; $K_{F-t_0}^{BT}$; $K_{F-t_0}^{BE}$: Initial tacit(T)/explicit(E) technical(H)/business(B) knowledge from firm(F)

K_t^{BT} ; K_t^{BE} ; K_t^{HE} ; K_t^{HT} : Overall tacit/explicit business knowledge available with the firm/vendor at any given time point

K_G : Total project-oriented knowledge

W_B : Weight for overall business knowledge

W_H : Weight for overall technical knowledge

W_B^T ; W_B^E : Weight for business tacit/explicit knowledge

W_H^T ; W_H^E : Weight for technical tacit/explicit knowledge

α_B^{TT} ; α_B^{ET} ; α_B^{EE} ; α_B^{TE} : Transfer rate of tacit/explicit business knowledge from one party to tacit/explicit business knowledge of another party.

α_H^{TT} ; α_H^{ET} ; α_H^{EE} ; α_H^{TE} : Transfer rate of tacit/explicit technical knowledge from one party to tacit/explicit technical knowledge of another party.