ISSN : 0974 - 7435 Volume 10 Issue 12

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(12), 2014 [6268-6279]

Relations' evolutionary in supply and demand network of enterprises with multi-function and opening characteristics

Deyi Tai[1,2]*, Fuyuan Xu[1], Wei Hu[1]
[1]School of Management, University of Shanghai for Science & Technology, (CHINA)
[2]Key Laboratory of Machine Vision and Intelligence Control Technology, Hefei University, (CHINA)
E-mail : taideyi@126.com

ABSTRACT

There are three relations exist in Supply and Demand Network of Enterprises with Multi-function and Opening Characteristics (SDN) that are competition, cooperation and neutrality relations, which's evolutionary will effects the stability of SDN. To reveal the evolution process and interactive of the three relations among enterprises of SDN, an evolutionary game model in SDN was build to solve the problem of real cooperative strategy selection. The model of enterprises relations evolutionary was established base on evolutionary game theory, and analyzed with numerical simulations in MATLAB. The research shows that the strategy selection of cooperation, competition and neutrality in SDN were mainly determined by transferable and non-transferable incomes. Enhancing supervision and punishment to opportunistic behavior and malicious competition in SDN, will improve enterprises' relations from neutrality to cooperation.

KEYWORDS

SDN; Relations; Evolutionary; Cooperation; Competition; Neutrality.

INTRODUCTION

Economic globalization and demands diversification requird enterprises providing more personalize, short cycle, lower cost and high quality product and service, which make many enterprises survive difficultly when only depend on their own resource. From this view, academic community put forward many business operation pattern, shift from an adversarial competition mode to cooperation mode. SDN[1] refers to a multifunction and full-open supply and demand network in a global scope, formed among relevant enterprises by their interactive "Supply and Demand Flow", with the aim to access global resource. The supply and demand flows refer to information, materials, funds, technology, human resources, management, etc. Different from Supply Chain mainly focuses on "products cooperation", SDN emphasizes the interactive of cooperation among products, information, technology, funds, management, corporate culture, facilities and other resources. Driven by information, the dynamic cooperation of enterprises was established among any nodes in the network. Discarded collaborate inside chain and competed outside chain, the concept of "full-open and win-win cooperation" was proposed, which encouraged to improve the competitiveness through cooperation within enterprises, and to gain cooperation through competition. The robustness of SDN and the system's benefits will thereby be maximized.

Cooperation, neutrality and competition are the main relations exist in enterprises of SDN, which emphasize expanding cooperation and decreasing competition to realize the system integrat effect of $1+1>2$. Neutral relation is far greater than cooperative and competitive relation in SDN, since most of the enterprises in SDN neither competition nor cooperation which is short-term dynamic relations in SDN. The scientifical define of neutral relation besides competitive and cooperative relations, effectively promote the transform of neutrality to cooperation not to competition, which tremendously increase the efficiency and stability of SDN.

Current researches on business relation mainly focused on the interior and outside cooperation and competition of Supply Chain[2-5], Virtual Enterprise[6,7], Cooperative R&D[8,9], Industry Alliance[10,11], which all ignored the neutral relation. Shidi Miao[12] optimized the competition-cooperation relations between two SC, from the view of optimizing the overall revenue. Audy[13] provided 5 coordinative suggestions on how to construct and manage internal cooperative and competitive relations in logistic cooperation of SC. Han[14] discussed the dynamic process of SC with VMI and VMI&TPL cooperation. Qing[15] discussed how the absorbing capacity impacted on the partners behavior in research and development alliance, and numeric simulate the impact of absorbing capacity and partition coefficient excess earnings on evolutionary stability. Wan[16] researched the evolutionary game in complex network, scale-free network with community structure, and Newman-Watts small-world network. Du[17]discussed the cooperative game based on risk driven. Xu[19] analyzed the stability of strategic alliances take advantage of stochastic evolutionary game, and give the criterion of stability.

This paper takes advantage of the theory of bounded rationality and evolutionary game, researched the relations' evolutionary mechanism of cooperation, competition and neutrality in SDN. Numerical simulation analysis the impact of revenue on the relationships among cooperation, competition and neutrality. The impact of supervision and punishment promoting the neutrality to cooperation was discussed.

MODELING

The notes of SDN include Resource Supplier (RS) and Resource Demander (RD), which can be exchange in transactions. Assuming that there only two strategies can be select for both RS and RD, the one is positive cooperation and the other is passive wait. Positive cooperation indicate to improve the comprehensive capability of SDN nodes, partners obtained revenue by investing cooperative cost.

Passive wait indicate that the partner want share the cooperative revenue by taking opportunistic behavior, not investing cooperative cost. Both RD and RS select the strategy according to the revenue, including transferable and can't transferable revenue, getting from the cooperation. In terms of selected strategy, there formed three relations of cooperation, competition and neutrality in SDN.

Both partners take positive cooperative strategy formed cooperation relation in RS and RD. Beside the revenue obtained in neutrality, they will get the cooperative spill revenue when pay the cooperative cost. Both partners take passive wait strategy formed neutrality relationships in RS and RD. Since nobody will invest the cooperative cost, the cooperation relation can't be formed, partners only get neutrality revenue. One partner take positive strategy and the other take passive wait strategy formed competitive relations. The passive wait partner share the spill revenue which was created by the other partner's investment.

Both RS and RD are bounde rationality, status equal, the choice of cooperation, competition or neutrality strategy only according to the partner's income. Under asymmetric information, market uncertainties the strategic choice is not a one-time game. The optimal strategy could not find initially, need continue learning and observing the behavior of the process to determine their strategy.

TABLE 1 gives the payoffs of RS and RD. S1, D1 refer to the cooperative payoff of RS and RD when they take cooperative strategy. S2, D2 refer to the positive payoff when the partners take passive strategy. S3, D3 refer to the passive strategy payoff when the partners take positive strategy. S4, D4 refer the payoffs both the partners take passive strategy. Usually S1> S2, D1> D2, S3>S3, D3> D4. Competitive strategy will always lead to the partners' lower incomes.

TABLE 1 : Payoffs Matrix

		Demander	
	Cooperative Strategy	**Positive (y)**	**Passive (1-y)**
Supplier	Positive (x)	S1, D1	S2, D3
	Passive (1-x)	S3, D2	S4, D4

Modeling

At time t, the ratio taken active cooperative strategy in RS is $x, x \in [0,1]$, taken passive waiting strategy is $1-x, 1-x \in [0,1]$,the RD taken active cooperative strategy is $y, y \in [0,1]$, taken passive waiting strategy is $1-y, 1-y \in [0,1]$. The average incomes of RS take active cooperative strategy is u_x.

$$\mathbf{u_x = yS_1 + (1-y)S_2} \tag{1}$$

The average incomes of RS taken passive wait strategy is u_{1-x}.

$$\mathbf{u_{1-x} = yS_3 + (1-y)S_4} \tag{2}$$

The average incomes of both strategies is u_A.

$$\mathbf{u_S = xu_x + (1-x)u_{1-x}} \tag{3}$$

The replicator dynamic equation of RS is:

$$dx = x(u_x - u_S) \tag{4}$$

Substitute (1), (2), (3) into (4), we can get :

$$\mathbf{dx = x(1-x)(u_x - u_{1-x}) = x(1-x) \times (S_2 - S_4 + y(S_1 + S_4 - S_2 - S_3))} \tag{5}$$

Similarly, the replicator dynamic equation of RD is:

$$\mathbf{dy = y(1-y)(u_y - u_{1-y}) \quad = y(1-y)[D_2 - D_4 + x(D_1 + D_4 - D_2 - D_3)]} \tag{6}$$

Combine (5) and (6), we can get the differential kinetic equation of SDN relations as follow:

$$\begin{cases} \mathbf{dx = x(1-x)[S_2 - S_4 + y(S_1 + S_4 - S_2 - S_3)]} \\ \mathbf{dy = y(1-y)[D_2 - D_4 + x(D_1 + D_4 - D_2 - D_3)]} \end{cases} \tag{7}$$

Analysis

Set $dx = 0, dy = 0$, solving differential (7), we can get 5 equilibrium points. $(0,0)$, $(0,1)$, $(1,0)$, $(1,1)$ and (x_0, y_0).

$$\mathbf{(x_0, y_0) = \left(\frac{D_4 - D_2}{D_1 + D_4 - D_2 - D_3}, \frac{S_4 - S_2}{S_1 + S_4 - S_2 - S_3}\right)}$$

According to the theory of differential equation [20], the stability of the equilibrium point is determined by the signs of determinant and the trace of the system's JACOBIAN matrix. The JACOBAN Matrix of (7) is :

$$\mathbf{J} = \begin{bmatrix} \frac{\partial(\mathbf{dx})}{\partial \mathbf{x}} & \frac{\partial(\mathbf{dx})}{\partial \mathbf{y}} \\ \frac{\partial(\mathbf{dy})}{\partial \mathbf{x}} & \frac{\partial(\mathbf{dy})}{\partial \mathbf{y}} \end{bmatrix} \tag{8}$$

$$\frac{\partial(\mathbf{dx})}{\partial \mathbf{x}} = \mathbf{(1-2x)[S_2 - S_4 + y(S_1 + S_4 - S_2 - S_3)]} \tag{9}$$

$$\frac{\partial(\mathbf{dx})}{\partial \mathbf{y}} = \mathbf{x(1-x)(S_1 + S_4 - S_2 - S_3)} \tag{10}$$

$$\frac{\partial(\mathbf{dy})}{\partial \mathbf{x}} = \mathbf{y(1-y)(D_1 + D_4 - D_2 - D_3)} \tag{11}$$

$$\frac{\partial(\mathbf{dy})}{\partial \mathbf{y}} = \mathbf{(1-2y)[D_2 - D_4 + x(D_1 + D_4 - D_2 - D_3)]} \tag{12}$$

Both the determinant and the trace of 5 equilibrium points show in TABLE 2, according to (8). $DetJ$ is the value of determinant and TrJ is the trace of the matrix.

TABLE 2 : Value and trace at equilibrium points of JACOBIAN Matrix

	DetJ	**TrJ**
(0,0)	$(S_2 - S_4)(D_2 - D_4)$	$(S_2 - S_4)+(D_2 - D_4)$
(0,1)	$-(S_1 - S_3)(D_2 - D_4)$	$(S_1 - S_3)-(D_2 - D_4)$
(1,0)	$-(S_2 - S_4)(D_1 - D_3)$	$(D_1 - D_3)-(S_2 - S_4)$
(1,1)	$(S_1 - S_3)(D_1 - D_3)$	$-(S_1 - S_3)-(D_1 - D_3)$
(x_0, y_0)	$-\begin{bmatrix} \frac{(D_1 - D_3)(D_2 - D_4)}{D_1 + D_4 - D_2 - B_3} \\ \times \frac{(S_1 - S_3)(S_2 - S_4)}{S_1 + S_4 - S_2 - S_3} \end{bmatrix}$	0

(1) When S1-S3>0, D1-D3>0, D2-D4<0, S2-S4<0.

Substitute the setting parameter into TABLE2, the value and trace at equilibrium points shown in TABLE3. At point $(0,1)$ and $(1,0)$ $DetJ > 0$ and $TrJ > 0$, so they are instability points. At point (x_0, y_0) $TrJ = 0$, so this point is saddle point. At points $(0,0)$ and $(1,1)$ $DetJ > 0, TrJ < 0$, the two points is the equilibrium points of system.

TABLE 3 : The value and trace at equilibrium points

	DetJ	TrJ
(0,0)	+	-
(0,1)	+	+
(1,0)	+	+
(1,1)	+	-
(x_0, y_0)	$\pm$	0

Active strategy can earn more income when the partners take active strategy, when the partners take passive strategy,and take passive can earn more incomes by avoiding invest cost. Evolutionary Figure of the system shows in Figure 1. Under strict supervision to opportunistic behavior, there have two evolutionary stability strategies, cooperation and neutrality, which determined not only by the initial strategy ratio but also by cooperative incomes.

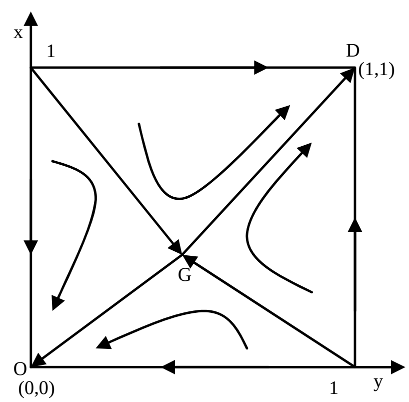

Figure 1 : System evolution diagram

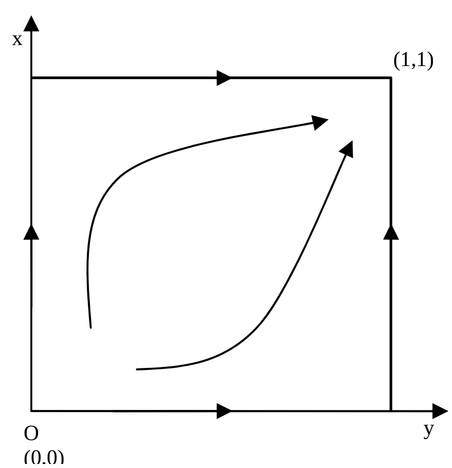

Figure 2 : Cooperative relations' evolutionary

(2)When S1-S3>0, D1-D3>0, S2-S4>0, D2-D4>0

Under the setting, $\frac{D_4-D_2}{D_1+D_4-D_2-D_3}>1$ and $\frac{S_4-S_2}{S_1+S_4-S_2-S_3}>1$, points (x_0, y_0) is insignificance. The only evolutionary stability points is $(1,1)$, and other three points are instability points. Figure 2 indicate that cooperation is the only stability strategy. No matter what strategy the other side taken, taken active strategy can always obtain greater incomes, which is an ideal SDN enterprise collaboration can induce the neutrality and competition partners transform to cooperation.

(3) When S1-S3<0, D1-D3<0, D2-D4<0, S2-S4<0

Point (x_0, y_0) is insignificance. The only evolutionary stability strategy (ESS) is $(0,0)$, passive wait, other three points are instability points. Figure 3 indicate that no matter what strategy the other partner taken, passive strategy can always get better returns. When the market significant uncertainty, passively wait will be the best choice at this time, actively cooperate disappeared, there is no relations of cooperation and competition, SDN turn into hibernation.

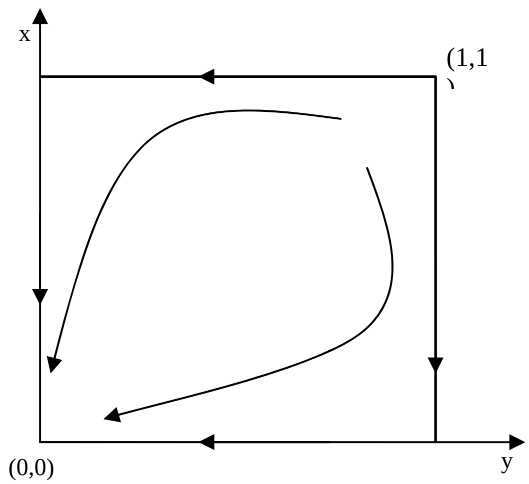

Figure 3 : Neutrality relations' evolutionary

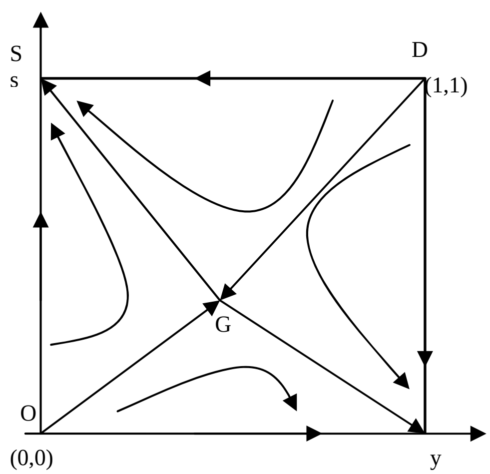

Figure 4 : Competitive relation' evolutionary

(4) When S1-S3<0, D1-D3<0, D2-D4>0, S2-S4>0

Ditto analysis, under this setting, $(0,0)$ and $(1,1)$ are instability points, points (x_0, y_0) is saddle point, points $(0,1)$ and $(1,0)$ are the evolutionary stability points.

Figure 4 indicate that when the one taken active strategy, the best choice of the partners is take passive strategy. Both passive wait strategy and active cooperative strategy coexist in the market, which full of competition. No cooperation exists in SND which will led to SDN dismiss. This equilibrium is harmful to the stability of SDN, which should be avoided.

Influencing factors analysis

In the real world, full cooperation and complete neutral relations is just an ideal model. Unfair competition is a bad status which reduced overall system revenue which should be avoid by adjusting and regulating. The more condition is between neutrality and cooperation in SDN, thus establishment of effective supervision and punishment mechanism which change the incomes expectations, will conducive to neutral relation convert to cooperative relation.

Assume in the process of cooperation, one side takes passive waiting strategy and make profit by taking opportunistic behavior, which will pay the penalty C, $C > 0$. Then the value of S3 and D3 should subtract a positive punishment C. The value of D changes to $(\frac{D_4 - D_2}{D_1 + D_4 - D_2 - D_3 + C}, \frac{S_4 - S_2}{S_1 + S_4 - S_2 - S_3 + C})$.

Because S1-S3>0, so D1-D3>0, D2-D4<0, S2-S4<0, at this moment, point G will approach to point O, just as Figure 5 show. Compare Figure 1 to Figure 5 we can get that the possibility of neutral relations convert to cooperation increased, which indicate that the supervision and punishment in SDN promote the neutral relation convert to cooperative relation.

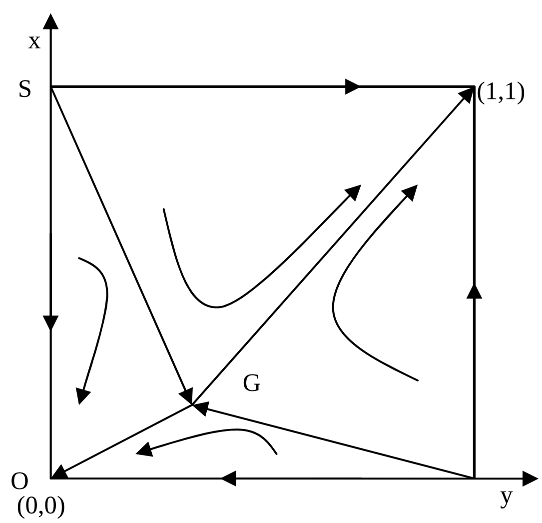

Figure 5 : Punishment's effect to the relation evolutionary

SIMULATIONS AND ANALYSIS

To analysis of the evolution of cooperative, neutral and competitive relations, we make numerical simulation in MATLAB under the assumptions of symmetry game and dissymmetry game. Symmetry game indicates that RS and RD have same payoff. Dissymmetry game indicates that RS and RD have different payoff.

(1) When S1-S3>0, D1-D3>0, D2-D4<0, S2-S4<0, neutrality and cooperation coexist in SDN.

1) Symmetry game

Set S1-S3=D1-D3, S2-S4=D2-D4, assume S1=D1=6, S2=D2=2, S3=D3=4, S4=D4=3, set multi initial value of x as 0.1, 0.3, 0.5, 0.7, 0.9. The simulation result shows as Figure 6.

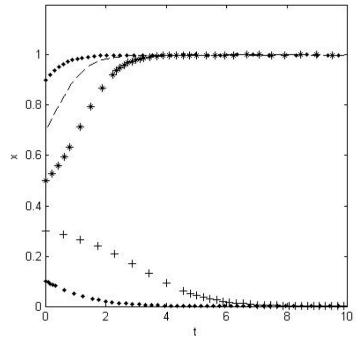

Figure 6 : The evolutionary of neutral and cooperative relations in symmetry game.

2) Dissymmetrical game

Set $S_1 - S_3 \neq D_1 - D_3$, $S_2 - S_4 \neq D_2 - D_4$. Assume S1=6, S2=2, S3=4, S4=3, D1=10, D2=4, D3=6, D4=8, multi initial value of (x,y) as [0.2 0.8], [0.4 0.6], [0.3 0.3], [0.7 0.4], [0.9 0.2], [0.1 0.7], [0.1 0.3], [0.1 0.4], [0.1 0.8], [0.1 0.6]. The simulation result shows as Figure 7.

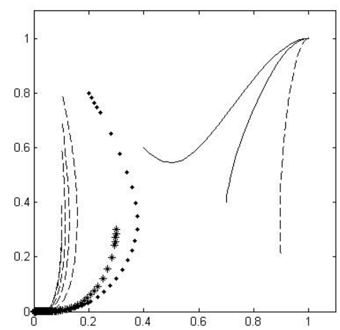

Figure 7 : The evolutionary of neutral and cooperation relations in dissymmetrical game

(2) Evolution of cooperation

When S1-S3>0, D1-D3>0, S2-S4>0, D2-D4>0, cooperation is the only ESS.

1) Symmetry game

Assume S1=D1=8, S2==D2=7, S3=D3=6, S4=D4=3, set multi initial value of x as 0.1, 0.3, 0.5, 0.7, 0.9. The simulation result shows as Figure 8.

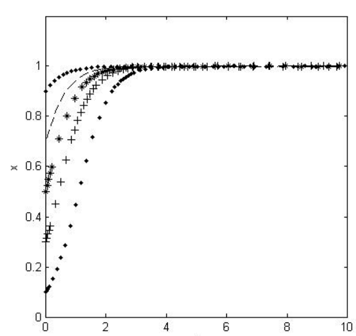

Figure 8 : The evolutionary of cooperation relation.

2) Dissymmetrical game.

Assume S1=8, S2=7, S3=6, S4=3, D1=6, D2=6, D3=4, D4=5, multi initial value of (x,y) are [0.2 0.8], [0.4 0.6], [0.3 0.3], [0.7 0.4], [0.9 0.2], [0.1 0.7], [0.1 0.3], [0.1 0.4], [0.1 0.8], [0.1 0.6]. The simulation result shown as Figure 9.

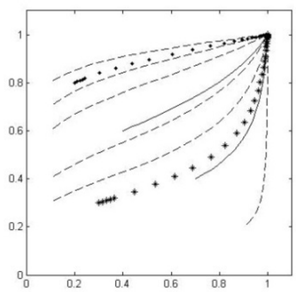

Figure 9 : The evolutionary of cooperation relation

(3) Evolution of neutral relation

When S1-S3<0, D1-D3<0, D2-D4<0, S2-S4<0, neutrality is the only ESS.

1) Symmetry game

Assume S1=D1=8, S2==D2=7, S3=D3=6, S4=D4=3, set multi initial value of x as 0.1, 0.3, 0.5, 0.7, 0.9. The simulation result shows as Figure 10.

2) Dissymmetrical game.

Assume S1=8, S2=7, S3=6, S4=3, D1=6, D2=6, D3=4, D4=5, set multi initial value of (x, y) as [0.2 0.8], [0.4 0.6], [0.3 0.3], [0.7 0.4],[0.9 0.2], [0.1 0.7], [0.1 0.3], [0.1 0.4],[0.1 0.8],[0.1 0.6]. The simulation result shown as Figure 11.

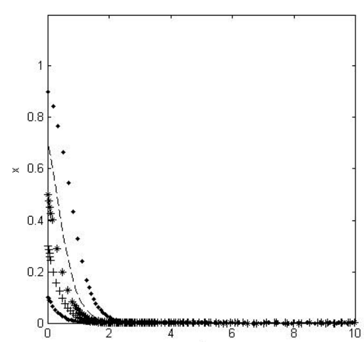

Figure 10 : The evolutionary of neutral relation in symmetrical game

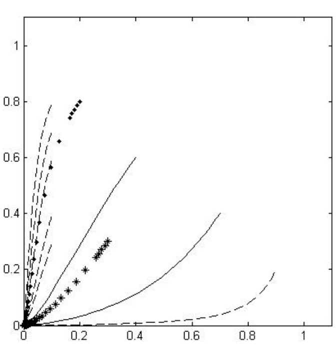

Figure 11 : The evolutionary of neutral relation in dissymmetrical game

(4)Evolution of competitive relation

When S1-S3>0, D1-D3>0, D2-D4<0, S2-S4<0, competition is the only ESS.

1) Symmetry game

Assume S1=D1=7, S2=D2=6, S3=D3=10, S4=D4=4, set multi initial value of x as 0.1, 0.3, 0.5, 0.7, 0.9. The simulation result shown as Figure 12.

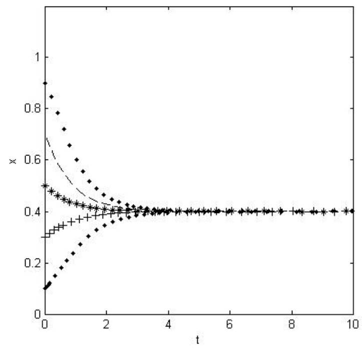

Figure 12 : The evolutionary of competitive relation in symmetrical game

2) Dissymmetry game

Assume S1=4,S2=3, S3=6, S4=2, D1=8, D2=6, D3=10, D4=4, set multi initial value of (x, y)as: [0.2 0.8], [0.4 0.6], [0.3 0.3], [0.7 0.4],[0.9 0.2], [0.1 0.7], [0.1 0.3], [0.1 0.4],[0.1 0.8],[0.1 0.6]. The simulation result shows as Figure 13.

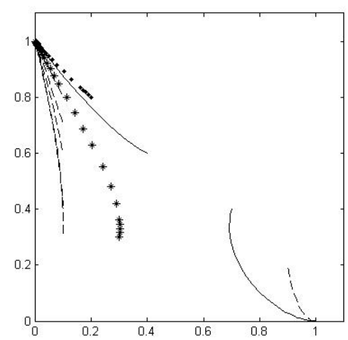

Figure 13 : The evolutionary of competitive relation in dissymmetrical game

It can observed from Figure 6 and Figure 7, whether symmetry or dissymmetry games, there have 2 ESS, cooperation and neutrality. The final ESS depends on not only comprehensive incomes but also initial strategy selection ratio. From Figure 8 and Figure 9, we can get that the only ESS in SDN is cooperation regardless of the select ratio, when cooperation is the best selection. Figure 10 and Figure 11 indicate that neutrality is the best selection, when there has not cooperative chance regardless of the initial ratio. Figure 12 and Figure 13 indicate that the competition is ESS regardless of initial strategy selection ratio. In that case SDN will be dismissed.

CONCLUSIONS

Lots of the researchs have focused on the evolution of the relations between cooperation and competition, lacking of systematic research on the neutrality relation. This paper initially established a competition, cooperation and neutrality evolutionary game model and given the MATLAB simulation. The research shows that:

(1) Cooperation relation will be the ESS when cooperative incomes greater than neutral incomes. The evolutionary speed from no-cooperation to cooperation is decided by incomes difference of cooperation and no-cooperation.

(2) Neutrality relation will be the final ESS when no-cooperation incomes greater than cooperation incomes, which indicated that market uncertainty with high-risk, any pay out cannot obtain returns.

(3) Competition is the final ESS, when competitive strategy can earn grater income regardless of the partners' strategy. The one's incomes obtain result in other's lost, which is harm to the stability of SDN, and should be avoid by adjusting the payoff in games.

(4) When both partners all take cooperative strategy gain maximum incomes, neutral incomes greater than cooperative incomes under partners take competition strategy, SDN system have 2 ESS, cooperation and neutrality. In this case supervision and punishment can improve the ratio of cooperation.

As a complex system, the dynamic evolutionary mechanism of SDN are uncertainty, some unknown factors are at work besides the consolidated incomes. In this paper, only the consolidated incomes as the sole basis for business cooperation choice, which did not consider the interaction and cooperation of people working, the individual risk preferences, external economic, political and cultural change, and other non-economic factors' disturbance.

ACKNOWLEDGMENT

This work is financially supported by the National Natural Science Foundation in China (No. 71171135), Anhui Natural Science Foundation in China (No. 1308085MG106), Shanghai Top Discipline Foundation Program in China (No. S1205YLXK), Anhui Soft Science Key Foundation Project in China (No. 1302053060). HUJIANF Foundation of USST (No. A14006).

REFERENCES

[1] Xu Fuyuan, He Jing; First study on supply and demand network with multi-functional and opening characteristics for Enterprise. Forecasing, **21(6)**, 19-22 **(2002)**.

[2] Rahdar, Mohammad, Nookabadi, S.Ali; Coordination mechanism for a deteriorating item in a two-level supply chain system. Applied Mathematical Modelling, **38(11-12)**, 2884-2900 **(2014)**.

[3] Hou, Yunzhang, Xiong, Yu Wang, Xiaoling; The effects of a trust mechanism on a dynamic supply chain network. Expert Systems with Applications, **41(6)**, 3060-3068 **(2014)**.

[4] Huo Baofeng, Zhao Xiande, Zhou Honggeng; The Effects of Competitive Environment on Supply Chain Information Sharing and Performance: An Empirical Study in China. Production and Operations Management, **23(4)**, 552-569 **(2014)**.

[5] Dao Son Duy, Abhary Kazem, Marian Romeo; Optimisation of partner selection and collaborative transportation scheduling in Virtual Enterprises using Ga. Expert Systems With Applications, **41(15)**, 6701-6717 **(2014)**.

[6] L.M.Camarinha-Matos, C.Pantoja-Lima; Cooperation coordination in virtual enterprises. Journal of Intelligent Manufacturing, **12(2)**, 133-150.

[7] Chang, Che-Wei, Wu Cheng-Ru, Liao Chia-Chun; The Virtual Cooperation Platform in Enterprise and Supplier Cooperation Models. Cyberpsychology Behavior and Social Networking, **13(4)**, 473-475 **(2010)**.

[8] R.Belderbos, M.Carree, B.Lokshin; Cooperative R&D and firm performance, Research Policy, **33(10)**, 1477-1492 **(2004)**.

[9] Ghosh Arghya, Lim Jonathan; Cooperative and non-cooperative R&D and trade costs. Research in Economics, 2012, 6(2):131–141. Journal of International Trade & Economic Development, **22(6)**, 942-958 **(2013)**.

[10] Cristóbal Casanueva, Ignacio Castro, José L.Galán; Informational networks and innovation in mature industrial clusters. Journal of Business Research, **66(5)**, 603–613 **(2013)**.

[11] Chemmanur, J.Thomas, Loutskina Elena; Tian Xuan; Corporate Venture Capital, Value Creation, and Innovation. Review of Financial Studies, **27(8)**, 2434-2473 **(2014)**.

[12] Shidi Miao, Chunxian Teng, Lu Zhang; System Dynamics Modeling and Simulation for Competition and Cooperation of Supply Chain on Dual-Replenishment Policy. Journal of Software, **7(12)**, 78-85 **(2012)**.

[13] J.F.Audy, N.Lehoux, S.D'Amours, M.Ronnqvist; A framework for an efficient implementation of logistics collaborations. International Transactions in Operational Research, **19(5)**, 633-657 **(2012)**.

[14] Han Chao-Qun, Liu Zhi-Xue; The Cooperation Mechanism of VMI&TPL Apply Chain Based on Evolutionary Game. Industrial Engineering and Management, **16(6)**, 21-29 **(2011)**.

[15] Qin Wei, Xu Fei, Song Bo; Evolutionary Game Analysis of Behavior in R&D Alliances with Absorptive Capacity Perspective. Industrial Engineering and Management, **16(6)**, 16-20 **(2011)**.

[16] Wang Long, Fu Feng, Chen Xiaojie; Evolutionary Games and Self-Organizing Cooperation. Journal of Systems Science and Mathematical Sciences, **27(3)**, 330-343 **(2007)**.

[17] Jinming Du, Bin Wu, Long Wang; Evolution of global cooperation driven by risks[J]. Physical Review E (Statistical, Nonlinear, and Soft Matter Physics, **85(5)**, 056117-056123 **(2012)**.

[18] Xu Yan, Hu Bin, Qian Ren; Analysis on stability of strategic alliances based on stochastic evolutionary game including simulations. Systems Engineering-Theory & Practice, **31(5)**, 920-926 **(2011)**.

[19] A.Erwin, P.Alex; On the stability of evolutionary dynamics in games with incomplete information. Mathematical Social Sciences, **58**, 310-321 **(2009)**.