Research on Information Sharing Mechanism of Network Organization Based on Evolutionary Game

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Abstract. This article first elaborates the concept and effect of network organization, and the ability to share information is analyzed, secondly introduces the evolutionary game theory, network organization for information sharing all kinds of limitations, establishes the evolutionary game model, analyzes the dynamic evolution of network organization of information sharing, through reasoning and evolution. The network information sharing by the initial state and two sides of the game payoff matrix of excess profits and information is the information sharing of cost and risk sharing are the influence of network organization node information sharing decision.

1. Introduction
Extensive use of the acceleration of economic globalization and information technology, the enterprise is facing the hitherto unknown pressure of competition, Shorter and shorter product life cycle, the diversification of customer demand, expand the fierce industry competition and functional alternatives so that enterprises continue to seek a breakthrough in the organization and external force, with a quick response the changeable market environment. To improve production technology and management of its own enterprise while the maximum, while breakthrough enterprise boundary constraints, based on the enterprises, seek cooperation and development, and a new type of alliance network organization began to appear. Today, the popularization of information is becoming higher and higher. An important feature of the network organization, information sharing and sharing degree can become important factors. Therefore, the research on information sharing of network organizations has attracted more and more attention, the previous research of its meaning from the perspective of game theory, the mechanism has made the corresponding results. On the basis of the previous research results, this paper takes the network organization as an evolutionary system and studies the information sharing mechanism from the evolutionary game.

2. Network Organization and Information Sharing Capability

2.1. Network Organization and Effect

2.1.1. Network Organization. Network organization is a kind of mechanism between market and hierarchical organization, as shown in Figure 1, is a group of equal status of the "nodes" rely on
common goals and interests together spontaneous organization, through long-term cooperation the formation of shared interests, structure complementary forces. In the structure the network like. Vertical organization hierarchy is weakened, and the right to information is distributed in all the nodes of the network, cooperation and communication level attention. Network structure such as the typical supply chain network, virtual enterprise network. The main interests of network organization is mainly reflected in: "information sharing", "strategic cooperation" and reduce transaction costs. The era of knowledge economy, more and more enterprises choose the network organization to develop core competitiveness, realize the information sharing and use heterogeneous technology, better adapt to the complex and changeable market operation Pattern.

![Figure 1. Market, Network Organizations and Bureau Relations](image)

2.1.2. Network Organization Effect. First of all, the formation of network organization can promote the sharing of information and communication, the network organization weakened level, strengthen the horizontal linkages, breaking the way of information transfer from top to bottom, which has better information transmission mechanism, information sharing is the foundation of network organization; secondly, optimize the network organization structure of rights, improve the organization the ability to adapt to the network organization, will be scattered in the right activity node, thereby improving the organization flexibility; thirdly, to promote the complementary ability between enterprises, each node of network organization resources and mutual access to technology, create new competitive advantages. Finally, to expand the sources of information, produce a product effect, as a kind of network organization social capital has perplexing social network to expand access to information.

2.2. Information Sharing Ability of Network Organization
The ability of information sharing in network organizations is manifested by the ability of nodes to share information through various contracts. It is affected by many factors, including the basic conditions of information sharing, the extranet and its utilization, information technology support, and information base construction Including information sharing organizational mechanism, that is, governance structure, business process reorganization incentive plan; Including active information sharing system, a process and information flow description, active information sharing control engine, process monitoring and process configuration, including the network Organizational culture, namely management system and operation mechanism, risk-taking awareness and sense of responsibility.

3. Evolutionary Game Theory
Evolutionary game theory comes from two theories, one is the theory of evolution, one is the game theory, its successful integration of rational economics and evolutionary biology, people will no longer be modeled as a game Super rational, that human is usually by trial and error method to reach equilibrium, and are common in biological evolution that choice is a function of the equilibrium process, thus influence the details of history, institutional factors and equilibrium process are multiple balance of game options. Unlike traditional game theory, evolutionary game theory is not involving people who are completely rational, do not require the conditions of complete information. Also will not focus on the static equilibrium and comparative static equilibrium, it emphasizes is a kind of dynamic equilibrium. Economists use evolutionary game theory to analyze the social norms, habits, body or system The influential factors of formation and the process of explaining its formation have also made remarkable achievements. Evolutionary game theory has become an important analytical tool of evolutionary economics, and has gradually developed into a new field of economics.

The best strategy of evolutionary game theory is to "learn" and constantly improve previous favorable strategies until the formation of evolutionary equilibrium strategy. The two basic concepts of evolutionary game model are evolutionary equilibrium strategy (ESS) and replication dynamics.
3.1. Evolutionary Balance Strategy (ESS)
If a strategy is ESS, the conditions for satisfying the evolutionary stabilization strategy are:

1. $S_0$ is a Nash equilibrium
2. When $S_0 \neq S$ satisfies $U(S_0, S_0) = U(S_0, S)$, $U(S_0, S_0) > U(S, S)$, ESS is defined as $X$ is a closed set of non-empty Nash equilibrium strategy, exist $\varepsilon \in (0,1), \sigma \in X, \sigma' \in BR((1 - \varepsilon)\sigma + \varepsilon\sigma')$, $0 < \varepsilon < \varepsilon'$, $(1 - \varepsilon)\sigma + \varepsilon\sigma' \in X$, Then X is evolutionary stable equilibrium.

3.2. Replicate Dynamic
The equation is described as: $\frac{1}{x_f} \frac{d_s}{d_f} = [u(g, s) - u]$, $g = 1, \ldots, G$, where $\alpha$ denotes the proportion of a population using strategy $f$. $u(g, s)$ represents the return function of strategy $g$ and $u$ represents its average return. Evolving from the principle of evolution, the condition for a strategy to develop in a population is its growth rate, that is $\frac{1}{x_f} \frac{d_s}{d_f} > 0$.

4. Network Organization Information Sharing Based on Evolutionary Game

4.1. Model Assumption
In order to systematically illustrate the policy selection process of information sharing among nodes in the network organization, we treat each node as a finite rational entrepreneur, and regard the process of sharing information as the evolutionary game. Each node is not only an information resource, but also users in the information resource network. Each time a strategy is chosen, the entrepreneur considers the strategies of other individuals and their own adaptability in the group. Therefore, each node passes "learning" and continues to adjust, whether the evolution of information sharing game.

The policy set of each node is (shared, not shared), that is, the information is shared or not provided, and the nodes of the network organization are simplified into two groups, namely, the information provider group $N_1$ and the information consumer group $N_2$. When both groups do not adopt the sharing strategy, the normal gains obtained are $V_1$ and $V_2$, respectively. When both groups implement information sharing, they can obtain increment gains $r_1$ and $r_2$, respectively. When $N_1$ and $N_2$ are different in the strategy, the increment of interest gained by the groups that implement the information sharing is $d_1$ and $d_2$ respectively, and the loss of the group decibels corresponding to the implementation of information sharing is $d_1$ and $d_2$, assuming that $d_1 < r_1$ and $d_2 < r_2$, so as to construct and evolve Game matrix, as shown in the following table.

|       | N1       | N2       |
|-------|----------|----------|
|       | Not Share| Share    |
| Not Share | $v_1, v_2$ | $v_1 + d_1, v_2 - d_2$ |
| Share   | $v_1 - d_1, v_2 + d_2$ | $v_1 + r_1, v_2 + r_2$ |

4.2. Model Building
If before the evolutionary game, $N_1$ choose not to share information of $\alpha$, then select the proportion of sharing information for $1 - \alpha$, $N_2$ ratio of $\beta$, choose not to share information, choose the proportion of sharing information for $\beta 1 - b$, group $N_1$ expected return for $UN_1N$ choose not to share information, choose the expected return for $UN_1Y$ Shared information, the average income of $UN_1$.

As shown in Table 1

$$UN_1N = v_1\beta + (v_1 + d_1)(1 - \beta) = v_1 + d_1 - d_1\beta$$  \hspace{1cm} (1)

$$UN_1Y = (v_1 - d_1)\beta + (v_1 + r_1)(1 - \beta) = v_1 + r_1 - \beta(d_1 + r_1)$$  \hspace{1cm} (2)
According to evolutionary game theory, when \( UN_1 = UN_1 Y \), the node profit relatively few in the network to imitate node relatively more profit, so the choice of different strategies of proportion of entrepreneurs began to change, this change depends on the two sides of the game to imitate the learning speed by the replicated dynamic equation, \( N_1 \) dynamic change speed sharing for information:

\[
F(\alpha) = \frac{d\alpha}{dt} = \alpha(UN_1 N - NN_1) = \alpha(1 - \alpha)(d_1 + \beta r_1 - r_1)
\]

(4)

Similarly, it can be concluded that the dynamic change rate of \( N_2 \) when it does not share information is:

\[
F(\beta) = \frac{d\beta}{dt} = \beta(UN_2 N - NN_2) = \beta(1 - \beta)(d_2 + \alpha r_2 - r_2)
\]

(5)

According to the formula (4) and (5) shows that only when \( \alpha = 0 \), \( \alpha = 1 \) or \( (d_1 + \beta r_1 - r_1) = 0 \), \( N_1 \) groups the proportion of using Shared strategy is stable, according to formula (5) \( \beta = 0 \), \( \beta = 1 \) or \( (d_2 + \alpha r_2 - r_2) = 0 \) \( N_2 \) groups sharing strategy used in the proportion of \( N_2 \) is stable.

For the equation (4) and (5), the partial derivative of \( \alpha \) and \( \beta \) is obtained, and the matrix is as follows:

\[
M = \begin{bmatrix}
(1-2\alpha)(d_1 + \beta r_1 - r_1) & r_1\alpha(1-\alpha) \\
r_2\beta(1-\beta) & (1-2\beta)(d_2 - r_2 + r_2\alpha)
\end{bmatrix}
\]

It can be seen from \( F(\alpha) = 0 \), \( F(\beta) = 0 \), the equilibrium point of the system is \((\alpha, \beta) : O(0,0), A(0,1), B(1,0), C(1,1)\) and \( D(1 - \frac{d_1}{r_1}, 1 - \frac{d_2}{r_2}) \), in these 5 equilibrium, it is the evolutionary stable strategy ESS of the evolutionary game, that is \( O(0,0) \) and \( C(1,1) \), the 2 nodes do not share information or share information.

In order to more accurately describe the dynamic evolution process of group game, can construct the network organization node information sharing behavior game dynamic replication phase diagram, as shown in Figure 2. Figure two unstable points A and C and the saddle point D, a discount, it said the implementation of the different critical line group selection slightly. Line OADC regional evolutionary game will converge to the O point, said the groups tend to choose the information sharing strategy, evolutionary game line ABCD region will converge to the B point, said the groups tend to choose not to share the information strategy. In this system, information sharing and sharing two states will coexist for a long time.
4.3. Model Analysis

It can be seen from the above phase diagram that each node in the network chooses whether or not information sharing is affected by the initial state. The evolution trend of each node selecting information convergence converges to different equilibrium points (information sharing or information not sharing) with the change of point D, The following specific discussion.

(1) by the replication dynamic phase diagram shows that when the initial state is less than \(1 - \frac{d_1}{r_1}\) and less than \(1 - \frac{d_2}{r_2}\), the nodes take the strategy of information sharing, the initial state point lies on the left side, then the game will eventually converge to the O point, each node will eventually that network organization adopted the strategy of information sharing. Each node in the network practice in the organization through various incentive mechanisms and incentives to stimulate the network organization for information sharing, is to maximize the organization to excess profits.

(2) when the initial state is greater than \(1 - \frac{d_1}{r_1}\) and \(1 - \frac{d_2}{r_2}\), that is, when the initial state node falls on the top right side, all nodes take the strategy of information not sharing, then the evolutionary game will eventually converge to the point, that is \(C(1,1)\), every node of the network organization will eventually adopt the strategy of information not sharing.

(3) when the initial state is greater than \(1 - \frac{d_1}{r_1}\) less than \(1 - \frac{d_2}{r_2}\) or less than \(1 - \frac{d_1}{r_1}\) or greater than \(1 - \frac{d_2}{r_2}\) in the initial state, the phase diagram of replication point falls on the top left or right below, the final result of the game is likely to converge to a point, \(O(0,0)\) and likely to converge to the point \(C(1,1)\), node network organization can adopt information sharing strategy and may also take the Ministry of information sharing strategy. The final equilibrium depends on each node of the network organization learning speed.

5. Conclusion

Information sharing is one of the basic characteristics of network organization, the degree of information sharing determines the profit growth of the network organization. Information sharing has attracted more and more attention by using evolutionary game of network organization information.
sharing research shows that network organization information sharing and payment matrix about, and is influenced by the initial state of the network at the same time, organizations can obtain excess profits and the size of the risk factor of information sharing and information sharing cost paid by the will affect the result of the game. The network organization should establish a good network environment, adhere to long-term interests, so as to achieve the purpose of sharing information, to maximize the excess profits.

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