International Journal of u- and e- Service, Science and Technology
Vol.9, No. 12 (2016), pp.97-108
http://dx.doi.org/10.14257/ijunesst.2016.9.12.09

Game Analysis on the Lower Bound of Optimal Interval of Knowledge Heterogeneity in Virtual Practice Community

Liu Jing, MaYanyang, GuoYanli and Chen Jianbin*

Department of E-business
Beijing Union University
Beijing, China
Jianbin.chen@buu.edu.cn

Abstract

Knowledge Heterogeneity is the source of Knowledge Collaboration in Enterprise while the Virtual Practice Community constructed with Web 2.0 technology is a very important way to gain heterogeneous knowledge. Active Cross-border Innovation makes the virtual practice community to be heterogeneous knowledge preference nowadays. However, the appropriate degree of knowledge heterogeneity that can excite the community to be synergy equilibrium is difficult to seek. This paper studies on the signaling game analysis of knowledge heterogeneity in Virtual Practice Community based on two-period reputation model. We mainly analyze the lower bound of optimal interval of knowledge heterogeneity to reveal the management meaning of this optimal interval.

Keywords:*Knowledge Heterogeneity; two-period reputation model; game analysis;optimal interval*

1. Introduction

With the rapid progress of Web 2.0 technology recently, many companies have built their virtual practice communities (VPC) based on Internet. For example, Procter &Gamble launched the *Connect+Develop program* which allows inside R&D employees to innovate with outside cooperators including research institutions, customers, suppliers, individuals and even competitors. Up to 2006, 35% of P&G products have innovative ingredients outside the company. R&D productivity has increased by nearly 60%, and innovation success rate increased by more than two times, while innovation costs decreased by 20%.

The virtual community of practice is a kind of virtual communication platform, which is across time and space, free and open. Community members cooperate to realize knowledge innovation through information exchange and knowledge collaboration, in the process of influencing each other and encouraging each other [1]. The digitalization and non-friction attributes of VPC reduces the cost of knowledge management substantially. Virtual communities of practice enable enterprise not only to facilitate development and internal knowledge sharing, but also to guide employees, customers, suppliers and others involved in the problem solving process so as to obtain more heterogeneity of external knowledge. External knowledge is beneficial to improve the heterogeneity of enterprise knowledge resources which is conducive to innovation, while excessive heterogeneity will adversely affect the innovation performance [2]. It has been revealed that the relationship between knowledge heterogeneity and innovation performance appears as inverted *U* curve, and there is an optimal" range of knowledge heterogeneity. However, the discussion of optimal range has been limited to qualitative inferences; there is no quantitative research on the upper and lower bounds or the optimal value of that range. Under this circumstance, it is

*Corresponding Author

ISSN: 2005-4246 IJUNESST

very essential to pay more attention to measure the relationship between heterogeneity degree of enterprise knowledge resource and knowledge collaboration performance directly for theory research and enterprise practice (Krishnaveni & Sujatha, 2012). In this paper, the two stage reputation model is used to analyze the signal game, to find the lower limit of the optimal range of knowledge heterogeneity.

2. The Knowledge Cooperation Game Model in VPC

The knowledge collaboration process based on heterogeneous knowledge is actually a series of complex activities of knowledge search decisions, while each decision making depends on the cost and profit tradeoff. Community members' will gain reputation and knowledge spillover effect based on trust and mutual benefit in knowledge search, while they need to pay the cost of knowledge transformation, signal recognition and processing, individual information loss and so on. When the search cost is too high, the knowledge searching process will stop. Therefore, the information searching theory and reputation model can be used to study the boundary problem of knowledge searching, that is, what degree of the knowledge heterogeneity can bring more effectiveness to push the decision of knowledge searching, which is the problem of the lower limit value of the optimal range of knowledge heterogeneity.

2.1.The Relationship between Knowledge Heterogeneity and Innovation Performance

Currently, there are many definitions of Knowledge Heterogeneity. For example, in the field of marketing, Bonne and Walker [3] consider that customer knowledge heterogeneity refers to the differentiation degree of product information obtained by the influential customers about the technology, market, strategy and the social effect. In the strategic area, Rodan and Galunic [4] define knowledge heterogeneity as the diversity degree of knowledge, know-how and skills that are available to the individual. In the field of technological innovation, Argyres [5] believes that the heterogeneity of technical knowledge is a measure of the narrow or wide range of internal technology development. In literatures at home and abroad, there are some concepts which are related with or similar to Knowledge Heterogeneity, such as Knowledge Diversity or Knowledge Variability [4], Technological Diversity [6], Cognitive Distance and so on.

The influence of knowledge heterogeneity on the growth and development of enterprises is the core issue in this field. Most scholars believe that the degree of knowledge heterogeneity will affect the knowledge innovation performance of enterprises, the relationship between them can be described as an inverted *U*-shaped (non-linear function) [6-8], which means that, with highly heterogeneous knowledge, enterprises have more opportunities to contact with external heterogeneous knowledge which is beneficial to knowledge innovation; but when the management cost of coordination and communication overcomes the benefit from heterogeneous knowledge, the total performance will decrease (as shown in Figure 1). In China, there are also many scholars who have studied this relationship, such as Ye [9], Ni [10], Wu [11], Xu [12] and Wang[13], *etc.*

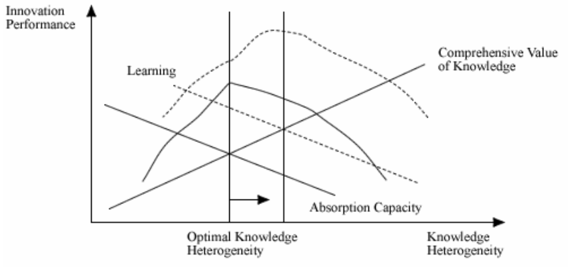


Figure 1. Relationship between Knowledge Heterogeneity and Knowledge Innovation Performance

2.2.The Game Analysis of Knowledge Cooperation in Practical Communities

Although it can be used to facilitate the business VPC to pursuit heterogeneous knowledge, Web 2.0 is only a technique. Whether the members in VPC are willing to participate in knowledge sharing and collaboration depends on personal consideration of knowledge as competitive resource. There are many factors influencing the knowledge sharing and collaboration decision, which mainly include personal preferences, group identity, and sense of honor, altruism and personal needs [14]. Other factors also include community organization environment, relation network establishment, reputation increase and expected income [15], *etc.* According to Rational behavior theory, individuals make decisions to maximize their utilities, the decision making process is a kind of game among the knowledge subjects Through the analysis of the static and dynamic game of the tacit knowledge sharing in the virtual community, Zhang *et. al.*, [16] proposes enhancing the ease of use, fulfilling the commitment, cultivating trust and other strategies can promote knowledge sharing. Sun [17] established an evolutionary game model of knowledge sharing within Web 2.0 environment, and the analysis shows that the sense of self-efficacy, material incentive, knowledge sharing cost, the loss after knowledge sharing, cost of searching and matching are factors that influence the strategy selection in knowledge sharing.

Social exchange theory thinks the innovation participants tend to participate in knowledge contribution, information providing, program improvement, questions reply for members of the community *etc.*, only based on their expectations on non-monetary or future earnings [28]. Only when the expected benefits are greater than costs, the knowledge contribution behavior is possible. Benefits include self-efficacy, pleasant feeling from altruism, organizational reward, reputation and possible reciprocity, while costs include compilation and interpretation cost of individual knowledge contribution [18]. Under the network environment, the enterprise knowledge innovation is embedded in the complex social network, the cooperative innovation and knowledge sharing is a part that cannot be neglected. Knowledge spillover effect increases the overall effectiveness of the community, which not only affects the cooperating intentions of community members, but also affects the knowledge collaboration mode and path selection [19].

2.3. Reputation Model of Knowledge Cooperation Game

Based on rational behavior theory and social exchange theory, VPC knowledge sharing/collaboration are heterogeneous knowledge exchange game behaviors in which reputation plays a significant role. The reputation of the previous stage often affects the utilities or profits gained in the next stage and later stage. Better reputation in present stage often means more utilities in the future. Therefore, some type of participants may pretend to be another type of participants to build reputation and obtain higher utility, and then they will take advantage of this reputation at the end of the game. However, it certainly needs cost to establish reputation, so it's a trade-off. Kreps *et. al.*, [20] introduced incomplete information theory into repeated game， and established the famous KMRW reputation model which solved the paradox of limited repeated game. Since then, the reputation model has been used to study the government governance [21-22], market negotiations [23] and other areas of the game problem. However, there are two limitations for traditional reputation models like KMRW model. Firstly, they are generally used to consider the repeated game which is static in a single stage, and don't consider the incomplete repeated game which means the decision (non-posterior inference) will influence the utility function of the next stage, but if the participants don't take positive action in the next stage, this effect will disappear. Secondly, they assume that the both sides in a game will act at the same time in a single stage, without considering the dynamic game in a single stage, such as signal game situation. While in reality, these two kinds of situations are more common. For example, the game of knowledge cooperation in the community has characteristics of incomplete repeated game and single stage dynamic game. Xiao & Sheng [24] established a two stage reputation model based on KMRW and signaling game (the first stage of signaling games), which provides helpful reference to the analysis in this paper.

3. The Cooperation Game Analysis in VPC based on Heterogeneous Knowledge Exchange

Suppose that there are two participants with a certain degree of knowledge heterogeneity in a VPC, which can be described as *s* (seeker) and *p* (provider). The optimal signal for separation equilibrium will be studied through the analysis of two-stage game of knowledge cooperation in the community; the optimal signal is the threshold of knowledge heterogeneity. Multi stage case can be regarded as the two stage game.

3.1.Basic Assumptions

The knowledge collaboration in VPC is a proper connection between the problem-driven knowledge seeker and provider [25], and the knowledge heterogeneity is a prerequisite for the collaboration. That is to say, it is a heterogeneous knowledge seeking process when the knowledge seeker presents questions to pursue solutions and cooperation. When the provider participates in the question solving process according to his understanding of the problem and his knowledge resources, a knowledge innovation process comes into being. In this process, there are certain degrees of heterogeneity between knowledge of the question, the answer to the question and the overall knowledge of the whole community, so the interactive question-answering process is just a process of knowledge collaboration and value appreciation.

Based on the theoretical analyses above, this paper proposes the following assumptions:

1) There are two kinds of participants in the VPC, which are the knowledge seeker and provider. There are certain degree of knowledge heterogeneity among each participant, the participants and the whole community. Knowledge heterogeneity is private information, other people can only predict the knowledge heterogeneity through observation of transmission of signals, knowledge collaboration results, and so on.

2) In a certain range, the higher the knowledge heterogeneity and the higher the cost of the problem describing and the knowledge processing, the greater value of knowledge innovation gains.

3) Each participant has a motivation to establish a reputation. Participants with low knowledge heterogeneity, due to the limitation of value-added space, have the possibility of using the reputation. Participants with high knowledge heterogeneity have lower possibility of reputation using.

4) The knowledge seeker sends the signal of knowledge collaboration, and the knowledge provider determines his knowledge heterogeneity, makes a decision to act according to the signal.

5) Sending a signal and providing the knowledge both need cost and bring negative effects, which include not only the direct costs of signal generation, knowledge process and others, but also the value decrease of private information disclosure.

3.2.Model Overview

In the first stage, knowledge seeker designated *s* has private information, and can be divided into two types, $t=(L,H)$; L means low degree of knowledge heterogeneity, and H means high degree of knowledge heterogeneity. Suppose that knowledge seeker *s* hasn't established a reputation or is the first time to participate in the practice community in the first stage, so it is uncertain of *s* is *L* or *H* for the community in this time. But to get higher heterogeneous knowledge in communities of practice, *s* usually act first and send knowledge collaboration signal which has heterogeneity of $\lambda_1 (1 \ge \lambda_1 \ge 0)$. Before sending signals, *s* has predicted the action of knowledge provider will take. The knowledge provider *p* will infer the types of *s* while receiving the signal, and take action $q_1 \ge 0$ depending on the inference. In the first stage, the utility function of *s* is assumed as [24]:

$$U_1(t,\lambda_1,q_1) = a_1q_1 - b_1(t)\lambda_1^{\ 2} - e_1\lambda_1 \tag{1}$$

In which a_1 >0, and the first item on the right side denotes the positive utility of knowledge seeker *s* get while knowledge providers *p* taking action q_1. The bigger q_1 is, the bigger positive utility for *s* will be. e_1 >0, $b_1(t)$ >0, the second and third items denote the negative utility of *s* brought by sending signal, namely, the signaling cost. The bigger the signal is, the greater the negative utility will be. The negative utility of the transmission signal of *L* type is larger than the negative utility of type *H*.

In the first stage, the utility function of knowledge provider *p* is

$$V_1(t,\lambda_1,q_1) = c(t)\lambda_1q_1 - dq_1^{\ 2} \tag{2}$$

Where $0 < c(L) < c(H)$, *p* is more in favor of the *H* type *s*, and the first item on the right side of the equation denote the positive utility taken from action *p* . When d >0, the second item denote the negative utility of *p* brought with action q_1, that is, the cost of action, the marginal negative utility increment.

In the second stage, the utility function of *s* can be set of

$$U_2(t,\lambda_1,\lambda_2,q_2) = a_2q_2 - b_2(t)\lambda_2^{\ 2} - f\lambda_2 + e_2\lambda_1 \tag{3}$$

Where a_2 >0; $b_2(t)$ >0; $b_2(L) > b_2(H) > 0$; f >0; e_2 >0. The last item of the right side denotes the positive utility brought by signals sent in the first stage.

3.3.Reputation Model Building

The knowledge seeker *s* with type *L* has motivation to establish a reputation in the first stage, and use this reputation in the second stage. (*s* with type *H* does not have this motivation.) Taking reputation into account, it is essential to calculate the optimal signal $\lambda_1{*}(t)$ sent in the first stage by *s* with type *L*. At this time, $t = H$. In order to calculate the optimal signal $\lambda_1{*}(H)$, the optimal signal $\lambda_2{*}(t)$ sent by *s* at the second stage need to be solved firstly.

First of all, we can know that in the first stage, the knowledge provider *p* and seeker *s* make the signal game, get a result of unique separation equilibrium. The knowledge provider *p* infer the type of *s* (*L* or *H*), and take action in accordance with this belief in the second stage in which the information is complete information. The game between *p* and *s* is the *Stackelberg* game, the reverse induction method is used to solve this problem.

To solve the utility function (2) of *p* on the first-order condition of q_2 with $i = 2$, the optimal reaction function will be

$$q_2(t,\lambda_2) = \frac{1}{2}c(t)d^{-1}\lambda_2 \tag{4}$$

To substitute (4) into (3), the first order condition of the λ_2 is obtained by the partial derivatives:

$$\frac{\partial U_2(t,\lambda_1,\lambda_2,q_2(t,\lambda_2))}{\partial \lambda_2}=\frac{1}{2}a_2c(t)d^{-1}-f-2b_2(t)\lambda_2=0 \tag{5}$$

The solution of (5) is then the optimal signal of *s* in the second stage. The solution is

$$\lambda_2*(t)=\frac{1}{4}a_2b_2^{-1}(t)c(t)d^{-1}-\frac{1}{2}b_2^{-1}(t)f \tag{6}$$

In the first stage, information is asymmetric and *s* has information advantage. Because the signal size in the first stage will affects the utility in the second stage, the knowledge seeker *s* should has a long-term point of view, paying attention to these effects. Denote δ ($0<\delta\le 1$) as the stage discount factor, the objective of *s* in the first stage is to maximize his two-stage discounted utility:

$$U(t,\lambda_1,q_1)=U_1(t,\lambda_1,q_1)+\delta U_2(t,\lambda_1,\lambda_2*(t),q_2(t,\lambda_2*(t))) \tag{7}$$

To solve the utility function (2) of *p* on the first-order condition of q_1 with $i=1$, the optimal reaction function can be get as

$$q_1(t,\lambda_1)=\frac{1}{2}c(t)d^{-1}\lambda_1 \tag{8}$$

Then we can get the Theorem 1: if the utility functions of *s* and *p* are determined by the formula (7) and (2), the perfect Bayesian Nash equilibrium outcome (*ISGPBE*) satisfying intuitive criterion exists and is unique, which is separating equilibrium.

To substitute (8) into (7), the first order condition of the λ_1 is obtained by the partial derivatives:

$$\frac{dU(t,\lambda_1,q_1(t,\lambda_1))}{d\lambda_1}=\frac{1}{2}a_1c(t)d^{-1}-2b_1(t)\lambda_1-e_1+\delta e_2=0 \tag{9}$$

Obviously the second order condition is also satisfied. Then the solution of formula (9) is the optimal solution.

$$\lambda_1*(t)=\frac{1}{2}b_1^{-1}(t)[\frac{1}{2}a_1c(t)d^{-1}-e_1+\delta e_2] \tag{10}$$

On complete information condition, the optimal point of type *t* is $(\lambda_1*(t),q_1(t,\lambda_1*(t)))$.

On incomplete information condition, the outcome *ISGPBE* of *s* with type *L* is the optimal point $(\lambda_1*(L),q_1(L,\lambda_1*(L)))$ on complete information condition.

$$U[L,\lambda_1,\frac{1}{2}c(H)d^{-1}\lambda_1]=U[L,\lambda_1*(L),\frac{1}{2}c(L)d^{-1}\lambda_1*(L)] \tag{11}$$

Solve (11) and get the maximum root:

$$\lambda_{1+}^{*}=\frac{1}{2}b_1^{-1}(L)[\frac{1}{2}a_1c(H)d^{-1}-e_1+\delta e_2 + \sqrt{[\frac{1}{2}a_1c(H)d^{-1}-e_1+\delta e_2]^2-4b_1(L)E}] \tag{12}$$

Where $E=[\frac{1}{2}a_1c(L)d^{-1}-e_1+\delta e_2]\lambda_1^{*}(L)-b_1(L)\lambda_1^{*2}(L)$.

Denote $\lambda_1^{*}(H)=\max\{\lambda_1^{*}(H),\lambda_{1+}^{*}\}$.

On the incomplete information condition, the outcome *ISGPBE* of *s* with type *H* is $[\lambda_1^*(H), \frac{1}{2}c(H)d^{-1}\lambda_1^*(H)]$.

3.4.The Solution of Reputation Model

The optimal signal $\lambda_1^*(H)$ sent by *s* with type *L* in the first stage is

$$\lambda_1^*(H) = \max\{\lambda_1^*(H), \lambda_{1+}^*\}$$

At the first stage, knowledge seeker *s* sends knowledge collaboration signal which has the heterogeneity of $\lambda_1^*(H)$ to establish reputation, and knowledge provider *p* takes the perfect action after thinking about this signal. The prefect action denote as

$$q_1(H, \lambda_1^*(H)) = \frac{1}{2}c(H)d^{-1}\lambda_1^*(H)$$

And *p* mistakes *s* as the type of *H* in the second stage. So *p* takes action as:

$$q_2(H, \lambda_2) = \frac{1}{2}c(H)d^{-1}\lambda_2$$

Therefore, the utility function of *s* with type *L* will be

$$U_2(L, \lambda_1^*(H), \lambda_2, q_2(H, \lambda_2))$$
$$= \frac{1}{2}a_2c(H)d^{-1}\lambda_2 - b_2(L)\lambda_2^{\ 2} - f\lambda_2 + e_2\lambda_1^*(H) \quad (13)$$

With same method to solve this equation, the optimal signal can be calculated as

$$\lambda_2^*(L) = \frac{1}{4}a_2b_2^{-1}(L)c(H)d^{-1} - \frac{1}{2}b_2^{-1}(L)f \quad (14)$$

where $c(H) > c(L) > 0$.

Hence, $\lambda_2^*(H) > \lambda_2^*(L) > 0$, which means that if the knowledge seeker *s* has established reputation in the first stage, the optimal signal sent in the second stage will be greater than the optimal signal without reputation consideration.

For *s* with type *L*, the reputation in the last stage can support the higher signal in the next stage. If *s* with type *L* pretends to be type *H* in the first stage, and uses the reputation in the second stage, then in equilibrium condition, his utility of the first stage will be less than or equal to the utility without considering reputation in the first stage in equilibrium. That is, the inequality holds as following.

$U_1(L, \lambda_1^*(H), q_1(H, \lambda_1^*(H))) \le U_1(L, \lambda_1^*(L), q_1(L, \lambda_1^*(L)))$ If the knowledge seeker *s* with type *L* pretending to be a type of *H* in the first stage, and using reputation in the second stage, then in equilibrium condition, his utility of the second stage will be greater than the utility of the second stage without pretending to be a type *H* in the first stage.

Thus, if *s* with type *L* establishes reputation in the first stage and uses it in the second stage, he will lose part of utility in the first stage, but will gain more utility in the second stage. If *s* with type *L* is rational, he will weigh the pros and cons, and compare the total utility of the two stages with reputation and without reputation, in order to determine the size of the transmission signal. In this case, the size of heterogeneity sent in the signal for knowledge collaboration determines the final utility. According to the assumption (2), in the process of knowledge heterogeneity increasing, the practice community is in favor of high heterogeneity knowledge, so the optimal signal $\lambda_1^*(H)$ is the trigger point of knowledge collaboration. The knowledge seeker *s* with type *L* should send knowledge collaboration signal with heterogeneity $\lambda_1^*(H)$ to make the participation of both sides in the game to get a balanced result, that is, knowledge providers have enough driving force to participate in collaborative activities.

4. The Significance of Curve Relationship for Enterprise Knowledge Management

4.1. Theoretical Significance

There is an inverted *U* curve relationship between knowledge heterogeneity and knowledge innovation performance, that is, there exists an optimal range of knowledge heterogeneity, which makes the innovation performance more significant. Then how to determine the lower and upper boundary of the interval is the problem. For the lower boundary, it means that when the knowledge heterogeneity is higher than this value, knowledge innovation performance will be promoted significantly. It can be regarded as the threshold of knowledge heterogeneity to work. In this paper, a reputation model is used to solve the optimal solution $\lambda_1^*(H)$ of the heterogeneity of the signal, which is the threshold value. When the enterprise knowledge heterogeneity is in the interval $(0,\lambda_1^*(H))$, it means that knowledge homogeneity is high, and the performance of enterprise knowledge innovation is low; when knowledge heterogeneity degree is in the interval $(\lambda_1^*(H),\lambda^*)$, knowledge heterogeneity will influence the performance of enterprise knowledge innovation significantly (as shown in Figure 2), where the value λ^* is the upper bound of knowledge heterogeneity. After the knowledge heterogeneity increases to the upper boundary, with the increasing of heterogeneity, the cost of knowledge processing and utilization rises rapidly. There are more and more risks in enterprise innovation, and the success rate becomes lower. In this case, the innovation profits cannot cover the cost of the loss, and the total performance will decrease rapidly. This paper mainly discusses the lower limit value.

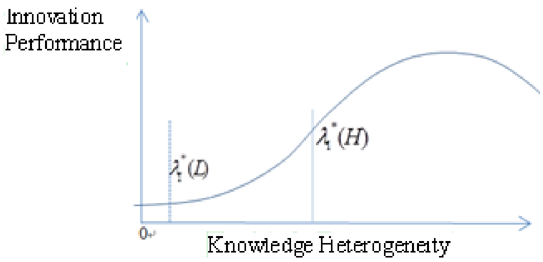


Figure 2. The Lower Limit of Optimal Range of Knowledge Heterogeneity

4.2. Practice Significance

For those enterprises within today's complex social and network relationship, the competitive advantage to a large extent depends on the knowledge resources occupancy and usage, especially the pursuit of heterogeneous knowledge. This is a significant characteristic in the Internet era of the sharing economic model. In this paper, we established a reputation model based on game theory, the lower boundary of knowledge heterogeneity has been analyzed. Its purpose is to help enterprises to grasp the size of knowledge heterogeneity and make use of the knowledge collaboration to increase the knowledge innovation performance. The specific guiding significance lies in:

1) The practice community should maintain knowledge at a “moderate" degree. If a community pursues interests and professionalism excessively, the knowledge

heterogeneity will stay at a lower level and the innovation performance will be affected. Therefore, heterogeneous knowledge sources should be introduced effectively so that the whole community's knowledge heterogeneity can span the point $\lambda_1^*(H)$ and be active in the $(\lambda_1^*(H),\ \lambda^*)$, which can increase the Knowledge Collaboration of the community tremendously.

2) The business VPC is an open system based on Web2.0 technology, in which the knowledge seeker and provider cooperate and share knowledge in order to reduce the cost of knowledge management. Therefore, we should actively guide the employees, customers, suppliers, *etc.*, to participate in the problem-solving process so as to obtain more heterogeneous external knowledge. At the same time, we should open up the boundary of the enterprise, increase the introduction and development of innovative talents, strengthen the supply of human resources, and provide platform support for the production, transfer and application of technology and knowledge resources.

3) The premise of the application of reputation model is that the lack of trust between the participants because of incomplete information. In order to improve the performance of knowledge innovation, enterprise should actively explore the establishment of trust mechanism between employees and enterprises within supply chain network besides the fine platform buildup. The important principle is to strengthen cooperation and take corresponding risks with sincerity attitude, especially to improve information sharing mechanism between suppliers and customers. Only in this way, enterprises can capture heterogeneous knowledge, technology innovation inspiration, ideas and opportunities more effectively.

Acknowledgments

The authors gratefully acknowledge the National Natural Science Fund Project "Quantitative Analysis on Knowledge Heterogeneity and Knowledge Collaboration Performance-An Empirical Study of Social Data of Community of Practice" (71572015) and the Funding project of research plan from the Education Committee of Beijing " Research on Capital High-tech Production Industry Decision-making Mechanism and its Application based on Web 2.0"(SZ201311417001)

References

[1] Z. Juanjuan, Y. Qinjian, H. Qi and D. Nannan,"Tacit Knowledge Sharing and Improvement Strategy of Virtual Community," Libray Theory and Practice, no.10, **(2014)** October, pp. 105-108.

[2] E. Enkel and S. Heil, "Preparing for Distant Collaboration:Antecedents to Potential Absorptive Capacity in Cross-industry Innovation," Technovation, vol. 34, no. 4, April **(2014)**, pp. 242-260.

[3] J. M. Bonner and O.C. Walker Jr., "Selecting Influential Business-to-Business Customers in New Product Development: Relational Embeddedness and Knowledge Heterogeneity Considerations," Journal of Product Innovation Management, vol. 21, no. 3, **(2004)** May, pp. 155-169.

[4] S. Rodan and C. Galunic, "More than network structure: how knowledge heterogeneity influences managerial performance and innovativeness," Strategic Management Journal, vol. 25, no. 6, June **(2004)**, pp. 541-562.

[5] N. Argyres, "Capabilities, Technological Diversification and Divisionalization," Strategic Management Journal, vol.17, no. 5, **(1996)** May, pp. 395-410.

[6] Y. F. Huang and C. J. Chen, "The impact of technological diversity and organizational slack on innovation," Technovation, vol. 30, no. 7-8, **(2010)** July-August, pp.420-428.

[7] B. Nooteboom, W. V. Haverbeke, G. Duysters, V. Gilsing and A. V. den Oord, "Optimal cognitive distance and absorptive capacity," Research Policy, vol. 36, no. 7, **(2007)** September, pp.1016-1034.

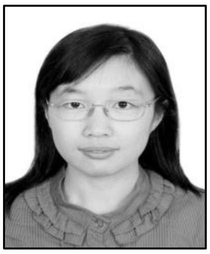
[8] V. V. de Vrande, "Balancing your technology-sourcing portfolio: How sourcing mode diversity enhances innovative performance," Strategic Management Journal, vol. 34, no. 5, **(2013)** May, pp. 610-621.

[9] Y. Jiangfeng, R. Hao and T. Chen, "The Mechanism of Knowledge Heterogeneity Facilitating Enterprise Innovation: Literatures.

[10] Review and Framework Building ," Science Of Science And Management Of S. & T., vol. 35, no. 9, **(2014)** September, pp. 120-129,

[11] N. Xudong and X. Xianfang, "The Operation Mechanism of Knowledge Heterogeneity Network Based on Team with Knowledge Heterogeneity," Advances in Psychological Science, vol. 21, no. 3, **(2013)** March, pp. 389–397.
[12] W. Yan, "Influence of Knowledge Heterogeneity on Entrepreneurial Performance of Entrepreneurial Team," Scicence Research Management, vol. 35, no. 7, **(2014)** July, pp. 84-90.
[13] X. Qiang and S. Fang, "The Relationship of Parent-Subsidiary Corporation from Knowledge-Structure Perspective," Science & Technology Progress and Policy, vol.21, no. 5, **(2004)** May, pp. 92-94.
[14] W. Ying and P. Can, "Research on the Relationship between Knowledge Heterogeneity and the Knowledge Innovation Performance: Based on the R & D Team," Science & Technology Progress and Policy, vol. 29, no. 4, **(2012)** February, pp.119-123.
[15] L. Zhihong and Z. Tao, "Research on the Knowledge Diffusion of Communities of Practice Based on the Weighted Small-world Network Model," Soft Science, vol. 24, no. 2, February **(2010)**, pp. 51-55.
[16] J. Hao and Z. Chuanhua, "Research on the Support Elementsfor Community of Practice in the Cultural Industries," Science and Technology Management Research, vol. 34, vol. 3, **(2014)** March, pp. 121-126.
[17] Z. Ru, "Analysis of the Evolutionary Game of Knowledge Sharing Behaviors among the Virtual Community Users Based on Trust Levels," Journal of Modern Information, vol. 34, no. 5, **(2014)** May, pp. 161-165.
[18] S. Jinglei, Z. Xi, Z. Mi and W. Wen, "Intra-organization Knowledge Sharing under Web2. 0 Environment Based on Evolutionary Game," Soft Science, vol. 27, no. 5, May **(2013)**, pp. 105-107.
[19] A. Kankanhalli, B. Tan and K. K. Wei, "Contributing Knowledge to Electronic Knowledge Repositories: An Empirical Investigation," MIS Quarterly, vol. 29, no. 1, **(2005)** March, pp.113-143.
[20] Z. Siwen and Y. Daming, "The Competition-collaboration Game of Enterprise knowledge Innovation under the Networks Environment," Systems Engineering, vol. 30, no. 10, **(2012)** October, pp. 98-102.
[21] D. M. Kreps, P. Milgrom, J. Roberts and R. Wilson, "Rational Cooperation in the Finitely Repeated Prisoners' Dilemma," Journal of Economic Theory,vol. 27, **(1982)** August, pp. 245-252.
[22] R. J. Barro, "Reputation in a model of monetary policy with incomplete information," Journal of Monetary Economics, vol. 17, **(1986)** January , pp. 3-20.
[23] J. Vickers, J. "Signalling in a Model of Monetary Policy with Incomplete Information", Oxford Economic Papers, vol. 38, **(1986)** November, pp. 443-455.
[24] D. Abreu and F. Gul, " Bargaining and Reputation," Econometrica,vol. 68, no. 1, **(2000)** January, pp. 85-117.
[25] X. Tiaojun and S. Zhaohan, "Two-period reputation model based on signaling game," Journal of Management Sciences in China, vol. 6, vol. 1, **(2003)** February, pp. 27-31.
[26] C. Jianbin, G. Yanli and X. Kaibo, "Performance of Knowledge Collaboration Based on Capital Appreciation," Science Of Science And Management Of S. & T., vol. 35, no. 5, **(2014)** May, pp. 35-43.
[27] R. Krishnaveni and R. Sujatha, "Communities of practice: An influencing factor for effective transfer in organizations," The IUP Journal of Knowledge Management, vol. 10, no. 1, **(2012)** January, pp. 26-40.
[28] R. V. W. de Joode and M. D. Bruijne, "The organization of open source communities: Towards a framework to analyze the relationship between openness and reliability," System Sciences, 2006. HICSS '06. Proceedings of the 39th Annual Hawaii International Conference on IEEE, vol. 6, **(2006)**, pp. 118b-118b.

Authors



Liu Jing(1979-), Is Lecturer of Information management at Beijing Union University, holds a master degree(2003) of management science. Recent years, she observes her interest on Knowledge Management or Knowledge Collaboration(KC), had published several journal articles and a book about KC.

Ma Yanyang(1991-), Is the postgraduate in Beijing Union University, majoring in Economics and Management of Technology, mainly engaged in cultural industry of Beijing.

Guo Yanli(1978-), Is Associate Professor of Information management at Beijing Union University, holds a master degree (2006) of management science and engineering and a doctor degree (2011) of management science and engineering. Recent years, he observes his interest on IT Service Supply Chain (SSC) or Knowledge Collaboration(KC), had published several journal articles and books.

Chen Jianbin(1970-), Is Professor of Information management at Beijing Union University, holds a master degree(1996) of system engineering and a doctor degree(2005) of Computer Application. Recent years, he observes his interest on Knowledge Management or Knowledge Collaboration(KC), had published several journal articles and a book about KC.