Research on the Mashup Behavior and Evolutionary Patterns of Enterprises in an Incomplete Information Environments

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Abstract. Starting from the actual background of building industry KB (knowledge base) process of mashup, this paper concerned the influence of bounded rationality and made the usage of an evolutionary game model. Based on prior work, this paper has constructed two different types of asymmetrical core competences of enterprises by anticipated additional net payoff, net partition coefficient, preparation costs and mutation probability and other factors. First, the “prisoner’s dilemma” problem came out. Second this paper do static analysis of non-cooperative game and then seek the ESS (Evolutionary Stable Strategy, ESS) of evolutionary game model. Ultimately, the evolutionary paths are analyzed from the perspective on spatial dimension and time dimension of mashup. At last but not least, a series of corresponding management enlightenments are given out based on the above analysis.

1. Introduction
In the process of national innovation and development, enterprises build industry knowledge base relying on the new generation of information technology and mashup services based on the demand for information driven. Supported by the development of technological environment, enterprises pay more and more attention to the discovery of relevant resources and services from multiple perspectives, multi class environments and various fields. They integrate a large amount of information in all aspects of the market, and look for a new breakthrough and innovation point, so as to strengthen the core competitiveness and innovation ability of the enterprise. Practice shows that the intangible asset value embodied in information transmission and development is more important than the circulation of tangible assets (Weiying Z, 2002). However, under the trend of information mashup, the understanding for the information mashup development trend of industry alliance is neither profound nor comprehensive. In the situation of great mashup, and great competition, the mashup scale is unprecedented in the history of the mashup of various industries, and the competition scale and depth are also very large. However, many enterprises chose to use traditional thinking to understand and integrate because of "limited rationality", which may lead to an irrational result (Chen Feng, 2002), for example, to cut off competitors' communication cables. In the topic of enterprise information mashup, it is one of the most important contents of this article to pay attention to the mashup behavior of enterprise organization. This paper established a hybrid Nash game model and evolutionary game model in the process of building industry knowledge base, analyzed the game strategy of enterprises from the perspective of behavioral economics and natural selection, and discussed industry alliance stability and forming path.

Although complete information game is a widely used research method, the hypothesis of "static game" is still too idealistic in reality. In fact, the game participants can not meet the premise hypothesis of "complete rationality" in the actual life, but it consciously analyzes or just fortunately finds by trial and error (Axelrod, 2007). Evolutionary game concerns in Weibull studied the robustness of multiple
game behaviors among many bounded rational participants (Weibull J W, 1997). Vincent et al argue that evolutionary game has important applications in resource management, macro micro economics, cooperative evolution and so on (Vincent T L, 2005). Jalali et al proposed a hybrid evaluation system to apply evolutionary game to supply chain management environment (Jalali Naini S G, 2001). Ellis et al used empirical to test the relationship between evolutionary psychology and learning behavior, and they found that constantly looking for and studying the practice of peer first class companies and taking it as a benchmark can make the competitiveness of enterprises has been continuously improved (Ellis S, 2002).

Based on the "sudden" dissolution of R & D alliance cooperation in recent years, Zhang Hongchao and He Ren used evolutionary game theory to evolve game analysis to cooperative innovation strategy (Zhang Hongchao, 2010). Based on the hypothesis of incomplete information, Sun Qingwen conducted an asymptotic stability analysis for 2*2 evolutionary game equilibrium, and gave the topological equivalence classification of qualitative behavior completely, and finally discussed the dynamic explanation of evolutionary game to economic behavior model (Sun Qingwen, 2003). Zheng Junjun et al applied evolutionary game theory to study bidding strategies among heterogeneous firms, obtained the general rule of bidding strategy evolution under different market supply and demand conditions (Zheng Junjun, 2013). He Xijun made use of evolutionary game theory to study the evolution process with the change of investment income in the supply network, and simulated the enterprise selection and revenue relationship through Netlogo. Research shows that firm evolution stability strategy is not limited to participation and cooperation (He Xijun, 2013). By studying the creative industry clusters at home and abroad, Mao Lei realized that the establishment of innovation networks is an important driving force for Creative Industry Clusters. Using evolutionary economics theory, he constructed an evolutionary game model of enterprise cooperation behavior of innovation industry cluster, and got the key variables influencing enterprise cooperation (Mao Lei, 2013).

The above studies do not consider the impact of the expected additional net income, net income distribution coefficient, preparation cost and mutation probability on the successful mashup of information fusion. At the same time, most studies do not consider the information mashup behavior and evolution path of cross industry and different enterprises under the new trend of integration. Firstly, this paper analyzed the strategic choice of foreign enterprises by static and non cooperative game theory, and got the "prisoner's dilemma" problem. In order to solve this problem, using the viewpoint of biological evolution, the author made an analysis of the static and non cooperative game of asymmetric information to obtain the equilibrium point of dynamic equation, and accordingly, the phase diagram of the evolutionary stability strategy was obtained. Then, the Matlab7.1 software was used to simulate the behavior selection strategy of the enterprise with the change of the behavior and time of the other side, and the simulation results were consistent with the evolutionary stable strategy selection path displayed by the phase diagram. Finally, this paper gave a series of corresponding management implications.

2. The game of organizational behavior between enterprises and enterprises in the building process of industry knowledge base

2.1. Game process of information mashup in industry

In the general process of integrating the knowledge of industry alliance members into the industry knowledge base, the necessary conditions for the formation of industrial alliances are: members have common interests among enterprises, the knowledge base of a member enterprise has almost no same or similar knowledge or information in a certain field. In reality, the information between members is asymmetric and mimics, his paper used evolutionary game to analyze the behavior decision of enterprises and enterprises in the process of information mashup and use of information, and finally, some management strategies to promote and perfect the integration service are obtained, as shown in Figure 1.
2.2. Basic assumptions
The mashup of information within an industry refers to the process of embedding and integrating the knowledge base of multiple enterprises by the participants of each alliance member. Whether members are competitive or cooperative is uncertain, which requires a game analysis involving some participants in the process, so, the following assumptions can be made:

![Figure 1: establishment process of industry knowledge base](image)

- The industry has two types of information integration of member enterprises, class A and B enterprises; There are almost no similar knowledge or information in the knowledge base of class A and B enterprises, that is, the core competence, scale and strength of the two types of enterprises are different;
- (3) the enterprises in the industrial alliance have common interests; (4) each enterprise in the industry alliance is "bounded rationality", which means that each kind of enterprise does not seek the optimal strategy immediately, but gradually adjusts the strategy by imitating the behavior of others in the other office; (5) each type of enterprise does not fully understand the strategic space of all other enterprises, the payment function, etc., that is, incomplete information”; (6) the stability (or equilibrium) of industrial alliances means that the frequency of various strategies is just the same as the benefits of various strategies, thus, no alliance member has the desire to change strategy, and the proportion of individuals with different strategies.

2.3. Symbol specification

2.3.1. Constant. R1 represents the normal income of class A enterprise when they use their own knowledge base;
- R2 represents the normal income of class B enterprises when they use their own knowledge base;
- $\Delta R$ represents the additional net income of the two types of enterprises after the expected information mashup;
- $S$ represents the proportion of net income earned by a class A enterprise, $0< S<1$;
- $1-S$ represents the proportion of net income earned by B enterprises;
- $C_1$ represents the preparatory cost for a class A enterprise to choose the "mashup" strategy, $C_1>0$;
- $C_2$ represents the preparatory cost for a class A enterprise to choose the "mashup" strategy, $C_2>0$.

2.3.2. Independent variable. x represents the probability of a class A enterprise adopting mashup strategy;
- $1-x$ represents the probability of a class A enterprise adopting "non mashup" strategy;
- y represents the probability of a class B enterprise adopting mashup strategy, $0\leq y\leq1$;
- $1-y$ represents the probability of a class B enterprise adopting "non mashup" strategy;
- W represents the probability of enterprise mutation adopting the strategy of "mashup" (non mashup) to adopt the strategy of "non mashup" ("mashup"). Let $w=\varepsilon x y$, $\varepsilon$ is a very small normal number, imply that the percentage of mutations occurring can be predicted and very small.
2.3.3. **Dependent variable.** \( E_{1O} \) represents the expected return of a class A enterprise adopting a "mashup" strategy;
\( E_{1N} \) represents the expected return of a class A enterprise adopting a "non mashup" strategy;
\( E_{2O} \) represents the expected return of a class A enterprises adopting different strategies;
\( E_{2N} \) represents the expected return of a class B enterprise adopting a "non mashup" strategy;
\( E_{2E} \) represents the total expected revenue of a class B enterprises adopting different strategies.

2.4. **Benefit matrix of industrial alliance member enterprises**
The normal earnings of class A enterprises and B enterprises before mashup activities are \( R_1 \) and \( R_2 \). When class A enterprises and B enterprises choosing to "mashup", the upfront costs to be invested are \( C_1 \) and \( C_2 \). When the enterprise A and B cooperate fully and integrate successfully, it will bring additional net income to the whole industry \( \Delta R \). When one kind of enterprises choose to mashup and the other kind of enterprises choose not to mashup.

We think that the enterprises that choosing "no mashup" still get the profits \( R_i \) when they operate normally, and the enterprises that choosing "mashup" also need to pay the preparatory cost \( C_i \) for "mashup" investment. When both sides choose not to integrate the knowledge, both sides still get the normal income when they operate independently. Based on the above hypothesis, the income matrix of the members of the industry alliance is established in the process of information fusion, as shown in Table 1. Therefore, in the complete information non cooperative single static game, the rational choice of each enterprise will lead each enterprise to choose strategy 2 (non mashup), thus resulting in "prisoner's dilemma", that is to say, both sides of the game will give up the strategy that can get a higher income (mashup), but the strategy 2 (non mashup).

| class A enterprise | strategy 1: mashup | strategy 2: non mashup |
|-------------------|--------------------|-----------------------|
| strategy 1: mashup | \( R_1 + S \cdot \Delta R - C_1, R_2 + (1-S) \cdot \Delta R - C_2 \) | \( R_1 - C_1, R_2 \) |
| strategy 2: non mashup | \( R_1, R_2 - C_2 \) | \( R_1, R_2 \) |

3. **Numerical examples and game analysis**
For a more intuitive description for the process of information mashup, evolutionary stability analysis of firm strategy with bounded rationality (Weibull J W, 1997). Then, taking enterprise 1 as an example, this paper takes the numerical example to analyze the evolutionary stability of the strategy, and uses Matlab7.1 software to simulate the dynamic evolution process of the strategy.

(1) The value of each parameter in the game payoff matrix are as follows: \( \Delta R = 5 \), \( C_1 = C_2 = 1 \), \( S = 0.5 \), so \( 0 < \frac{C_2}{(1-S) \cdot \Delta R} = 0.4 < 1 \), \( \frac{C_1}{S \cdot \Delta R} = 0.4 \), if \( y > 0.4 \), the dynamic evolution process of enterprise 1 strategy with time is shown in Figure 3. As shown in the graph, with the passage of time, the probability of enterprise 1 choosing "mashup" strategy will eventually converge to 1, and the convergence rate will increase with the increase of initial probability, that is to say, for enterprise 2 choosing the strategy of "mashup", when the probability is greater than 0.4, the enterprise 1 will eventually adopt the strategy.
(2) If $y < 0.4$, taking $x < 0.4$, \[ \frac{\partial x}{\partial t} < 0, \quad \frac{\partial y}{\partial t} < 0, \] the point in the plane converges to O (0,0); Horizontal red line with abscissa represents when \[ y = \frac{C_1}{S \cdot \Delta R}, \quad \frac{\partial x}{\partial t} = 0, \] x is stable, that is, the probability of an enterprise's 1 choice of "mashup" strategy will not change over time, as shown in Figure 3.

4. Management implications

(1) Increase the penalties for defectors. Smaldino believes that the cluster of collaborators needs to strengthen barriers to defectors when the environment is not too bad, only in this way can the cluster gradually expand and form a dense and overlapping social relation map. In a very bad environment, cooperation may initially develop rapidly, but then defectors counter attack, forming network social relation graph (Smaldino P E, 2013). The theory takes into account the finiteness of resources and the role of external environment in the enterprise. The market has bounded rationality, opportunism, uncertainty and small number conditions, and the evolution of cooperation needs to build a new organizational structure of the enterprise as a substitute for the original organizational structure. Just like the genomes, cells, multicellular organisms, and even the entire animal community and human society, they are evolving with time and environmental changes. Therefore, the enterprise must innovate the system, enhance the absorptive capacity and innovation capability of enterprises, and strengthen enterprise communication, reduce the population of the relationship between risk and moral risk, to adjust or reconstruct the organization, to clear the traditional Pyramid structure to the knowledge base established roadblocks, the organization changed from vertical structure to horizontal structure. Optimize the enterprise culture, improve the cooperation motivation of the members of the alliance and
enhance the trust between each other, improve the technical system of knowledge management, in order to eliminate all kinds of obstacles affecting the cost.

(2) Fair responsibility and benefit distribution mechanism are the guarantees for enterprises to choose information mashup. The distribution of responsibility interests includes the establishment of information mashup platform and the joint investment of resources in the earlier stage; the common resource support in the middle of information fusion platform; the sharing of common resources in the late stage of information integration platform. The prophase resource input is the foundation of information integration platform construction. The members of industry alliance should participate and build together to save the limited resources and give full play to the group effect of the alliance. Therefore, the owners and investors of information mashup must protect their property rights according to law and clarify the rights and responsibilities of all parties, so as to ensure the co construction and sharing of information mashup platform. The construction enterprises of information fusion platform want to acquire the information, technology and knowledge resources they need from the industry knowledge base, therefore, only through the cross and integration of information, technology and knowledge sharing among different enterprises, can the information be integrated. The market mechanism often leads to the flow of resources to the optimal benefit, but for the long-term stability of the alliance, all stakeholders can actively participate in the construction and sharing activities of information fusion platform. It is also necessary to allocate economic benefits fairly and equitably in light of the situation of various industries.

(3) Economic interest is still the decisive factor for enterprises to choose information mashup. For most members of the alliance, economic benefits are the decisive factor in their choice of information fusion. The synergy effect of resource complementarity and technology, product and management, and the external positive effect of alliance spillover between industry alliance member enterprises can bring extra net income to the entire alliance. In practice, enterprises should coordinate the relationship between net income and cost, and pay attention to coordinating the production cost, inventory cost and the relationship between the cost and the input cost of the alliance members. It is possible that the initial cost is very large, but the production cost and inventory cost are greatly reduced, thus increasing net income. It can be possible that the initial cost is very small, but the production cost and inventory cost are increased greatly, but the net income is reduced.

(4) Adapt to the change of the market with its own changes. As time goes on, we adjust the upfront cost, allocation mechanism and additional net income according to the actual situation. As time goes on, there may be a mutation in a class B enterprise that chooses a particular strategy and a class A enterprises that chooses another strategy. After entering the new population, if the small group of mutation gains more than the original income, then the mutation is successful, otherwise, the mutation small group disappears in the evolution process. It is found that if the probability of mutation is large enough, the saddle point and the E3 point will converge to the stable point O. That is to say, the alliance is easy to disintegrate, and if we want to cooperate for a long time, we must establish reasonable management rules to cope with the changing internal and external market environment.

5. Conclusion
In the era of knowledge economy, relying on the new generation of information mashup technology, enterprises can discover, acquire relevant resources and services, and integrate a large amount of information in all aspects of the market from multiple perspectives, multi class environments and multiple domains, in order to strengthen the core competitiveness and innovation ability of the enterprise. How to use the industry alliance to produce efficiency and benefit? How to describe the behavior of each individual enterprise and its relationship with the industrial alliance? How to sum up the formation mechanism of individual behavior and the various factors involved in it into the evolutionary game model? These are important topics of interest in enterprise organization and academic research.

This paper points out that in the process of information mashup, the expected additional net income, the net income distribution coefficient, the preparation cost and the mutation probability affect the behavior path and benefit of the enterprise. Therefore, this paper focuses on the stability and formation
path of industry alliance to analyze the game strategy of member enterprises from the perspective of static game theory and evolutionary game theory, and the corresponding management inspiration is given from the spatial dimension and temporal dimension of information mashup. In this paper, the behavior selection strategy was simulated with the change of behavior and time, and the simulation results showed that the selection path of evolutionary stability strategy was same with that of phase map. Finally, this paper intends to give a series of corresponding management implications.

The study of this paper is a preliminary study for the above problems. Although static game is a widely used research method, the hypothesis of "static" is still too idealistic in reality. In future research, the author will further consider the "game", build a macro model with micro foundation, which can reflect the behavior of the main psychological diversity and complexity, can also be used as the basis to control macro group behavior. In the future, the author will combine micro psychology and macro sociology to do further research, in order to constantly improve the theory and practice of knowledge transfer and sharing in information mashup.

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