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GAME ANALYSIS OF KNOWLEDGE SHARING IN ENTREPRENEURIAL TEAM

Dan Bai[1,2] and Junfang Yin[1,2]

[1]School of Economics and Management
Dalian University
[2]Liaoning Key Laboratory of Cross-Border e-Commerce and Data Science
No. 10, Xuefu Street, Jinzhou New District, Dalian 116622, P. R. China
baidan@dlu.edu.cn; 976436623@qq.com

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Abstract. *The research related to the combination of knowledge sharing and game in entrepreneurial team is still in a relatively lagging state. Knowledge sharing plays a direct or indirect role in the development of entrepreneurial team, the fulfillment of psychological contract among team members and the performance of entrepreneurship. Based on the static game and dynamic game situation of two members in the same entrepreneurial team which is built on the complete information, the prisoner's dilemma model is used to analyze whether the member is willing to share their own knowledge with each other or not.*

Keywords: Knowledge sharing, Entrepreneurial team, Game analysis

1. **Introduction.** Individual is the smallest unit of the team, and his knowledge stock is the source of team knowledge. In another aspect, it is also the fountain of teams to create knowledge [1]. Knowledge sharing was increasingly recognised as the fundamental premise for organization to work effectively in the team. With the wide application of team work characterized by mutual cooperation, how to promote team knowledge sharing seems particularly important [2]. From the perspective of personal motivation, organizational culture and individual work performance, Li and Wang analyzed the correlation of knowledge sharing in organizations by positive research. These survey results have shown that these three dimensions and knowledge sharing have positive correlation with each other [3]. Feng and Liu pointed out the relationship between knowledge sharing behavior and the members of scientific research team in network location [4]. Hendriks studied knowledge sharing motivation through information and communication technology, and the empirical investigation explained that different information and communication technology influenced knowledge sharing behavior in different environments [5]. For the structure conditions of work groups, Cummings used logit to analyze the connections between the value of external knowledge sharing and employee performance. The results showed that the more complex the working group structure is, the closer the link between external knowledge sharing and performances [6]. Bartol and Srivastava thought that the relationship between monetary reward and knowledge sharing presented positive correlation, and that trust between individuals and organizations was also a key factor that prompted knowledge sharing to happen [7]. Cabrera and Cabrera stressed the importance of knowledge sharing in groups and which organization interventions facilitated knowledge sharing [8]. Above all, knowledge sharing has a great significance in individuals, organizations and groups. Research in the literature demonstrates that the majority of

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the researches about knowledge sharing are based on positive research; however, most of them are conducted on the basis of specific models for individual, few of them will be based on actual applications and used in the study of groups, and it is even rare to combine knowledge sharing and game in the entrepreneurial team. In the society, the more actively people are engaged in repeated games, the more people are willing to cooperate with each other. This article uses prisoner's dilemma model, assuming that the two members of the entrepreneurial team are in the process of static game and dynamic game under the full information. Through repeated games, analyze under what circumstances they will choose to share, and under what circumstances they will choose to unshare. Then the Nash equilibrium and subgame-refined Nash equilibrium are proposed; the proposal will show how to promote knowledge sharing and maintain the maximization of their respective interests.

2. **Theoretical Backgrounds.** Entrepreneurial team will be the main force in expanding the new business in the future. A number of actual situations indicate that the success rate of entrepreneurial team is much higher than individual entrepreneurship. However, the failure rate of starting a business at this stage is still much higher than the success rate. For example, Ran Gao, a journalism major at Tsinghua University, started his own business in 2004. Then, it ended in failure. In February, 2005, Ran Gao met Di Deng, a classmate from Tsinghua university, and another classmate from Peking University computer system, He Zhang. Their company merged to create Mysee.com. Then, attract millions of dollars in venture investment. Ran Gao continued to find project partners. With the project partner, they often communicate with each other. In their joint efforts, the road of entrepreneurship turned out successfully. In the context of theoretical background, other studies showed that good knowledge sharing had a significant and positive effect on interaction between members and it also could improve entrepreneurial performance. Given the research on this topic is scant and the findings are inconsistent, this paper tries to develop a better understanding of the topic. In the meanwhile, limited research has used the prisoner's dilemma to analyze the problem of knowledge sharing in entrepreneurial team. According to "Fortune Magazine", the failure rate of starting a business in the world is as high as 70%. In China, the failure rate of starting a business at the first time is more than 90% [9]. However, with the development of entrepreneurial economy on a global scale, entrepreneurial activity has driven economic growth and technical progress; in the meanwhile, the activities have also increased employment opportunities. Entrepreneurship is essentially the process of how an entrepreneur or team discovers opportunities and integrates resources to create value. Whether the members of the entrepreneurial team are willing to share their knowledge or not needs to combine with actual analysis. Instead of using positive research, this paper uses the prisoner's dilemma game method and aims to improve people's willingness to cooperate with others. From the perspective of non-cooperative game, we analyze the willingness of members to cooperate in the team by repeated games. In practical application, the success of entrepreneur team is of great interest both in increasing job opportunities and social development.

3. **The Influence of Various Key Drivers on the Knowledge Sharing Game.** Timmons and Spinelli built the entreprenurial process classical model and put forward entrepreneurial four elements in it, namely, entrepreneurs or teams, entrepreneurial opportunities, entrepreneurial resources and entrepreneurial environments [10]. Knowledge sharing among startup team members is one of the ways for startup teams to acquire resources. The knowledge sharing behavior among the members of the startup team will involve shared benefits, costs, earning and expected benefits. Among all these key drivers,

they are closely related to each other. At the same time, it is important for members to use the key features that facilitate knowledge sharing. For example, if the value is greater than the cost, members will choose to unshare their knowledge. Besides, something closely related to these factors are the reputation of the members in the team, the trustworthiness of the members and the communication atmosphere of the members. Both of them directly or indirectly affect whether knowledge sharing can proceed smoothly among members or not. If these factors can be well considered and resolved, it is more conducive to the development of knowledge sharing, the odds of team success will also increase.

4. Game Analysis of Prisoner's Dilemma in Entrepreneurial Team.

4.1. **Research hypothesis.** The prisoner's dilemma, a classic non-cooperative game model in the game model was put forward by Tucker in 1950 [11]. Two prisoners were separately herded into 2 rooms to lock up. In this way, test whether they choose to be frank or not when they cannot communicate with each other [11]. Next, to draw on this model, it represents the best individual choice, not the best choice for the group. However, the choice of knowledge sharing subjects to share strategies with each other often resembles the "prisoner's dilemma". On the basis of this model, we analyze the problem of knowledge sharing among the entrepreneurial teams according to the practical problems. And then put forward a solution to improve the knowledge sharing between teams. In order to facilitate the analysis, this article only analyzes the sharing game between the two dominant members A and B in the entrepreneurial team. With the development of games, prisoner's dilemma game model is not a single model. It is usually divided into static game of complete information, dynamic game of complete information, static game of incomplete information and dynamic game of incomplete information [12]. In the entrepreneurial team, this article analyzes the static game of complete information and the dynamic game of complete information in the prisoner's dilemma model. Suppose that two members have complementary knowledge, they can choose shared knowledge or unshared knowledge in the case of mutual independence, so, there are two strategies (shared, unshared). The main factors influencing the selection strategy of two members are the benefits U by having this knowledge in the team. The choice of sharing knowledge is beneficial to the balanced development and growth of the entire team. Choosing to unshare knowledge is conducive to the rapid development of individuals in the team. Moreover, there is also the value of shared knowledge V, the cost of shared knowledge C, the utility of shared knowledge V-C (value-cost). Because of sharing knowledge with the team members, there are some individual benefits P they lost. Due to the members sharing knowledge, there are also some expected profit L. Benefit matrices of member A and member B have been shown in Figure 1.

4.2. **Complete information static game based on entrepreneurial team.** Under full information conditions, the static game means that member A and member B fully understand the characteristics of each other. Both parties make decisions at the same

		Member A	
		shared	unshared
Member B	shared	$V_A - C_A - P_A - C_A + U_A + L_{B\to A}$ $V_B - C_B - P_B - C_B + U_B + L_{A\to B}$	$V_A - C_A + L_{B\to A}$ $V_B - C_B - P_B - C_B + U_B$
	unshared	$V_A - C_A - P_A - C_A + U_A$ $V_B - C_B + L_{A\to B}$	$V_A - C_A$ $V_B - C_B$

FIGURE 1. Two members' benefit matrix

time and only once. After giving the selection behavior of one party, the game player chooses the best one he can choose. A good strategy is to seek a Nash equilibrium. The benefit matrix is shown in Figure 1, while one member makes a decision, it does not affect another member to make his own decision. In the Nash equilibrium, when members choose their own strategies, they treat the other members' strategies as given, and they do not think about how their choices affect their opponent's strategy. Member A, B have two choices, shared and unshared. Suppose B chooses to share, A chooses to share the benefit is $V_A - C_A - P_A - C_A + U_A + L_{B\to A}$, choosing unshared the benefit is $V_A - C_A + L_{B\to A}$, which strategy A will choose depends on the size of $P_A + C_A$ and U_A. When B chooses to unshare, A chooses to share, the gain is $V_A - C_A - P_A - C_A + U_A$; and A chooses to unshare, the gain is $V_A - C_A$. At the same time, the choice of A depends on the size of $P_A + C_A$ and U_A. When $P_A + C_A > U_A$, A's optimal strategy is "unshared", when $P_A + C_A < U_A$, A's optimal strategy is "shared". Similarly, after A chooses, the result B faced is the same as A, the decision is exactly the same as A, B whether shared knowledge or not depends on the size of $P_A + C_A$ and U_A, therefore, the decision made by A and B is related to the loss P of the individual, and it is also related to the sum P + C of the sharing cost C and the size of the return U, but has nothing to do with the return L. When $P_A + C_A > U_A$, both of the team did not want to see the results (unshared, unshared) appeared, so in order to make $P + C < U$, make the results attained Pareto optimality, it is necessary to improve various tasks within the team to make the system more rational and avoid situations of mutual unshared, and break the prisoner's dilemma.

4.3. **Complete information dynamic game based on entrepreneurial team.** Compared with static game, dynamic game is not a simple game, but a multiple game. The essence of dynamic is a repeated game. Under the complete information dynamic game, both of the members are rational actors. In the startup team, most of the games among members are repeated. The members can research action reputation of each other among repeated games; in all these efforts, they will pay more attention to long-term benefit. Every time the results will be the reference of next time [1]. Moreover, all of the questions of dynamic game are trustworthiness. If you want to break prisoner's dilemma, you need to enhance trust level among members. The higher the level of trust is, the stronger the willingness to share knowledge is. Based on this, assumption that trust gives two members positive effect as R_A and R_B, distrust gives two members negative effect as T_A and T_B. Make $R_A = R_B = R$ ($R > 0$), $T_A = T_B = T$ ($T > 0$), time discount factor is δ ($0 < \delta < 1$), and it reflects that future benefits have impact on present. There are three concepts in dynamic games. That is subgame perfect Nash equilibrium, tit-for-tat strategy and time discount factor. Among unlimited times of dynamic games, we assume that both sides use tit-for-tat strategy. In the first game, the two parties both choose sharing policies. In infinite games, both sides choose sharing policies in the beginning, and then, they will choose the strategy the same as the first time in future choices. However, as long as one member chooses unshared, another member will choose unshared forever. In this case, because of the tit-for-tat strategy, (shared, sshared) is a subgame perfect Nash equilibrium of infinite games. In repeated games, the profit matrix of the two members is shown in Figure 2.

Under tit-for-tat strategy, assume that member A chooses to share in the first time, when member B also chooses to share, B gains $V_B - C_B - P_B - C_B + U_B + L_{A\to B} + R$, both parties will also choose in future games; at this moment, the discount value of the total benefit is

$$\pi_1 = (V_B - C_B - P_B - C_B + U_B + L_{A\to B} + R)\sum_{i=1}^{\infty}\delta$$
$$= \frac{V_B - C_B - P_B - C_B + U_B + L_{A\to B} + R}{1-\delta}.$$

If B chooses to unshare, B gains $V_B - C_B - P_B - C_B + U_B - T$, but it will cause A to choose unshare all the time to revenge B. In the meanwhile, B can only choose unshared policy, benefit is always $V_B - C_B - T$, and the discount value of the total benefit is

$$\pi_2 = (V_B - C_B - P_B - C_B + U_B - T) + (V_B - C_B - T)\sum_{i=1}^{\infty}\delta$$
$$= (V_B - C_B - P_B - C_B + U_B - T) + (V_B - C_B - T)\frac{\delta}{1-\delta}.$$

When $\pi_1 > \pi_2$, that is $\frac{P_B+C_B-U_B}{R+T+L_{A\to B}}$, B will choose to share; otherwise, unshared will happen. This phenomenon is the same as A. At this point (shared, shared) is subgame perfect Nash equilibrium. Only when the discount factor δ is large enough, will both parties choose to share.

	Member A		
		shared	unshared
Member B	shared	$V_A - C_A - P_A - C_A + U_A + L_{B\to A} + R$ $V_B - C_B - P_B - C_B + U_B + L_{A\to B} + R$	$V_A - C_A + L_{B\to A} + R$ $V_B - C_B - P_B - C_B + U_B - T$
	unshared	$V_A - C_A - P_A - C_A + U_A - T$ $V_B - C_B + L_{A\to B} + R$	$V_A - C_A - T$ $V_B - C_B - T$

FIGURE 2. The profit matrix for two members

5. **Conclusion.** The combination of game model and knowledge sharing, brings new thinking to knowledge sharing among teams. The research has indicated that knowledge sharing behavior will happen in complete information static game when the sum of knowledge sharing cost and the individual loss by knowledge sharing was much lower than acquired. Another case is when time discount factor is big enough in the complete information dynamic game, knowledge sharing behavior will also happen. Through the whole analysis, there are many valuable references to solve external development of team, internal integration and the effective implementation of knowledge sharing. In the meanwhile, the passage seeks out Nash equilibrium and subgame perfect Nash equilibrium through repeated game in the prisoner's dilemma. Then, propose the solution of the problem. On one hand, we should improve the level of trust between both sides; on the other hand, we can increase the odds of cooperative behavior and improve the chances for success of any business. From the analysis of the model of knowledge sharing in prisoner's dilemma, we should reduce sharing costs, increase sharing of benefits, coordinate the various elements of the team. In the meanwhile, promote the sharing of knowledge among startup teams. In the follow-up study, we should define rational people's own and rational meanings based on the premise of bounded rational people, and we should further analyze the repeated games under value rationality and objective rationality, improve the methods for solving prisoner's dilemma and strengthen cooperation among members. At the same time, we will establish a more comprehensive knowledge-sharing incentive mechanism, a corporate culture, and increase the expected benefits.

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