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Game Analysis of Knowledge Sharing of Repatriates in Multinational Corporations

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Abstract: Repatriates international knowledge is vital to the success of creating international competitive advantage for multinational corporations. This research presents a game analysis for repatriates knowledge transfer and exchange in product innovation team. According to the different roles in product development and learning, team members' knowledge is divided into two dimensions, namely the supplementary and complementary knowledge. Three typical scenarios were discussed to analyze the knowledge transfer and exchange activity, including knowledge sharing with individual decision making, knowledge sharing with overall coordination, and knowledge sharing with incentive mechanism. Results show that overall coordination and appropriate incentive mechanism can motivate knowledge transfer and exchange, and the elastic coefficients of supplementary and complementary knowledge can be used to manage the balance between these kinds of knowledge transfer and exchange.

Keywords: Repatriates, Heterogeneous knowledge, Knowledge sharing, Product innovation, Game theory, Incentive mechanism

1 Introduction

In present highly competitive, turbulent market environment, innovative products and speed to market are vital to the success of Multinational Corporations (MNCs)[1]. Product innovations have become more complex, expensive, and perilous because of varying customer preferences, highly competitive pressure, and technological progress[2]. Since product innovation is a knowledge-intensive and cross-functional activity, knowledge is believed to be the most important input in product innovations[3]. Knowledge is a unique, inimitable, and valuable resources for firms, and it disperses in different units and embedded in different individuals[2]. Therefore, developing, transferring, and exploiting knowledge is vital to the success of Multinational Corporations in global markets.

Repatriates are people who return to parent company when expatriation is finished, and they play an important role in transferring international knowledge to parent company. Employees can acquire abroad knowledge through expatriation, and transfer the knowledge to the organization when they are repatriated[4]. The international knowledge includes knowledge related to foreign cultures, foreign markets, products, and customers etc.[5] If this knowledge can be transferred effectively to the parent company, it will make headquarters get a better comprehension of international operations, fill knowledge base vacancy of the parent company, and consequently help create international competitive advantage for the parent company.

However, the repatriates' international knowledge repatriation cannot be automatically obtained. Firstly, the success of product innovation team depends on effective knowledge transfer and exchange between repatriates and ordinary members who have no overseas experience. In the knowledge sharing process, free riding is a known phenomenon that usually results in selfish behavior. Free riders enjoy the benefits of the common good without making efforts to its establishment and maintenance. Members tend to make no effort and enjoy other's fruits when there is no supervision or negotiation[6]. Additionally, members and organizations do not always have the same objective about using knowledge to get a competitive advantage. More specifically, knowledge transaction is full of tension between the interests of members and communitise[7]. How to avoid the emergence of free rider problem in knowledge transfer and to improve the enthusiasm of members' knowledge sharing are crucial for transferring and exploiting members' knowledge.

Many scholars have done some researches about organization members' knowledge sharing. Various approaches have been applied to understand this issue. For example, Dyer et al. indicated that creating rules for members in the organization helps to eliminate the free rider problem and adopting incentive scheme for

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knowledge acquisition and application is effective to knowledge share[8]. Ba et al. contended knowledge share is difficult to achieve without proper incentives.[9].

Ardichvili et al. indicated that, knowledge flows easily when it is considered as a public good[10]. Developing knowledge-based and institution- based trust can remove the identified barriers of knowledge flow.

Shih et al. proposed a knowledge sharing framework using game theory to solve the employee's free-rider problems[11]. They suggested team learning firm with agent contest and reward systems would develop a competitive knowledge sharing environment.

Jiang et al. built an evolutionary game model to analyze knowledge sharing in virtual community[12]. The results show that the game rule and social network structure have a major influence on the users' cooperation and knowledge sharing.

Sharma et al. found four types of organizational knowledge dilemma: silos of knowledge, tragedy of the knowledge commons, knowledge friction and knowledge toxicity, and resolved them using game theory[13]. They indicated that game theoretic reasoning helps to obtain effective strategies and achieve desired organizational outcome. In addition, Li et al. studied knowledge-sharing incentives for members in communities of practice[6].

The studies mentioned above have traditionally treat knowledge in the organization as a public good, and have not involved heterogeneous knowledge. Actually, heterogeneous knowledge has been described by many possible ways, such as tacit and explicit[5], equivocal and canonical[15], external and internal[16], and specific and generic[15]. The reason for distinguishing between various knowledge characteristics is that different types of knowledge have different value to the organization. This study focuses on the important characteristic of international knowledge: the overlap of the organizational knowledge. According the overlap ratio, international knowledge can be categorized into the supplementary and complementary knowledge. The former refers to high redundancy and similar knowledge and skills[17]. This knowledge can give faster and more success of product development in the short run, but has only a limited learning potential [14]. On the contrary, the latter has low redundancy and different knowledge and skills[18]. This knowledge may take longer to utilize, but has a higher potential for learning and promises a long-term success[14]. Thus, managers have to get a balance between short and long term benefits by managing the transfer and exchange of supplementary and complementary knowledge. This balance is similar to that of exploration and exploitation in organization learning[19].

This research focuses on a product innovation team, and separates knowledge transfer into two dimensions: the supplementary knowledge transfer and the complementary knowledge transfer in order to better understand repatriates' knowledge transfer activities. The team contains repatriates and ordinary members, who have no overseas experience. We will analyze how team members spend their effort on these two types of knowledge transfer and how to improve the knowledge transfer activities by using game theory. The second section gives the knowledge transfer model. Three typical organizational scenarios are discussed and modeled using game theory. In Section Three, simulations are presented to verify the theoretical analysis. Section Four proposes the major findings and management guidelines to promote members' knowledge transfer activities in.

2 The Model

Consider a product innovation team. The team has n members, and its objective is to aggregate and share knowledge to achieve competitive advantage. The team is composed of two types of members: η repatriates and $n-\eta$ ordinary members, who have no overseas experience. These members want to develop new products through knowledge transfer and exchange. Each member has two types of knowledge: complementary knowledge and supplementary knowledge. In [20], a member's knowledge value is viewed as high, K_h, or low, K_l, where $K_h > K_l > 0$. Since we have two types of knowledge, we use $K_{ci} \in \{K_{ch}, K_{cl}\}$ to denote the a member's complementary knowledge value, and $K_{si} \in \{K_{sh}, K_{sl}\}$ to denote a member's supplementary knowledge value. Each member decides on x_{ci}, x_{si}, x_{pi}, the efforts he makes on complementary knowledge, supplementary knowledge and his personal work affairs, respectively. Thus, a member's complementary knowledge contribution in the team is $K_{ci}x_{ci}$, and supplementary knowledge contribution $K_{si}x_{si}$. This notation is adopted because a high-value member contributes more than a low-value member when they makes equal effort. Hence, the amount of complementary and supplementary knowledge aggregation can be defined as $Q_c = \sum_i K_{ci}x_{ci}$ and $Q_s = \sum_i K_{si}x_{si}$, respectively.

Suppose each member in the product innovation team can get others' knowledge by direct interaction or by proper media. Then the knowledge sharing benefit a member enjoys can be formulated as $f(x_{pi}, Q_c, Q_s)$. For the sake of analytical convenience, we assume the benefit function $f(\cdot)$ can be represented by the Cobb-Douglas utility function $f(x_{pi}, Q_c, Q_s) = \alpha \ln x_{pi} + \beta \ln Q_c + \gamma \ln Q_s$, where α, β, γ are elastic coefficients. In addition, we define $C_{ci} \in \{C_{ch}, C_{cl}\}$, $C_{si} \in \{C_{sh}, C_{sl}\}$, and C_{pi} as the cost of a member's complementary knowledge, supplementary knowledge, and personal affairs, respectively. Each member receives a reward M_i for his/her efforts. Suppose all members are rational and self-interested in order to maximize the benefit under a given reward. Next we will discuss three types of setting to illustrate the performance of knowledge share: knowledge share with individual decision making (form 1), knowledge share with overall coordination (form 2), and knowledge share with incentive scheme (form 3).

2.1 Individual decision making

When making effort without overall coordination, a member would select x_{ci}, x_{si}, x_{pi} to maximize individual benefit function: $\max f(x_{pi}, Q_c, Q_s$, subject to $C_{ci}x_{ci} + C_{si}x_{si} + C_{pi}x_{pi} \leq M_i$. Solving the model simultaneously for each member yields Nash equilibrium.

Proposition 1

1. Lower knowledge-cost ratio members are free riders. Formally, $x_{ci}^* = \frac{\beta}{m_c \lambda_i C_{ci}}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $x_{ci}^* = 0$; $x_{si}^* = \frac{\gamma}{m_s \lambda_i C_{si}}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $x_{si}^* = 0$. $R_{\max c}$, $R_{\max s}$, m_c, m_s are defined in the proof.
2. The amount of complementary and supplementary knowledge aggregation is increasing with the proportion of members with that knowledge. Formally, $Q_c^* = \beta R_{\max c}$, $Q_s^* = \gamma R_{\max s}$.

Proof: Solving $\max f(x_{pi}, Q_c, Q_s) + \lambda_i(M_i - C_{ci}x_{ci} - C_{si}x_{si} - C_{pi}x_{pi})$ (λ_i is Lagrange multiplier) yields $\partial f/\partial x_{pi} = \lambda_i C_{pi}$, $\partial f/\partial Q_c K_{ci} = \lambda_i C_{ci}$, $\partial f/\partial Q_s K_{si} = \lambda_i C_{si}$. Then, we have $Q_c = \frac{\beta K_{ci}}{\lambda_i C_{ci}}$, $Q_s = \frac{\gamma K_{si}}{\lambda_i C_{si}}$, $x_{pi} = \frac{\alpha}{\lambda_i C_{pi}}$. So $x_{ci} = \frac{\beta}{\lambda_i C_{ci}} - \frac{1}{K_{ci}}\sum_{j \neq i} K_{cj}x_{cj}$, $x_{si} = \frac{\gamma}{\lambda_i C_{si}} - \frac{1}{K_{si}}\sum_{j \neq i} K_{sj}x_{sj}$. Thus, when $\frac{K_{ch}}{\lambda_i C_{ch}} \neq \frac{K_{cl}}{\lambda_j C_{cl}}$ and $\frac{K_{sh}}{\lambda_i C_{sh}} \neq \frac{K_{sl}}{\lambda_j C_{sl}}$ hold, we have a corner solution. The Nash equilibrium in this case is given by $x_{ci}^* = \frac{\beta}{m_c \lambda_i C_{ci}}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $x_{ci}^* = 0$; $x_{si}^* = \frac{\gamma}{m_s \lambda_i C_{si}}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $x_{si}^* = 0$, where $R_{\max c} = \max\{\frac{K_{ci}}{\lambda_i C_{ci}}\}$, $R_{\max s} = \max\{\frac{K_{si}}{\lambda_i C_{si}}\}$, m_c and m_s denote the quantity of members with higher complementary knowledge, supplementary knowledge, respectively. $\lambda_i = (\alpha + \frac{\beta I_c(i)}{m_c} + \frac{\gamma I_s(i)}{m_s})/M_i$, where $I_c(i) = 1$ if member i has higher complementary knowledge-cost ratios, otherwise $I_c(i) = 0$; $I_s(i) = 1$ if member i has higher complementary knowledge-cost ratios, otherwise $I_s(i) = 0$.

2.2 Overall coordination

Next, we illustrate the performance of form 2. In this scenario, each member's action is directed by overall coordination. Under overall coordination, we will prove that the performance of this form is more efficient. The model for knowledge-sharing under overall coordination can be given as $\max \sum_{i=1}^{n} f(x_{pi}, Q_c, Q_s)$ subject to $C_{ci}x_{ci} + C_{si}x_{si} + C_{pi}x_{pi} \leq M_i$ ($i = 1, 2, \ldots, n$). Solving the model, we get proposition 2.

Proposition 2

1. Higher knowledge-cost ratio members makes contribution to knowledge sharing activity. Formally, $x_{ci}^* = \frac{n\beta}{m_c \lambda_i C_{ci}}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $x_{ci}^* = 0$; $x_{si}^* = \frac{n\gamma}{m_s \lambda_i C_{si}}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $x_{si}^* = 0$.
2. The complementary and supplementary knowledge aggregation quantity grows with the team size and the proportion of members with that knowledge. Formally, $Q_c^* = n\beta R_{\max c}$, $Q_s^* = n\gamma R_{\max s}$.

Proof: Solving $\max \sum_{i=1}^{n} f(x_{pi}, Q_c, Q_s) + \lambda_i(M_i - C_{ci}x_{ci} - C_{si}x_{si} - C_{pi}x_{pi})$ (λ_i is Lagrange multiplier) yields $\sum_{i=1}^{n} \partial f/\partial Q_c K_{ci} = \lambda_i C_{ci}$, $\sum_{i=1}^{n} \partial f/\partial Q_s K_{si} = \lambda_i C_{si}$, $\partial f/\partial x_{pi} = \lambda_i C_{pi}$. Then, we have $Q_c = \frac{n\beta K_{ci}}{\lambda_i C_{ci}}$, $Q_s = \frac{n\gamma K_{si}}{\lambda_i C_{si}}$, $x_{pi} = \frac{\alpha}{\lambda_i C_{pi}}$. Therefore, when $\frac{K_{ch}}{\lambda_i C_{ch}} \neq \frac{K_{cl}}{\lambda_j C_{cl}}$ and $\frac{K_{sh}}{\lambda_i C_{sh}} \neq \frac{K_{sl}}{\lambda_j C_{sl}}$ hold, the effort of each member is given by $x_{ci}^* = \frac{n\beta}{m_c \lambda_i C_{ci}}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $x_{ci}^* = 0$; $x_{si}^* = \frac{n\gamma}{m_s \lambda_i C_{si}}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $x_{si}^* = 0$, where $\lambda_i = (\alpha + \frac{n\beta I_c(i)}{m_c} + \frac{n\gamma I_s(i)}{m_s})/M_i$.

2.3 Incentive scheme

Finally, we will introduce an incentive scheme, and hope the scheme may promote individual knowledge sharing in the case of no overall coordination. In this scheme, members choose x_{ci}, x_{si}, x_{pi} to optimize individual benefit. Formally, The problem is formally expressed by $\max f(x_{pi}, Q_c, Q_s)$ subject to $C_{ci}x_{ci} + C_{si}x_{si} + C_{pi}x_{pi} \leq M_i + P_{ci}x_{ci} + P_{si}x_{si}$, where $P_{ci}x_{ci}$, $P_{si}x_{si}$ is the reward for member i.

Proposition 3

The knowledge share benefit in form 3, can be equal to that of form 2, if each member is given reward $P_{ci}x_{ci}$, $P_{si}x_{si}$ according to his type. Formally, $P_{ci} = \frac{(n-1)C_{ci}}{n}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $P_{ci} = 0$; $P_{si} = \frac{(n-1)C_{si}}{n}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $P_{si} = 0$.

Proof: Solving $\max f(x_{pi}, Q_c, Q_s) + \lambda_i(M_i + P_{ci}x_{ci} + P_{si}x_{si} - C_{ci}x_{ci} - C_{si}x_{si} - C_{pi}x_{pi})$ (λ_i is Lagrange multiplier) yields $\partial f/\partial x_{pi} = \lambda_i C_{pi}$, $\partial f/\partial Q_c K_{ci} = \lambda_i(C_{ci} - P_{ci})$, $\partial f/\partial Q_s K_{si} = \lambda_i(C_{si} - P_{si})$. Then, we have $Q_c = \frac{\beta K_{ci}}{\lambda_i(C_{ci} - P_{ci})}$, $Q_s = \frac{n\gamma K_{si}}{\lambda_i(C_{si} - P_{si})}$, $x_{pi} = \frac{\alpha}{\lambda_i C_{pi}}$,. Thus, comparing Q_c here with $Q_c$in the proof of proposition 2, that is $\frac{\beta K_{ci}}{\lambda_i C_{ci} - P_{ci})} = \frac{n\beta K_{ci}}{\lambda_i C_{ci}}$, we have $P_{ci} = \frac{(n-1)C_{ci}}{n}$. Only higher knowledge-cost ratio members make contribution to knowledge aggregation. Therefore, only they receive compensation. Formally, $P_{ci} = \frac{(n-1)C_{ci}}{n}$ if $\frac{K_{ci}}{\lambda_i C_{ci}} = R_{\max c}$, otherwise $P_{ci} = 0$. Similarly, we have $P_{si} = \frac{(n-1)C_{si}}{n}$ if $\frac{K_{si}}{\lambda_i C_{si}} = R_{\max s}$, otherwise $P_{si} = 0$.

3 Simulations

In this section, we present a simulation example to verify the theoretical analysis. In the simulation, we choose $n = 30$, $\eta = 10$, $\alpha = 0.1$, $\beta = 0.2$, $\gamma = 0.2$, $K_{ch} = 6$, $K_{cl} = 2$, $K_{sh} = 6$, $K_{sl} = 2$, $C_{ch} = 2$, $C_{cl} = 1$, $C_{sh} = 2$, $C_{sl} = 1$, $C_{pi} = 1$, $M_i = 8$. Assume the repatriates have higher complementary knowledge than ordinary members, and ordinary members have higher supplementary knowledge than repatriates.

In this scenario, the simulation results are shown in Tab. 1 (The variables with subscript *r* and *o* denote variables related to repatriates and ordinary members, respectively). From the table we know that Q_c and Q_s in form 1 are less than these in form 2. It shows that individual decision making leads to insufficient knowledge aggregation. Q_c and Q_s in form 3 are equal to these in form 2. The compensations for member are $P_{cr} = 1.93, P_{co} = 0, P_{sr} = 0, P_{so} = 1.93$. It shows that individual decision making with incentive mechanism is as efficient as overall coordination. In addition, we can see $x_{sr} = 0$ and $x_{co} = 0$. Only repatriates exert effort to complementary knowledge aggregation and only ordinary members exert effort to supplementary knowledge aggregation. It seems reappearance of the free rider problem, but in fact it would make best use of human resource and let proper people do proper things.

Tab. 1 Simulation results

form	Q_c	Q_s	x_{cr}	x_{sr}	x_{pr}	x_{co}	x_{so}	x_{po}
1	40	43.6	0.67	0	6.67	0	0.36	7.27
2	205.7	360	3.43	0	1.14	0	3	2
3	205.7	360	3.43	0	7.77	0	3	7.8

In the following, we will analyze the sensibility of the parameters η, M_i, β, n. Let η vary from 1 to 29; we can get the curves of Q_c and Q_s (Fig. 1 and Fig. 2). Fig. 1 shows complementary knowledge aggregation increases with the number of repatriates. Fig. 2 shows supplementary knowledge aggregation decreases with the number of repatriates. This shows that the proportion of members influences the knowledge aggregation. This result is different from that in [6], where they propose that the amount of knowledge aggregation is fixed when the team size is fixed. The reason for the difference might lie in they do not refer to personal effort constraint and knowledge heterogeneity.

Let M_i vary from 2 to 10; we can get the curves of Q_c and Q_s (Fig. 3 and Fig. 4). The results show that complementary and supplementary knowledge aggregation increase with rewards paid by enterprises.

Let β vary from 0.1 to 0.6; we can get the curve of Q_c (Fig. 5). Let γ vary from 0.1 to 0.6, we can get the curve of Q_s (Fig. 6). Fig. 5 and Fig. 6 show complementary and supplementary knowledge aggregation increase with elastic coefficients of complementary and supplementary knowledge, respectively. Hence, managers may manage the transfer and exchange of supplementary and complementary knowledge by adjusting the elastic coefficients.

Let n vary from 20 to 50; we can get the curves of Q_c and Q_s (Fig. 7 and Fig. 8). The results show the amount of complementary and supplementary knowledge aggregation with individual decision making do not change with team size. The complementary and supplementary knowledge aggregation quantity with overall coordination and individual decision making with incentive mechanism increases with the team size, respectively.

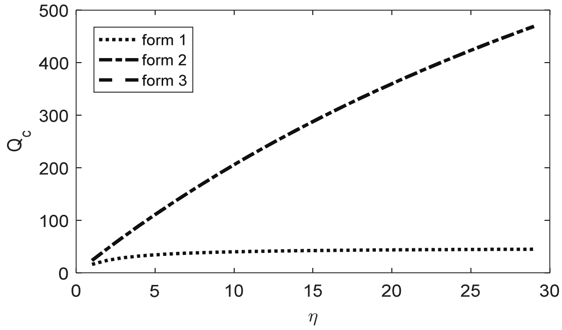

Fig. 1 Q_c and η

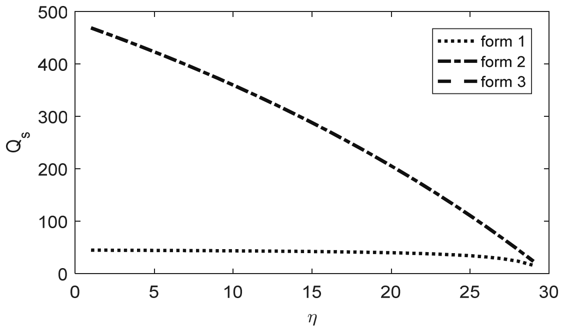

Fig. 2 Q_s and η

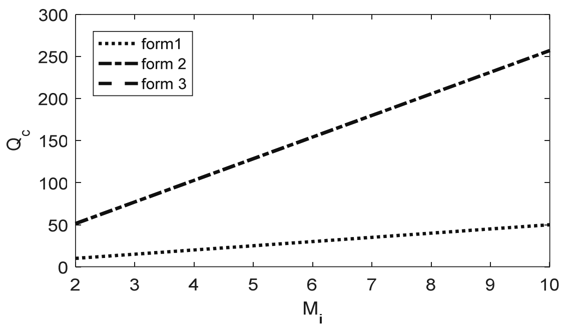

Fig. 3 Q_c and M_i

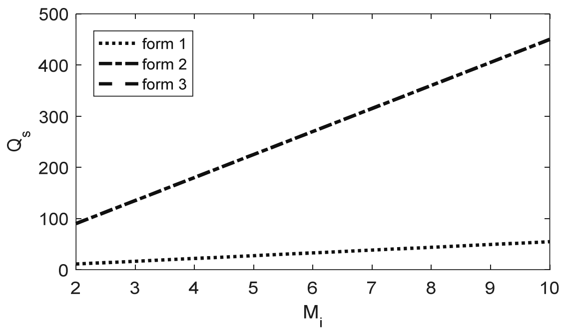

Fig. 4 Q_s and M_i

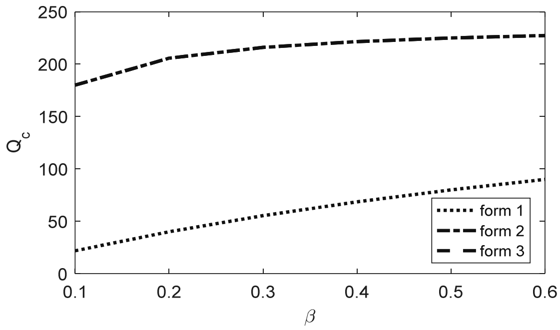

Fig. 5 Q_c **and** β

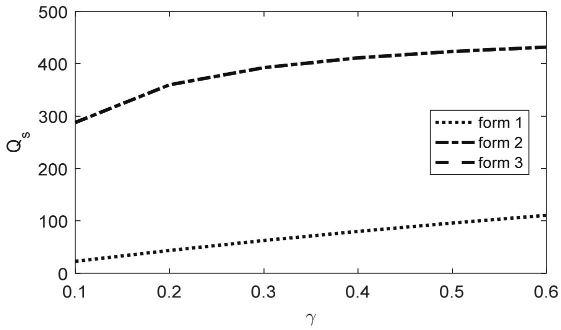

Fig. 6 Q_s **and** γ

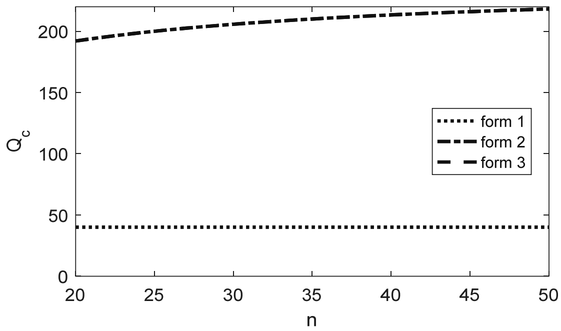

Fig. 7 Q_c **and** n

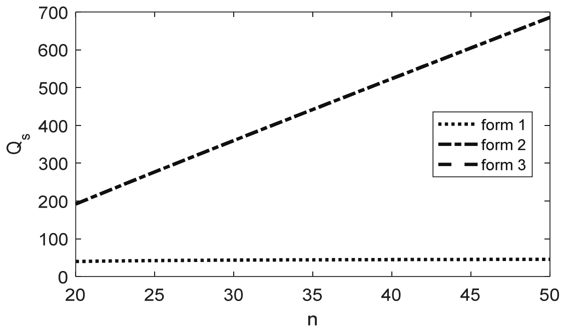

Fig. 8 Q_s **and** n

4 Conclusions and Discussions

This paper built a game model for repatriates knowledge transfer and exchange. According to the different value to the organization, knowledge heterogeneity is considered in the model. Knowledge of repatriates and ordinary members is divided to supplementary and complementary knowledge. Three typical scenarios were discussed to analyze the performance of knowledge sharing, including knowledge sharing with individual decision making, knowledge sharing with overall coordination, and knowledge sharing with incentive mechanism.

We do some improving work based on the existing literature. (1)The individual member's effort is limited, so we add a constraint to reflect this condition. (2)In the actual product development process, the knowledge is not homogeneous. According to the different roles in the process of product innovation, we divide knowledge into complementary knowledge and supplementary knowledge. (3) Actually, team members have some private work to do. So we add a variable, which is related to personal work, but not related to knowledge aggregation.

The following new findings are obtained on the basis of theoretical and numerical analysis. (1) The authors point out that the amount of knowledge aggregation is fixed when the team size is fixed in individual decision making case. However, we find that, when the team size is fixed, the amount of knowledge aggregation is increasing with the proportion of members with that knowledge. Therefore, when the team size is fixed, we can aggregate more required knowledge by increasing the proportion of members with the required knowledge. (2) Obtaining a balance between short and long term benefits is challenging. Managers can adjust the elastic coefficients of knowledge to manage the transfer of supplementary and complementary knowledge, and accordingly get a balance between short and long term benefits. (3) Both rewards paid by enterprises and compensations from the incentive mechanism can increase the amount of knowledge aggregation. Rewards paid by enterprises can promote both the complementary and supplementary knowledge aggregation, whereas compensations for the type of knowledge can only increase the corresponding knowledge aggregation. (4) The amount of complementary and supplementary knowledge aggregation with overall coordination and with incentive mechanism is greater than that with individual decision making.

According to these new finding, we have the following recommendations for mangers to improve effectivity of repatriates' knowledge transfer and exchange in product innovation team. Managers could motivate team members' knowledge transfer and exchange by planning and guiding members' efforts through overall coordination, or by designing appropriate incentive mechanism. Additionally, supplementary knowledge and complementary knowledge have different functions in product development. Managers can manage the transfer and exchange of supplementary and complementary knowledge by adjusting the elastic coefficients of the type of knowledge, and accordingly get a balance between short and long term payoffs.

One of future interesting topic is how to deal with incomplete information, such as the unobservable member's knowledge profile due to the knowledge tacitness. On the other hand, knowledge transfer and exchange relay on the interaction network among members. Therefore, the research efforts might focus on the knowledge transfer and exchange in the interaction network.

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