COOPERATION INNOVATION OF VIRTUAL INDUSTRY CLUSTER----BASED ON EVOLUTIONARY GAME

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ABSTRACT

In this paper, we researched on effects of knowledge resources to the enterprise cooperation innovation strategy select, and established an evolutionary game model of cooperative innovation between members of Virtual Industry Cluster. This study got some results like: the probability of cooperative strategy has positive correlation with income coefficient of knowledge resources and mutual confidence level between partners, and has negative correlation with costs and risks of knowledge resources getting. And based on these results, our team put forward the strategy advice to incentive members of virtual industry cluster to cooperation based on knowledge network.

Keywords: *Virtual Industry Cluster, Cooperative Innovation, Evolutionary Game, Knowledge Resource*

1. INTRODUCTION

Virtual Industrial Clusters originally derived from the concept of the EU 'SACFA in 1997, which funded by 7 universities such as Brazil University of Sao Paulo formed a research network. The network will be defined VIC as The rapid construction and operation of virtual enterprises based platform, by having a certain specialty enterprise composed of aggregates, the main function is to provide and regulate through members of the core ability of the enterprise, participate in the virtual enterprise operation in order to allow members to share the market opportunities [1]-[2]. Along with the domestic and foreign scholars study on the virtual industry clusters deeply, there are quite a few scholars believe that the virtual industrial cluster is the combination of virtual enterprise and industry cluster, this new type of cluster organization model of enterprise played a great role in promoting innovation ability advantages of cluster innovation to maintain and upgrade. Businesses and other organizations mechanism use virtual space agglomeration, its ultimate purpose is to access to innovative resources needed (mainly is the knowledge resources) [3].

Koh & Kim (2004), Murray (2006), Lu Cheng (2010) etc., in-depth analysis on according to knowledge sharing, communication, cooperation and innovation connect closely. Along with the development and popularization of network techniques, cross region cooperation reduce the dependence on material resources, logistics and other factors, to cooperate and focus on knowledge resources sharing and communication [4] -[6]. At the same time, the reduction of transaction costs, innovation risk factors have also been shown to be cooperative innovation driving factors (Robertson 1998, Maria 2005, Sheng Yanchao 2007, Cao Xing, Chen Qi, Guo Ran 2010) [7] -[10]. In fact, based on the knowledge resources of cooperative innovation between members and information sharing are usually require sensitive knowledge , but with the cooperation , the main body of the existence of the relationship of competition, will cause conflicts because of share or exclusive cooperative innovation achievements, thus main body of cooperation of innovation in the process of game (Cyert&Goodman 1997, Chung 2003, Chen Xu, Li Shiming 2007, Zhang Qi 2009, Deng Guangjun Ceng Yong 2011) [11]- [15].

On the basis of the above scholars' research, this paper agreed with: knowledge resources are a VIC member for one of the most important foundations of cooperative innovation activities. Members of the cooperation between the innovation and the transfer are coupled to each other. Based on exchange and sharing of knowledge resources, the whole process of cooperation innovation, in addition to cooperation benefits, enterprise will also acquire knowledge resources quantity. The increase of quality, this means that with the cooperation process, knowledge of the spiral process is completed, and then brings the knowledge resources. At the same time, we realized that knowledge acquisition and utilization are also need to pay cost, for example, knowledge search cost

that finding the right potential partners based on knowledge resource and identified it, confirm whether it has the possibility of cooperation. In addition, their learning and knowledge absorptive capacity also affects the knowledge resource using cost, if their knowledge accumulation is insufficient, this will lead to increase the cost of knowledge resources utilization. (Costing of cooperative innovation) Thus affecting the cooperative innovation activities carried out smoothly.

2. MODEL CONSTRUCTION OF COOPERATIVE EVOLUTIONARY GAME

According to the replication dynamic evolution game method [16], the VIC members between enterprises based on knowledge resources cooperation innovation process. As an assumption, the cooperation between enterprises depends on knowledge resources sharing and complementary. To meet this condition, the enterprises choose "cooperation" for more revenue. And the parties have bounded rationality, i.e., they can not play game only one time for finding the best income strategy, but have go through repeated games to achieve that. In addition to the above content outside, for simplify the analysis process; put forward the premise in constructing game model.

（1）There are only two enterprises (A and B) play on knowledge resources cooperation innovation game in VIC. The strategy set are {cooperation, not cooperation}, due to the existence of bounded rationality, A or B can adjustment their strategies according to the other strategy. A and B are adopt cooperative strategy, their income for U_A, U_B, if both of them will not cooperation strategy, their income for E_A and E_B.

（2）When A and B take cooperation strategy, if A pay knowledge as I_A, B pay knowledge as I_B, we use Q_A and Q_B to be increase of knowledge resources through the

cooperation (knowledge resource income), r_A and r_B represent respectively that A and B knowledge resources income coefficient. Now we get $Q_A = r_A I_A$, $Q_B = r_B I_B$, $(r_A, r_B > 0)$.

（3） C is used to be cost of knowledge resources acquisition, related to some factors like knowledge resources quantity, quality, some learning costs. A, B based on knowledge resources cooperation cost for $C_A = c_A I_A$, $C_B = c_B I_B$, among them c_A, c_B for cost coefficient.

（4） Besides cooperative innovation, the enterprise itself also has the self-study, a new ability; it will bring additional knowledge, the extra income. This part of the extra income mainly comes from its self-study and innovation ability, with V said, $V_A = k_A I_A$, $V_B = k_B I_B$, $(k_A, k_B > 0)$, including k_A, k_B said enterprise A and B self-study ability coefficient.

（5）As a matter of fact, Cooperation process have to face some risk, including knowledge overflow objectively which leading to cooperation revenue decline, partner defaulting will bring trust risk, The renewal of the knowledge resources caused by the decrease of the prospective earnings , etc. Thus, it can be argued that cooperation risk D and knowledge resource income coefficient, cooperation risk factor. Knowledge pay level and the level of trust related. A cooperation risk factor as l, the enterprise mutual trust level for t_{ij} $(t_{ij} \in [0,1], i \neq j)$ .Thus $D_A = (1 - t_{AB}) l_A r_A I_A$, $D_A = (1 - t_{BA}) l_B r_B I_B$

According to the above conditions, we construct a game matrix, as is shown in Table 1:

Table 1 Based on the knowledge resources cooperation innovation game matrix

		Enterprise B	
		cooperation	no cooperation
Enterprise A	cooperation	$E_A + r_A I_A + k_A I_B - c_A I_A - (1 - t_{AB}) l_A r_A I_A$ $E_B + r_B I_B + k_B I_A - c_B I_B - (1 - t_{BA}) l_B r_B I_B$	$E_A - c_A I_A$, $E_B + k_B I_A$
	no cooperation	$E_A + k_A I_B$, $E_B - c_B I_B$	E_A , E_B

3. STABILITY ANALYSIS

Usually, A and B will get more income than sum of each cost plus risk, if they choose cooperative strategy both. That is, $Q > C + D$. Assume that A choose the probability of cooperation as p_A, not choose the probability of cooperation as $1 - p_A$, B choose the probability of cooperation for p_B, not choose to the probability of

cooperation as $1 - p_B$, $(0 \le p_A, p_B \le 1)$, and a choice of cooperation strategy, knowledge resource income for:

$$\vartheta_A{}' = E_A + p_B I_A r_A [1 - (1 - t_{AB})l_A] + p_B k_A I_B - c_A I_A$$

A not choose to cooperation strategy, knowledge resource income for:

$$\vartheta_A{}'' = p_B(E_A + k_A I_B) + (1 - p_B)E_A = E_A + p_B k_A I_B$$

Thus, A knowledge resources average income for:

$$\vartheta_A = p_A \vartheta_A{}' + (1 - p_A)\vartheta_A{}'' = E_A + p_A p_B r_A I_A [1 - (1 - t_{AB})l_A] + p_B k_A I_B - p_A c_A I_A$$

By the same token cans B average knowledge resource income for?

$$\vartheta_B = p_B \vartheta_B{}' + (1 - p_B)\vartheta_B{}'' = E_B + p_A p_B r_B I_B [1 - (1 - t_{BA})l_B] + p_A k_B I_A - p_B c_B I_B$$

$$\frac{dp_A}{dt} = p_B(1 - p_A)I_A \{ p_B r_A [1 - (1 - t_{AB})l_A] - c_A \} \quad (1)$$

$$\frac{dp_B}{dt} = p_A(1 - p_B)I_B \{ p_A r_B [1 - (1 - t_{BA})l_B] - c_B \} \quad (2)$$

To this, based on the knowledge resources cooperation between enterprise and the evolutionary game by (1), (2) was described, and its stability by this equation than Jacob matrix local

stability calculation, the following points several ways are discussed.

(I) When $r_A > \dfrac{c_A}{1 - (1 - t_{AB})l_A}$, $r_B > \dfrac{c_B}{1 - (1 - t_{BA})l_B}$

From the above equation calculation can be made in the local stability of the five points:

$O(0,0)$ 、 $A(1,0)$ 、 $B(0,1)$ 、 $C(1,1)$ 、 D

($r_A > \dfrac{c_A}{1 - (1 - t_{AB})l_A}$, $r_B > \dfrac{c_B}{1 - (1 - t_{BA})l_B}$) , As shown in chart 2:

Table 2: $r_A > \dfrac{c_A}{1 - (1 - t_{AB})l_A}$, $r_B > \dfrac{c_B}{1 - (1 - t_{BA})l_B}$ *of partial equilibrium stability*

Local equilibrium	Determinant symbol	Determinant of mark symbols	The results
0,0	+	-	ESS
0,1	+	+	Unstable point
1,0	+	+	Unstable point
1,1	+	-	ESS
$r_A > \dfrac{c_A}{1 - (1 - t_{AB})l_A}$, $r_B > \dfrac{c_B}{1 - (1 - t_{BA})l_B}$	-	0	Saddle point

Obviously, point O and C with local stability, known as the ESS (evolutionary stable strategy). Point O corresponding to the enterprise A and B are the enterprise not to cooperation strategy, point C corresponding to the A and B when A choose cooperative strategy. Points A and B for unstable point, point D for saddle point. Based on the knowledge resources cooperation between

enterprise and the game process of evolution as shown in Figure 1 shows:
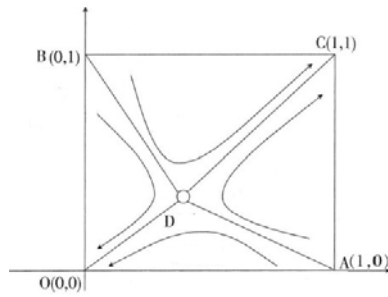
Figure 1: Cooperative game evolution process

In the figure above, enterprise cooperative innovation game different state of critical path by A, D, B three connection into curve said, A, B, C, D four constitute area, on behalf of the game both sides adopt A cooperative strategy, the evolutionary game theory at $C(1,1)$ point convergence. A, D, B, O consisting of four area, game both sides take not cooperation strategy, evolutionary game theory in $O(0,0)$ point

convergence. If the saddle point (i.e. point D) change, the evolution in different direction will the equilibrium convergence.

(II)   If A and B both choose cooperative strategy, it will get above results, but if through the cooperation , the knowledge resource income less than the sum of the cost and risk, namely $Q < C + D$, there will be three kinds of circumstances, will to be discussed respectively

（1）When $r_A < \dfrac{c_A}{1-(1-t_{AB})l_A}$, $r_B < \dfrac{c_B}{1-(1-t_{BA})l_B}$

The stability analysis such as shown in Table 3, the system has four local stable point. $O(0,0)$, $A(1,0)$ and $B(0,1)$, $C(1,1)$, system in point O convergence, the enterprise will take no cooperation strategy.

Table 3: $r_B > \dfrac{c_B}{1-(1-t_{BA})l_B}$, $r_B < \dfrac{c_B}{1-(1-t_{BA})l_B}$ of partial equilibrium stability

Local equilibrium	Determinant symbol	Determinant of mark symbols	The results
0,0	+	-	ESS
0,1	-	Uncertainty	Saddle point
1,0	-	Uncertainty	Saddle point
1,1	+	+	Unstable point

（2）When $r_A > \dfrac{c_A}{1-(1-t_{AB})l_A}$, $r_B < \dfrac{c_B}{1-(1-t_{BA})l_B}$,means a cooperative enterprise strategy, its knowledge resources earnings are more than cooperation cost and risk, the enterprise B knowledge resource

income less than cooperation cost and risk, the local stability of the point, see Table 4, thus, A and B are not to cooperation strategy is the evolutionary stable strategy, its evolution track convergence in point O.

Table 4: $r_A > \dfrac{c_A}{1-(1-t_{AB})l_A}$, $r_B < \dfrac{c_B}{1-(1-t_{BA})l_B}$ partial equilibrium stability

Local equilibrium	Determinant symbol	Determinant of mark symbols	The results
0,0	+	-	ESS
0,1	-	+	Unstable point
1,0	-	Uncertainty	Saddle point
1,1	-	Uncertainty	Saddle point

（3） When $r_A < \dfrac{c_A}{1-(1-t_{AB})l_A}$, $r_B > \dfrac{c_B}{1-(1-t_{BA})l_B}$, it indicates that the enterprise a cooperative strategy, the knowledge resource income less than cooperation cost and risk, the enterprise b knowledge resource income more than cooperation

cost and risk, the local stability of the point Table 5, thus, a and b are not to cooperation strategy is the evolutionary stable strategy, its evolution track convergence in point O.

Table 5: $r_A < \dfrac{c_A}{1-(1-t_{AB})l_A}$, $r_B > \dfrac{c_B}{1-(1-t_{BA})l_B}$ of partial equilibrium stability

Local equilibrium	Determinant symbol	Determinant of mark symbols	The results

0,0	+	-	ESS
0,1	-	Uncertainty	Saddle point
1,0	+	+	Unstable point
1,1	-	Uncertainty	Saddle point

4. PARAMETER ANALYSIS AND INCENTIVE COOPERATION STRATEGY

Based on the analysis results, it can be seen that the main system evolution path with r, c, t three coefficient correlation. The following are discussed and design the corresponding VIC incentive strategy.

1) Knowledge resource income coefficient r. Through the cooperation r of the prospective earnings, $ABCD$ area, the system to $(1,1)$ point of convergence of the greater the probability, that is to say, the enterprise A and B both choose cooperative strategy probability will then increase. This means that knowledge resource gains good - - - - - - enterprise more willing to cooperate with you - - - - - - better knowledge resource benefits, so as to form a virtuous cycle. To promote the benign lectured formation, improving r can adopt the following measures: ①To strengthen cooperation in the process of communication, VIC has the characteristics of cross-domain, since as traditional cluster that, in the cooperation between partners besides formal communication outside, still can use "it" and so on. Based on the network, virtual space has formed cross practice; span space communication characteristic, though it should make full use of the virtual cluster communication advantages.

cooperation knowledge overflow level and knowledge learning ability, avoiding objective overflow or inadequate learning ability that will cause knowledge resources prospective earnings decline.

management platform, keep VIC internal knowledge network integrity and stability, and create a good and stable external environment for cooperation among VIC members.

(2)Cooperation cost coefficient c. Usually, the c depends on the knowledge environment of the enterprise. When c is small, $ABCD$ area is larger, convergence in $(1,1)$ point may be the greater. VIC inside enterprise tends to choose cooperation strategy. Therefore can adopt the following measures: ①VIC information platform construction, the use of network to realize long distance information collection and search between different enterprises, shorter time, lower cost of an cooperation, so that enterprises can meet the purpose of cost reduction coefficient. ②Increasing default cost, not only keep default cost within the cooperation agreement, but also should be by means of laws, policies, and other means to reduce the probability of default.

(3)Trust level and cooperation risk factor l. Cooperation between the two sides increased trust coefficient t with risk coefficient l is reduced, thus ABCD area will be increased. T and l depend on cluster atmosphere, credit line, members of the factors such as the credit decision. This can be used as follows measures:

①The construction

knowledge resources VIC cooperation atmosphere. Culture, encourage cluster members of knowledge sharing and transfer, policies, the members of the enterprise cooperation based on certain policy, financial help and support (of course, this cannot leave the relevant government department's support).

②Establish   VIC

evaluation system. The establishment of the evaluation system in addition to members behavior with constraint, but also help potential partners for the enterprise to carry out the recognition, so as to shorten the practice of building trust, and to reduce the cost of cooperation and cooperation the purpose of risk.

5. SUMMARY

②Both parties should promote their

This paper by means of the evolutionary game theory and methods, based on the knowledge resources cooperation between enterprise and the evolutionary game model. Research on cooperative innovation strategy selection problem, which based on knowledge resources of enterprises. The results of the study show that, the probability to choose cooperation strategy is positive correlation with knowledge resource income, enterprise mutual trust levels. And Negative correlation with knowledge resources cost and risk. Based on this, this paper puts forward to promote enterprise between knowledge resources as the foundation of cooperation innovation measures.

③Should build knowledge in VIC

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