A Game Theory Analysis of Enterprises of Independent Innovation and Imitating Innovation

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Abstract: This paper analyzes enterprises of both independent innovation and imitating innovation from the game theory angle, and probes into disadvantage and dilemma of imitating innovation practice as well as the vital role of independent innovation to a long-term development of an enterprise. Conclusion has been drawn through the modeling of a complete information static state that for the reason that path dependency is a characteristic of imitating innovation, it is necessary to improve independent innovation ability to realize a long-term development of the enterprise.

Keywords: independent innovation; imitating innovation; static game theory of complete information

Selection of the technical innovation model is one of the core contents in enterprise strategy formulation. Which technical innovation model to choose sets, to a great extent, the development direction of an enterprise. At present, selection of innovation in China concentrates upon two modes, which are independent innovation and imitating innovation. And there are now a large number of researches focusing on game analysis based on direct cost and income as well as limited ones focusing on invisible benefits gained by independent innovation of a company and effects of that in future technical innovation. For the past few years, development of a few new industries has brought about by technology import and imitating innovation. However, in the meantime, dependence of imitating innovation has also to some extent restrained development of independent innovation.

Why do we encourage companies to self-dependent innovate? Will company of independent innovation and that of imitating innovation succeed a long-term development in the long competition game of market? The answers to these questions hold magnificent practical and theoretical significance, which is no other than the issues this paper will research and settle.

1. Conception of independent innovation and imitating innovation and the status quo in China

Independent innovation refers to a kind of technical innovation activity in which on the basis of self-dependent research and development, the company produces technical breakthrough and overcomes technical difficulties through self-efforts and exploration, and then on this basis push forward the successive stages of innovation to finish the commercialization of technique and obtain the commodity profits, thus, achieving the expected goal. Imitating innovation refers to a practice by which through learning and imitating methods of leading innovators, the company introduces and purchases the core technique and technical know-how of leading innovator, and then on this basis improve and innovate (Fu Jiaji [1998]). Nowadays, enterprises always make a choice from independent innovation and imitating innovation. Foreign scholars accumulate many research productions in this field, and bring us an inspiration. In the research of the path of technical innovation, in developed countries, Utterback and Abernathy (1975) linked it with life cycle theory. In the research of technique catch-up in developing countries, most studies emphasized to realize the goal by learning mature technology of developed country. Lee and Lim (2001) summed up three different patterns of catching-ups through the analysis of technology-pursuing in developing countries. Chinese scholars studied two choices from various perspectives. Xiao Kaihong and An Yanjie analysed the pattern which is basis on the strength of the enterprise. Song Geng and Zeng Jinze proposed that imitating innovation transform to independent innovation in developing country.

Over the past two decades since the reform and opening-up drive, on the basis of models of practical experience from Japan and Korea (see Yi Xianzhong [2007] ; Kim [1999]), as well as the combination of China's practical national conditions, rapid development of a few industries has brought about successfully, especially new industries, through large scale technology import and foreign direct investment etc. In the meantime, China's scholars also analyzed the advantages and conditions of China's imitation innovation mode from various angles. Nian Zhiyuan (2004) discussed how to choose the object and mode of imitation innovation from investment, risk and efficiency standpoints in terms of small and medium-sized enterprises. ZhuLiLi (2008) discussed how to perfect the system of intellectual property rights protection, thus guiding the legal imitation innovation to serve for national technical innovation. However, some phenomena exists during imitating innovation in China, such as emphasizing import but neglecting development, as well as a large amount of dependence and original equipment manufacturer in production etc. These phenomena have led companies neglect independent innovation and digestive absorption. The companies do not breakthrough the restriction of path dependence of imitating innovation, and they even lapse into a dilemma of introducing, falling behind, introducing again and then falling behind again. In the short term, technical capacity has already become a significant bottleneck restricting competition ability of

the company. How to improve technology level to conduct technical innovation is a key point for Chinese companies to carry through technology catching-up.

2. Model hypothesis and its description

We suppose that there are two innovation models available for enterprises---independent innovation and imitating innovation, and that they have constructs a static game model with complete information for the independent innovation and imitating enterprises' innovation, which analyses theoretically the internal mechanisms of enterprises' independent innovation and imitating innovation. Assume that there are only two enterprises in the market: A and B, they compete with each other with goods of the same quality. Suppose that, during the competition of the last technical programmed, enterprise A chooses independent innovation model, while enterprise B chooses imitating innovation model. Now another technical innovation programmed comes up, which is the follow-up of the previous one, and enterprise A and B has to go into research and development of this programmed. Assume the probability of enterprise A to succeed with independent innovation is p_1 , and the gain of the success is r_1 ; the probability of enterprise B to succeed with independent innovation is p_2 , and the gain of the success is r_2 . The new cost for independent innovation is c. If only one enterprise succeeds, the other one will go into imitating innovation and it has to pay the intellectual fees d, such as the patent fee, to the former enterprise.

In the previous research and development of the last technical programmed, enterprise A chooses the independent innovation model, therefore, the ratio of the R&D costs saved due to the intellectual accumulation is e (0 < e < 1), and $p_1 > p_2$. From the above description, we can safely know that there are four strategies for the two enterprises: (independent innovation, independent innovation), (independent innovation, imitating innovation), (imitating innovation, independent innovation), (imitating innovation, imitating innovation).

If, in the payment matrix, the strategic combination of the two enterprises is (independent innovation, independent innovation), the expected gain of enterprise A is: $p_1p_2[r_1-c(1-e)] + p_1(1-p_2)[r_1-c(1-e)+d] + (1-p_1)p_2[r_1-c(1-e)-d] - (1-p_1)(1-p_2)c(1-e) = p_1(r_1+d) + p_2(r_1-d) - p_1p_2r_1-c(1-e)$ 1-e)

And the expected gain of enterprise B is:

 $p_1p_2(r_2-c)+p_1(1-p_2)(r_2-c-d)+(1-p_1)p_2(r_2-c+d)-(1-p_1)(1-p_2)c=p_1(r_2-d)+p_2(r_2+d)-p_1p_2r_2-c$

If the strategic combination of the two enterprises is (independent innovation, imitating innovation), the expected gain of enterprise A and B is:

 $p_1[r_1-c(1-e)+d]-(1-p_1)c(1-e)=p_1(r_1+d)-c(1-e);$ $p_1(r_2-d)$ If the strategic combination of the two enterprises is (imitating innovation, independent innovation), the expected gain of enterprise A and B is:

 $p_2(r_1-d)$ $p_2(r_2-c+d)-(1-p_2)c=p_2(r_2+d)-c$

If the strategic combination of the two enterprises is (imitating innovation, imitating innovation), it means that the two enterprises do not go on independent R&D. Because there are only 2 enterprises in the market, the gain for both enterprises is 0.

Therefore, we can get the payment matrix (table 1) which shows the competition between enterprise A and B.

В	independent innovation	imitating innovation
A		
independent	$[p_1(r_1+d)+p_2(r_1-d)-p_1p_2r_1-c(1-e)]$	$[p_1(r_1+d)-c(1-e), p_1(r_2-d)]$
innovation	,	
	$p_1(r_2-d)+p_2(r_2+d)-p_1p_2r_2-c$]	
imitating	$[p_2(r_1-d), p_2(r_2+d)-c]$	(0,0)
innovation		

Table 1. the payment matrix which shows the competition between enterprise A and B

3. Equilibrium analysis

1. When the strategic combination of the two enterprises is (independent innovation, independent innovation), we can assume that $r_1=r_2$ due to the same quality of their products.

If this strategic combination fulfills the Nash equilibrium, the payment maxim must satisfy the following condition:

 $\begin{cases} p_1(r_1+d)+p_2(r_1-d)-p_1p_2r_1-c(1-e) > p_2(r_1-d) \\ p_1(r_1+d)-c(1-e) > 0 \\ p_1(r_2-d)+p_2(r_2+d)-p_1p_2r_2-c > p_1(r_2-d) \\ p_2(r_2+d)-c > 0 \end{cases}$

After calculation, we can conclude:

$$\begin{cases} p_1(r_1+d) - p_1 p_2 r_1 - c(1-e) > 0 & (1) \\ p_2(r_2+d) - p_1 p_2 r_2 - c > 0 & (2) \end{cases}$$

Because $r_1 = r_2$, and $p_1 > p_2$, after comparing (1), (2),

we can know that enterprise A fulfills the conditions better than B. If the market fluctuates and the condition turns into $p_2(r_2+d)$ - $p_1p_2r_1$ -c=0, independent innovation still works better for enterprise A, while 2 situations can occur for B's payment.

If the payment for B is:

$$\begin{cases} p_1(r_2-d) + p_2(r_2+d) - p_1 p_2 r_2 - c < p_1(r_2-d) \\ p_2(r_2+d) - c > 0 \end{cases}$$

Then, independent innovation still works better for enterprise A, while there are no strategies working better for B. As a result, the originally dominance equilibrium turns into Iterated dominance equilibrium under the condition of independent innovation. And (independent innovation, independent innovation) will become the Iterated dominance equilibrium for both enterprises.

If the payment for B is:

 $\begin{cases} p_1(r_2-d) + p_2(r_2+d) - p_1 p_2 r_2 - c < p_1(r_2-d) \\ p_2(r_2+d) - c < 0 \end{cases}$

Then imitating innovation will become B's dominance equilibrium. Enterprise A and B will form a new

dominance equilibrium that is (independent innovation, innovating innovation), as figure 1 shows:



Figure 1: B's strategic choice

2. When the strategic combinations of two enterprises are independent innovation and imitating innovation respectively, it means that enterprise A is going through an independent innovation while enterprise B is doing the imitating innovation by research and development of enterprise A. Under the competition environment, because of the initiatives of independent innovation establishes the dominant position of innovator, therefore $r_1 > r_2$.

If in such strategic portfolio meet the Nash equilibrium, the payoff matrix will meet:

$$\begin{cases} p_1(r_1+d) + p_2(r_1-d) - p_1p_2r_1 - c(1-e) > p_2(r_1-d) \\ p_1(r_1+d) - c(1-e) > 0 \\ \\ p_1(r_2-d) + p_2(r_2+d) - p_1p_2r_2 - c < p_1(r_2-d) \\ p_2(r_2+d) - c < 0 \end{cases}$$

Calculate:

$$\begin{cases} p_1(r_1+d) - p_1 p_2 r_1 - c(1-e) > 0 & (3) \\ p_2(r_2+d) - c < 0 & (4) \end{cases}$$

By putting the two together:

$$c(1-e)/p_1 - r_1(1-p_2) < d < c/p_2 - r_2$$
 (5)

If the D value equal to $\frac{c}{p_2} - r_2$, the payment of independent innovation and the imitating innovation are:

$$[p_1r_1 - c(1 - e) + p_1\left(\frac{c}{p_2} - r_2\right), [p_1r_2 - p_1\left(\frac{c}{p_2} - r_2\right)]$$

If the D value equal to $\frac{c(1-e)}{p_1} - r_1(1-p_2)$, the payment of independent innovation and imitating innovation are:

$$[p_1r_1 - p_1r_1(1 - p_2), p_1r_2 + p_1r_1(1 - p_2) - c(1 - e)]$$

As shown in figure 2, when (5) is right, the dominant strategic of enterprise B is always imitating innovation. So, enterprise A could price in the range of $\left[\frac{c(1-e)}{p_1}-\right]$ $r_1(1-p_2)$, $\frac{c}{p_2}-r_2$] when D improve each unite, enterprise A can get p1 unit income, but enterprise B will p1 unit income. This could mean that reduce independent innovation of enterprise A on the last project will increase the income gap between enterprise A and enterprise B. because of the income has transferred to enterprise A in the form of IP Royalties such as royalties etc., which has influenced the income distribution between two enterprises, and realized a firm's profit maximization. Therefore, during the strategic combination of two enterprises, the choice of the independent innovation of the last project will increase the income gap between enterprise and other enterprises, and establish the dominant position under the competition environment.



3. Combinations of two enterprises are imitating innovation and independent innovation respectively, and enterprise A is doing the imitation innovation from the research achievements of enterprise B. Also, because of imitative of independent innovation, say $r_1 < r_2$

If in such strategic portfolio meet the Nash equilibrium, the payoff matrix will meet:

$$\begin{cases} p_1 (r_1+d) + p_2 (r_1-d) - p_1 p_2 r_1 - c (1-e) < p_2 (r_1-d) \\ p_1 (r_1+d) - c (1-e) < 0 \\ p_1 (r_2-d) + p_2 (r_2+d) - p_1 p_2 r_2 - c > p_1 (r_2-d) \\ p_2 (r_2+d) - c > 0 \end{cases}$$

Calculate

$$\begin{cases} p_1(r_1+d) - p_1 p_2 r_1 - c(1-e) < 0 & (6) \\ p_2(r_2+d) - p_1 p_2 r_2 - c > 0 & (7) \end{cases}$$

By putting two together:

$$\frac{c}{p_2} - r_2(1 - p_1) < d < \frac{c(1 - e)}{p_1} - r_1(1 - p_2) \quad (8)$$

when (8) is right, if D value equal to $\frac{c(1-e)}{p_1} - r_1(1-p_2)$, the payment of imitating innovation and independent innovation are:

$$\left\{ p_2 \left[r_1 - \frac{c(1-e)}{p_1} - r_1(1-p_2) \right], \ p_2 \left[r_2 + \frac{c(1-e)}{p_1} - r_1(1-p_2) \right] - c \right\}$$

If D value equal to $\frac{c}{p_2} - r_2(1 - p_1)$, the payment of imitating innovation and independent innovation are:

$$[p_2(r_1+r_2)-c-p_1p_2r_2, p_1p_2r_2]$$

As shown in figure 3, because $\frac{c}{p_2} > \frac{c(1-e)}{p_1}$ and $(1-p_1)$

< $(1-p_2)$, so the changed range of D will be limited by the above two numerical. Therefore, enterprise A will largely influence enterprise B to price d. The enterprise A fixes D value within $\frac{c(1-e)}{p_1} - r_1(1-p_2)$, which moves limit the room of increasing profit of enterprise B in the form of royalties. At the same time, enterprise A controls the expenditure of technology development properly through its effect on enterprise B.



Combined with the above analysis, we could see that the strategic goal of independent innovation scores the first by capturing market. That strategy will show obviously competitive advantage in the long-term competition. Firstly, independent innovation is benefit to cultivate independent research ability through the practice of deepening the technical knowledge and research concept understanding, strengthening independent innovation, based on the success of a core technology development drive subsequently a series of related product development, and formed cluster phenomenon. Secondly, independent innovation is benefit to establish technical barriers, by formulating patent rate to affect the choice of the similar enterprises about innovation strategy. Based on the patent protection for the core technology and controlled the key technology transfer, which would make enterprise maintain the dominant position in competition, and even in a certain extent influence the technical development of an industry. Finally, although independent innovative enterprises should pay higher research cost, however if we want to get rid of the highly dependent difficulties from foreign countries, and truly achieve the ascension of innovative capability, we must strengthen the input for the innovation of science and technology. By independent research gets the core technology which owns the propriety intellectual property rights, forming the core competitive in the continuous technology competition, achieving long-term sustainable development.

4. Conclusion and suggestions

Although independent innovation has many advantages in the aspect of forming the enterprise's core competence, the autonomous- innovated enterprise has to take risks because of its highly uncertain. Beyond that, how to train and maintain an efficient R&D team also becomes a primary question. As the enterprise, to train their core competence has to focus on the research and development of key technology, in order to realize independent innovation and achieve key across. As government, to improve the mechanism for rewarding innovation and steer the public opinions, they can encourage and support enterprise for independent innovation form many aspects, such as policy and financial, and work to create a good environment and atmosphere to help enterprise's independent innovation.

Low-cost labour and strong mimetic ability has great improve the China's influence. With further development of society, this influence will become a resistance of Chinese enterprises' development. Although Chinese enterprises' size is rising, its development pattern has not changed at all. Chinese enterprises are still in a weak position in the process of competition with the world-class enterprises. So during twelfth five-year, Chinese enterprises have to focus on the foresight research, breakthrough and innovation of development, in order to promote its leap frog development and seize the opportunities of globalized technical innovation. It will make Chinese enterprises successfully completed to achieve its growth, from henchman of the industry to pacemaker.

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Vitae

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