The Sharing Mechanism Study of IT Enterprises' Knowledge Alliance

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Abstract

Knowledge alliance is a kind of strategic alliances, which is to analyze the alliance motive and content from the point of view of knowledge. This paper analyzes the impact factors, mechanism of knowledge sharing and spillover effect between IT Duopoly by building a two-stage game model and Prisoner's Dilemma model. In addition, IT enterprises' knowledge sharing process is also simulated by using MATLAB software. The results suggest that the optimal sharing level of technical knowledge will be reduced with the increasing of network effect of IT product and the equilibrium profits will increase; the bigger the complementary of technical knowledge, the lower the level of technical knowledge sharing which leads to more equilibrium profit and less equilibrium profit; with the increasing of network effects of IT products, company will share less technology and the equilibrium profit has increased; with strengthen of complementary capabilities of technical knowledge, company will share less technology, whereas the equilibrium profit increases firstly and then decreases.

Keywords: IT Enterprise; Knowledge Sharing; Knowledge Alliance; Sharing Mechanism; Spillover effect; Equilibrium Profits

1 Introduction

Broadly speaking, Knowledge Alliance refers to organizations or other institutions to jointly create new knowledge and knowledge transferring by way of an alliance [1]. Any enterprise, no matter how specific industry and product characteristics of the combination of both, is an organic combination of the variety of knowledge, knowledge sharing is the enterprise in the competition to win the cooperation innovation and the fundamental driving force to maintain a competitive advantage [2].Currently, there are much research on knowledge sharing abroad, such as Japanese scholars Nonake and Takeueh iproposed the knowledge sharing played a key role in high level of knowledge innovation, and proposed the classical knowledge generation and transfer theory [3]. David took 9 years of data of 23 top IT companies as the research object, and arrived at a conclusion that close cooperation between enterprises were closely related to the technological innovation and evolution [4]. XIA and CAI analyzed the cost factors of knowledge sharing under network computing environment and built a cost model of knowledge sharing by using fractal theory [5]. XU and WEI analyzed some enterprise IT's primary feature such as network effects, path dependence, increasing returns, etc and its competitive models [6]. LIU and GUO built a knowledge sharing model of hierarchical style with pertinence solutions to knowledge sharing within the enterprise IT [7]. ZHANG and GUO investigated comprehensively three large-scale enterprises and proposed three models of enterprise knowledge sharing [8]. Ping et al. presents knowledge resource space model represents knowledge resources of different types in view of dynamic virtual enterprise knowledge sharing problem, including explicit knowledge and tacit knowledge. Furth more, he illustrate a dynamic knowledge in virtual enterprises using agent-based solution [9]. In view of the research and development alliance knowledge sharing and protection, Marcel set up R&D cooperation in the framework of knowledge transfer network, puts forward two concrete strategies mainly-knowledge sharing and communication and distributed cooperation plan, to implement the alliance knowledge sharing and open innovation [10]. Nune et al. study of the enterprise research center in cooperation with industry knowledge interaction, points out that the government policy makers should strengthen the policy incentives, thus strengthening the different nature of the inter organizational knowledge collaboration, in order to achieve the goal of knowledge sharing [11]. Kerstin et al. analyzed Empirical data on the EU project cooperation, deemed that knowledge sharing has a significant effect on tissue culture of pluralism, overcome technical dispersion and limited opportunities for informal communication [12]. In tacit knowledge sharing, Scott & Dail compared the professionals in the sharing and use of tacit knowledge in the process, affective trust and cognitive trust of the role, that cognition based trust plays a larger role[13]. Jan thinks that the organization's management, the owner and the performer uncertainty between the exchange of information between the parties to contribute to the establishment of the organization cooperation, respect and trust relationship, so as to better realize the knowledge sharing [14]. Hung & Ching researched that high technology enterprise's organization members and colleagues, superiors and

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organizational relationship influences on knowledge sharing, and believed that, in order to improve the level of knowledge sharing, the organization shall establish and maintain good relationship between members of the atmosphere [15]. Block established a large organization knowledge sharing model to analyze the process of knowledge sharing by using the transaction cost theory, and pointed out the relationship between knowledge sharing and organizational level in large organizations [16].

Based the above results on Knowledge Innovation Alliance sharing mechanism research, a conclusion can be got that some scholars has achieved remarkable results from enterprise technology alliance knowledge sharing situation, the influencing factors of knowledge sharing, virtual organizations, members of the alliance trust relations, alliance knowledge industry protection, especially the research on enterprise technology alliance knowledge sharing. In addition, knowledge sharing mechanism research mainly concentrated in the incentive mechanism, trust mechanism, influencing factors of knowledge sharing, organizational culture, characteristics of the individuals and groups in organizations and their mutual relations, those aspects almost plays an important role on organizational knowledge sharing and benefits the effective development of internal organization knowledge sharing.

To sum up, currently, the research on knowledge sharing between knowledge union members is still relatively fragmented, and it has not formed a complete theoretical system. In addition, the article which combines the characteristics of a specific industry and analyses in depth and discusses the knowledge sharing between inter-organization is still relatively rare. Based on Bertrand price competition model, this paper combines the characteristics of IT enterprise, in-depth studies and discusses knowledge sharing behaviour and its influencing factors between IT Duopoly. The purpose of this paper is to analyze how network effects of IT products and complementary of two enterprises' technical knowledge work on the optimal sharing level of technical knowledge and equilibrium profit, and understand some inherent law of knowledge sharing in organization cooperation and innovation.

The contribution of this article is as follows: this paper combines closely the characteristics of Oligopolistic IT and discusses these effects to the knowledge sharing behavior between organization members and sharing efficiency; this paper not only builds a knowledge sharing mathematical model between organization members, but also designs and simulates the knowledge sharing process by using MATLAB simulation soft. At last, knowledge spillover effect is analysed by considering the two participants of the game into the Prisoner's Dilemma.

2 Model and analysis

It is necessary that some assumptions are given in order to simplify the problem.

2.1 MODEL ASSUMES

(A.1) The product market is an imperfectly competitive market, and the Oligopolistic IT produces similar alternative products. In addition, there is Bertrand price competition between the enterprises. Since the utility of IT products often can be divided into two different parts: utility the products bring by themselves and network effects of IT products. The former one is the utility the consumer gets by consuming product or enjoying services; the latter is utility consumer obtains from other interaction users which depends on the number of other users. Based on these, we assume the demand function of the two companies is as follows:

$$q_i = u - p_i + dQ, q_j = u - p_j + dQ, \tag{1}$$

where q_i, q_j are consumer demands for the two companies' products respectively; $Q = q_i + q_j$ is the total demand; u is the quality of the IT products; p_i, p_j are product prices; parameter d is network effects coefficient of IT products, which stands for the induced demand for total demand by a single enterprise demand. There assume $0 \le d \le 1$. In addition, the consumers have the same preference for the same quality of IT products is also supposed.

Reorder the formula (1) and then get the demand function of the two companies as follows:

$$q_i = \frac{(d-1)p_i - dp_j + u}{1-2d}, q_j = \frac{(d-1)p_j - dp_i + u}{1-2d}, \tag{2}$$

(A.2) It is assumed that k_i, k_j are technical knowledge input of the two companies respectively. In addition, the technical knowledge of two companies is complementary. The technical knowledge output is a function of technical knowledge input of the two companies $K = r(k_i + k_j)$, where $r (0 \le r \le 2)$ stands for the complementary capabilities of technical knowledge from two companies. To facilitate analysis, it supposes that the technical knowledge input of the two companies is continuous, that is any technical knowledge input of the both companies corresponds to a certain amount of knowledge output.

(A.3) It's supposed that the technical knowledge output reflects as the reduction of the marginal cost, which promotes companies' profit. So suppose the marginal cost after knowledge sharing is $c_3 = e^{-r(k_i + k_j)}$.

(A.4) Taking into account the production process of IT products generally can be divided into two phases. The first stage is the stage of R&D investment, which requires a lot of intellectual, human, material and other costs in order to create the first information product. The second stage is the replication phase of products, which is low cost, that is, the marginal cost tends to zero. Therefore, this model takes the technical knowledge input as production cost. That is, $s_i = k_i$, $s_j = k_j$ [17].

2.2 MODEL AND SOLUTION

Initially, the Oligopolistic IT produces the similar alternative product. However, due to intensified market competition or other reasons, the Oligopolistic IT plan to input technical knowledge to create new technologies, thereby reducing the marginal cost of product, in order to maximize the ultimate profits. Then, both are faced with two choices. One is to develop new technologies alone; and the other is to form an alliance and share knowledge, joint development of new technologies. As a rational economic human, enterprises will choose the decision which can receive a higher yield to implement innovation. For the two enterprises, if the development of new technology is successful (the other fails), it will receive much profit. But R&D alone faces a great risk of failure. Knowledge sharing creates opportunities for enterprises to learn and improve their competitiveness from the alliance partners. However, the information asymmetry and incomplete information are widespread in knowledge sharing, which lead to opportunistic behaviour, moral hazard and free riding [18].

In this paper, a two-stage game model devoted to knowledge sharing studies the optimal sharing level of technical knowledge and equilibrium profit. In this game model, the Oligopolistic IT are participants, the first phase of game companies decide to invest their share of technical knowledge; the second stage of game each enterprise's strategy is to decide respectively on its price, which is involved in Bertrand price competition. In addition, this paper examines the case of information asymmetry of knowledge sharing, that is, the level of sharing of technical knowledge at stage one is not observed in this stage, which is decided by viscosity, ambiguous and other nature of knowledge. In the following, we will analyze and discuss the mathematical model. Backward induction method will be used here to solve the sub game Nash equilibrium of this game.

In the second stage, given level of sharing of technical knowledge k_i, k_j, the two companies choose simultaneously prices to maximize profits. π_i, standing for the profit of company i in the second stage, can be expressed as:

$$\pi_i = R_i - s_i = (p_i - c_3)q_i - k_i \quad . \tag{3}$$

From the optimized first-order conditions:

$$\frac{\partial \pi_i}{\partial p_i} = q_i + (p_i - c_3)\frac{\partial q_i}{\partial p_i} = 0 \, . \tag{4}$$

We obtain the price reaction function of company i. By the symmetry, the price reaction function of company j also can be obtained. Simultaneous both reaction functions can get the equilibrium prices of two companies in the second phase of Bertrand price competition as follows:

$$p_i^* = p_j^* = \frac{(d-1)c_3 - u}{d-2} \, .$$

In the first phase of the game, the two companies choose simultaneously level of sharing of technical knowledge in order to maximize profits. Also from the optimized first-order conditions $\frac{\partial \pi_i}{\partial k_i} = 0$, this can obtain the level of sharing of technical knowledge reaction function of company $i: F_i(k_i, k_j) = 0$. By the symmetry, the level of sharing of technical knowledge reaction function of company $j: F_j(k_i, k_j) = 0$ also can be obtained. Simultaneous both reaction functions can get the optimal sharing level of technical knowledge of two companies $k_i^* = k_j^* = -\frac{1}{2r}\ln c_3$. Now, the equilibrium profits of two companies are

$$\pi_i^* = \pi_j^* = A(u - c_3)^2 + \frac{1}{2r}\ln c_3 \, ,$$

where $A = \frac{1-d}{(d-2)(1-2d)}$, $c_3 = \left(u + \sqrt{u^2 + \frac{4(d-2)(1-2d)}{r(d-1)(4-d)}}\right)/2$.

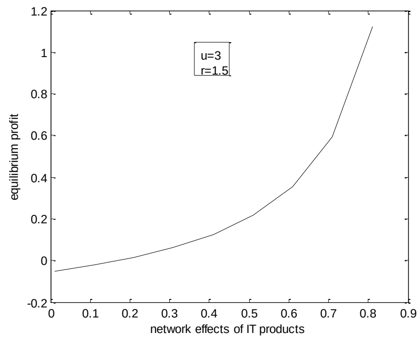
2.3 MODEL CONCLUSION ANALYSIS

Through the expressions of optimal sharing level of technical knowledge k_i^*, k_j^* and equilibrium profits of two companies π_i^*, π_j^*, it is important that whether company is willing to share with the alliance members or not and the level of sharing of technical knowledge depend on network effects of IT products d, complementary capabilities of technical knowledge from two companies r, and quality of the IT products u etc. According to the comparative static analysis of the equilibrium results, we have the following conclusions:

Conclusion1: with the increasing of network effects of IT products, company will reduce the optimal sharing level of technical knowledge and the equilibrium profit has increased.

Proof: enterprises for optimal technology sharing the knowledge level k^* and IT equilibrium profit π^* can be given by solving the first derivative of network effects d for IT products about company i.

$$\frac{\partial k_i^*}{\partial d} < 0 \, , \quad \frac{\partial \pi_i^*}{\partial r} = \frac{\partial A}{\partial d}(u - c_3)^2 - A2(u - c_3)\frac{\partial c_3}{\partial d} - \frac{\partial k_i^*}{\partial d} > 0 \, .$$



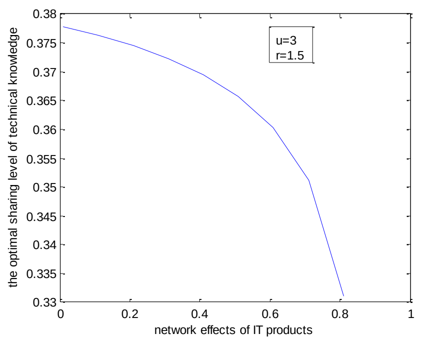


FIGURE 1 Relationship between equilibrium profit, the optimal sharing level of technical knowledge and network effect of IT products about manufacturer *i*.

With the increasing of network effects of IT products, consumers can obtain more utility from the same product as before. In this case, sharing less technical knowledge can directly reduce the cost of technology inputs of company, and also the increasing of network effects will improve the utility of consumers, thereby enhancing the consumption of consumer and maximizing the equilibrium profit. Figure 1 is MATLAB simulation diagram of the equilibrium profit and optimal sharing level of technical knowledge of company i with network effects.

Conclusion2: With the strengthening of complementary capabilities of technical knowledge, the company will reduce the optimal sharing level of technical knowledge, whereas the equilibrium profit increases firstly and then decreases. We can get this conclusion from Figure 2 which is MATLAB simulation diagram of the equilibrium profit and optimal sharing level of technical knowledge with complementary capabilities of technical knowledge.

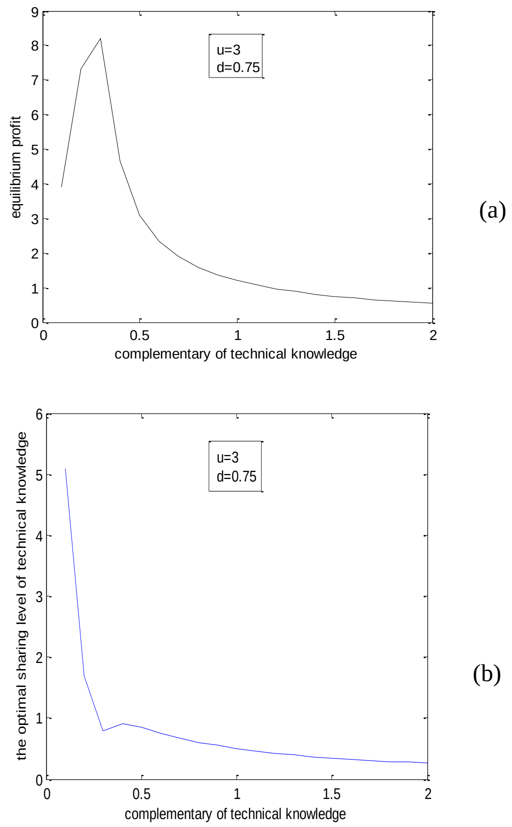


FIGURE 2 Relationship between equilibrium profit, the optimal sharing level of technical knowledge and complementary of technical knowledge.

With the strengthening of complementary capabilities of technical knowledge, the company just need to share less technical knowledge to get quite output, or even more, thereby reducing the marginal cost of product and maximizing equilibrium profit. Also sharing less technical knowledge can directly reduce the cost of technical inputs. Considering these two aspects, the company will be appropriate to reduce the optimal sharing level of technical knowledge, and then the equilibrium profit also improves. However, when the complementary capabilities of technical knowledge increases to a certain extent (seen from Figure 2, the critical value of complementary capabilities of technical knowledge is about 0.3), the equilibrium profit changes in the opposite direction with the complementary capabilities.

3 Analysis of knowledge spillover

There are many enterprises in the industry cluster which share the cluster's competitive advantage. Each company's action such as knowledge spillover will affect the behavior of other enterprises. The process of knowledge spillover in the cluster is a profit game among these enterprises associated with each other. Each member enterprise of the cluster is a decision-making body in the game. As a rational decision-making body, each enterprise makes decision based on the expected return arising from the action of knowledge spillover, namely, the aim of the project is to get the maximum return.

For simplicity, this paper's analysis will be restricted between two zero difference enterprises A and B in the cluster. Assumptions of the model are as follows:

(B.1) A and B have the same strategy set {spillover, no spillover}.

(B.2) Knowledge stores of the enterprises are divided into two parts, one part is transferable, the other part is untransferable, and the former can overflowed completely.

(B.3) The value of untransferable knowledge owned by each company is V_1, the value of transferable knowledge owned by each company is V_2.

(B.4) The ability to absorb knowledge is indicated by $x(1 < x \le 1)$, and if x=1, the knowledge overflowed will be absorbed completely.

(B.5) The synergy value created by knowledge sharing during the process of knowledge spillover is indicated by V_3, which is obtained by the recipient entirely.

(B.6) The side from which knowledge spilled suffers a loss, and the negative utility is indicated by V_4.

On the base of these assumption, we can find that: if the two enterprises all choose "no spillover", the return of knowledge value obtained by each side can be indicated by $N = V_1 + V_2$; if the two enterprises all choose "spillover", the return of knowledge value obtained by each side can be indicated by $M = V_1 + V_2 + xV_2 + V_3 - V_4$; if one firm chooses "spillover" while the other chooses "no spillover", the former will get the return indicated by $L = V_1 + V_2 - V_4$ and the latter will get the return indicated by $U = V_1 + V_2 + xV_2 + V_3$. Normally, the size relations are $U > M > N > L$. The payoff matrix is shown in the following table 1.

TABLE 1 The payoff matrix of the two participants

	Enterprise B		
Enterprise A		spillover	no spillover
	spillover	M, M	L, U
	no spillover	U, L	N, N

The payoff matrix is common knowledge of the two participants, and they know entirely the structure of the game and the situation of each other. A and B decide independently whether to choose "spillover", and they play the game only once. Here, we analyze the game of knowledge spillover. For enterprise A, B has two choices "spillover"and "no spillover". If B chooses "spilover", the best choice foe A is "no spillover"; if B chooses "no spilover", the best choice foe A is "no spillover". No matter what, A will always chooses "no spillover".In the same way, B will always chooses "no spillover" as well, because we have supposed that the two enterprises are absolutely identical. Then, they sink into the "prisoner's dilemma". Nash equilibrium solution of the knowledge spillover game is (no spillover, no spillover). However, the Pareto-optimal solution is not N for each enterprise or for the group, it should be M produced by the strategy (spillover, spillover). The game reveals the contradiction benween individual rationality and collective rationality. Namely, the action based on individual interests always can't lead to the best interests of the group, and it even can't help to realize the best interests of the individual.

Conclusion 1: If the game of knowledge spillover occurs for only one time in the short run, the two participants of the game will get into the Prisoner's Dilemma. And there will be no knowledge spllliover.

From the above analysis we can see that if the two enterprises want to get the best interests, they have to choose "spillover" simultaneously to realize cooperation. If the two firms intend to cooperate with each other, they will face Trust Game. Here, we will analyze the game by an assumption of knowledge collaboration. Suppose enterprise A is the owner of knowledge assets, who hopes to realize the value of knowledge by cooperation and obtain the value-added income of knowledge assets. The enterprise B is a potential partner. A is willing to spill knowledge actively to B to show its cooperative sincerity, hoping for a successful cooperation. B takes the "tit-for-tat" strategy, namely, if A chooses to cooperate, B will choose to cooperate too, if A chooses not to cooperate, B will choose not to cooperate forever. A's action of spilling knowledge will be regarded as a signal of co-operation. Accordingly, B will show a very positive attitude to contribute to the success of co-operation.

We use δ to represent the degree of proactivity of knowledge spillover. Let's try to determine the scale range of a. $\delta = 0$ shows that the attitude of A is extremely negative and passive. Then, we think A has no cooperation intention, and the cooperation can not be realized. $\delta = 1$ shows that the attitude of A is extremely positive and active. Then, we believe that A has exposed its assets completely and lost the initiative. Obviously, the rational enterprise A will not do it like this. From another angle, B's strategy is "tit-for-tat", however, its rational aim is to maximize its own interests as well. So, if B can obtain all knowledge of A, it will withdraw from the cooperation, which causes the paradox of knowledge sharing. To sum up, δ must satisfy the two conditions: $\delta \neq 0$ and $\delta \neq 1$. Furthermore, δ is a random variable distributed in the interval (0,1). And the larger δ is, the stronger proactivity of knowledge spillover is.

Suppose the cooperative benefit is indicated by r when δ approachs 1 infinitely. Both sides share the cooperative benefit according to the ratio of s/(1－s). As a result, A will get $s*r$ and B will get $(1-s)*r$. These benefits are expected satisfactory return, so the cooperation will not be terminated and the maximum benefits will be realized. A never spills knowledge completely in actual cooperation, but controls the magnitude of δ and spills knowledge incompletely. Suppose the real cooperative benefit is r'. Both sides share the cooperative benefit according to the ratio of s/(1－s), so A will get $s*r'$ and B will get $(1-s)*r'$. The benefit is regulated by δ, the larger δ is, the more benefits they will obtain. Therefore, we can suppose that there is a linear relationship $r' = \delta r$ between the real bebefit and the expected benefit.

The strategy of an enterprise to obtain the maximum benefit is to take the same action as the other side does. The cooperation based on trust needs the joint effort of the two sides. If A is willing to spill knowledge actively to B to show its cooperative sincerity, B will approve the positive attitude and sincerity of A with the increasing δ (the degree of proactivity of knowledge spillover). Finally, B will choose to cooperate positively, and the expected benefit decreases step by step. The ultimate result is obvious; both sides will try their best to cooperate with each other on the condition that they all have good cooperative sincerity. Then, the expected profit takes a back seat. Explanation in the reality is that the individual enterprise of a cluster may find it difficult to accomplish a task independently, and then cooperation is necessary. Thus, an individual enterprise is willing to spill knowledge positively, even if the expected cooperation benefit is low. In so doing, it can win trust of the potential partner and promote the substantial cooperation between them.

Conclusion 2: The participant who makes knowledge spillover initiatively will be considered to have good sincerity of cooperation in the Trust Game of knowledge spillover, which will lower the minimum standards on expected earnings of the two sides. And it will do good to the occurrence of knowledge spillover.

4 Conclusion

Based on Bertrand price competition model, against knowledge sharing behaviour and its influencing factors between Oligopolistic IT which produce similar alternative products, this paper builds a two-stage game model to study how network effects of IT products, complementary capabilities of technical knowledge work on the optimal sharing level of technical knowledge. It shows that, with the increasing of network effects of IT products, company will share less technology and the equilibrium profit has increased; with strengthen of complementary capabilities of technical knowledge, company will share less technology, whereas the equilibrium profit increases firstly and then decreases.

These conclusions have a certain referential value to promoting the activity of knowledge spillover in the cluster. First, the organizer and governor should try hard to construct a cluster which is steady and pursues long-term development and encourage the enterprises to develop good cooperative relationships. What's more, the collective idea should be strengthened in the cluster. The short-term behavior should be avoided. Second, consider designing an effective mechanism of encouragement and restraint, increase the discount factor η and the expected benefit of knowledge spillover. Third, try to reduce $(U-M)/(U-N)$, such as by increasing M through extra incentives, which can reduce the minimal requirement for discount factor when trying to achieve the Pareto-optimal strategy combination. Finally, try to cultivate harmonious organizational culture of the cluster, which can promote knowledge spillover activities and the construction of long term cooperation relationship.

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