On Choices of Innovation Strategy of Chinese Pharmaceutical Enterprises from Perspective of "Wise Pig Game"

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Abstract

"Wise Pig Game" is a classical model of modern game theory. Just like the piglet in the model, the pharmaceutical companies of China is gambling with the global pharmaceutical companies and growing cautiously. In this game, the "piglet" not only has to survive, but also should shoulder the heavy responsibility of promoting our national pharmaceutical industry. Therefore, it is very important to choose the right direction of developmental strategy. Through analysis of the model, this paper establishes the choice of innovation strategy for China pharmaceutical enterprises.

Keywords: Wise pig game, Pharmaceutical enterprises, Innovation

Along with the evolving economic globalization, world economy becomes more changeable. Global industrial structure faces up with new adjustment and upgrade. Since 80s in last century, the world pharmaceutical industry dominated by multi-national pharmaceutical giants has experienced world- shaking changes, driven by the economic development, the technological progress, and the increasing pharmaceutical market in world. In order to establish the position in world competition, and grasp world market, and allocate resources in a global scope, multi-national pharmaceutical giants keep on engineering their organizational structures by merge and purchase, seeking for technological innovation, and investing more in new medicine's research and development. As a result, the competitive pattern in global pharmaceutical industry changes a lot. Under the environment with fierce competition in global pharmaceutical market, China's pharmaceutical enterprises began to perform strategic transformation and technological reform in order to sustain their existence and development. This paper will discuss the options of innovation strategies for China's pharmaceutical enterprises based on a classic mode in game theory.

1. Wise pig game

This theory was a typical game case advanced by Nash, the founder of non-cooperative game theory and the winner of Nobel Prize for Economics (Weiying Zhang, 1996). There is one button on one side of the sty and output of food and crib on the other side. Press the button once, ten-unit food will enter the crib. But this action will consume certain labor that equals to the consumption of two-unit food. Every pig has to make decision on whether wait beside the crib for food or press the button.

The problem is that the button and the crib locate on different sides of crib respectively. As the pig that pressed the button run to the crib, the other pig has already begun to eat food. If the big pig waits for food, as the big pig has eaten nine-unit food, the small big would eat only one-unit food. If they came at the same time, the big pig can eat seven-unit food and the small pig three-unit food. If the small pit waits for food, the small pig can eat four-unit food and the big pig six-unit food. Use the net food eaten by big pig and small pig to reflect the won of them. Then the "wise pig game" can be expressed by the won matrix as follow (Table 1).

The result of this game is determined by the big pig's judge on the small pig's behavior. If the small pig presses the button, the big pig would like to wait beside the crib and eat the nine-unit food. If the small pig chooses to wait the big pig will press the button and then come back to eat four-unit food, what is better than waiting in hunger. For the small pig, situation is very clear. No matter how the big pig acts, the best choice is to wait beside the crib. Therefore,

equilibrium of this game is: the big pig presses the button and come back to eat food, and the small pig just waits for food ------ coexistence.

Therefore, the Nash equilibrium of "wise pig game" is that the big pig presses the button and the small pit waits for food. The wise small pig gains the best result. If the small pig fails to judge the situation correctly and chooses to press the button, it may suffer from a great loss that equals to -1 payment.

2. Theoretical inspiration

This game theory has profound inspiration: choosing the right game strategy according to the specific situations and the rivals' conditions is extremely important. The technological innovation strategy of enterprises is a game with competitors in market in essence. In general, most pharmaceutical enterprises in China are small. Even for China's state-owned large enterprises, considering the size, the production output, the capital investment, and the technological level, they are merely small pigs comparing with the large pharmaceutical companies in developed countries and the multi-national companies. The common enterprises in China are almost piglets.

The technological innovation and new medicine research and development, and accompanied market benefits in one industry are equal to the "press-button" and the "food". These enterprises form this mode. So they should obey the industrial and similar game rules. However, under present situation, China's pharmaceutical enterprises are merely "small pigs" or even "piglets". In this mode, their strategy is nothing but wait. Considering the pharmaceutical industry, the strategy is imitation. To imitate medicine is the base for China's pharmaceutical enterprises' survival at present. Domestic pharmaceutical enterprises can sustain existence and development by imitation in medicine production. At the same time, the imitation can help to save costs in research and development. However, in the pharmaceutical industry, the ratio of return of "big pig" and "small pig" in equilibrium is not 1:1 but N:1. Therefore, under this equilibrium, the distance between "big pig" and "small pig" will become larger.

The inspiration of this mode is more than the point mentioned above. If China's pharmaceutical enterprises prefer to follow others all the time, they will never grow strong and compete with world pharmaceutical companies. Therefore, being bigger and stronger is the goal of China's pharmaceutical enterprises. However, imitated innovation can not help "small pigs" grow well. Considering China's condition, because small- and medium-enterprises are limited in sizes, capitals, and abilities of research and development, a few of powerful enterprises can choose to perform self-innovation in their advantage fields and imitated innovation in disadvantage fields. They can combine three innovation strategies, namely self-innovation, imitated innovation, and cooperative innovation organically (Hong Wang, 2006, p124-126).

3. Choice of strategies

3.1 Self-innovation

In contrast with the introduction of technology and the imitation, self-innovation is kind of creative activity. It possesses the exclusive property right of unique core technology and can help to realize the value of new products. In other words, the core technology used in self-innovation is generated from the internal technological breakthrough in enterprises, getting rid of dependence on the introduction of technologies and the technological imitation. The core technology is obtained by self strengths and independent research and development activities. The essence is to grasp the initiative right of the core ring of innovation and master the property right of core technology. The fruits of self-innovation include scientific discoveries, technologies, products, and brands with independent knowledge property right (Wei Zhang. & Xuanliang Zhang, 2006, p956).

3.1.1 Improve pharmaceutical enterprises' consciousness of self-innovation

Pharmaceutical enterprises should realize that innovation is urgent. In history, from the introduction of technology and the imitated innovation, to the self-design and the self-innovation, most technologically lagged-behind countries, especially developing countries, usually take it as an effective way to develop technologies. If China pursues to become strong in pharmaceutical filed, it is a must to improve pharmaceutical enterprises' ability of self-innovation. Only by cultivating a core competence by self-innovation, can China's pharmaceutical enterprises achieve sustainable development and hold an invincible position in world pharmaceutical market.

3.1.2 Create favorable environment and mechanism to improve the ability of self-innovation

China should create a system frame for pharmaceutical enterprises' self-innovation, constructing an enterprise-dominated, market-guided, and production-study-learn-combined system for technological innovation, forming a fundamental mechanism frame for self-innovation. Government should ensure effective policy supply for pharmaceutical enterprises' technological innovation, adjust the financial supportive policy for pharmaceutical enterprises, perfect the purchase policy, and give priority of buying new technologies and products with own property right. Invest more in pharmaceutical enterprises' self-innovation. Build up relatively normative capital

market and venture mechanism as soon as possible. Perfect the investing and financial mechanism and the service system for pharmaceutical enterprises' technological innovation. For example, construct and perfect a multi-level innovation mode and form a multi-participated investment system in which the government shoulder the responsibility of guidance, enterprises are the subjects, banks provides with loans, and social capitals and introduced foreign capitals serve as capital complement, and by which pharmaceutical enterprises can obtain amounts of capitals. As far as the short of patents, the government should provide with policy support for enterprises' property protection, and help to enhance the system of protecting property right in enterprises. Enterprises can improve their self-research and development ability by enhancing the professional techniques of researchers and technologists and improving the scientific and technological management mechanism (Xiaoqin Xu. & Hongyan Yang, 2007, p108-110; Yafei Luo. & Yucan Jiao, 2007, p71-77). Perfect and improve a service-support system for enterprises' self-innovation ability. Create a favorable environment for "small pigs" becoming "big pigs".

3.1.3 Emphasize the three stages of self-innovation

(1) Construct a strong base for initial innovation. Initial innovation, namely the basic original innovation, is the source of self-innovation. A successful initial innovation is determined by a series of special factors, including deep scientific accumulation, nice international cooperation, creative academic team, flexible innovative techniques, and fair performance-evaluation mechanism. For powerful "big pigs", it is not hard to create the conditions for initial innovation. But for China's pharmaceutical enterprises, namely "small pigs", it is not easy to obtain necessary elements and conditions for initial innovation. Therefore, the government should provide with support in fields of technologies and capitals to help enterprises to create their core technologies and core competence.

(2) Drive the breakthrough innovation fully. As we enhance the construction of initial innovation, we should emphasize the mutual cooperation between pharmaceutical industry, and source of innovation and technologies, improving the research and development of common technologies in pharmaceutical industry, driving the development of important substitute in dragon enterprises in pharmaceutical industry, and achieving the successive and breakthrough innovation in enterprises.

(3) Continue to deepen the secondary innovation. As "small pigs", China's pharmaceutical enterprises have to choose the technological innovation mode scientifically, and combine technological innovation and the introduction of technologies effectively, in order to improve their self-innovation abilities. Based on self-innovation, they can introduce foreign latest technologies. And in this process, they should emphasize the consumption and assimilation of technologies instead of purchase, applying the new technologies to their production.

3.2 Imitated innovation

New medicine's research and development is expensive, and has a longer term and higher risks. In 1999, Glaxo Wellcome invested 11.7 percent of income in R&D, Roche 17.36 percent, Merck 16.84 percent, and Novartis 18.13 percent. In contrast, the percent is merely about 1 percent or so in China's pharmaceutical enterprises (Sino Trust, 2005). It will cost ten years and 300 million dollars to develop a compound into a medicine that can enter the market, what is not easy for China, a developing country. Data show that during the twelve months before June, 2006, the sales of global medicine increase by 5.9 percent, reaching 580 billion dollars. The sales of imitated medicine increase by 8.9 percent, reaching 54.8 billion dollars. In 2006, the sales of invalid patent medicine reaches 23 billion dollars, and in 2008 the number will exceed 80 billion dollars (Weizhong Shen, 2007, p59-60), which means unpredicted opportunities for the production of non-patent medicine. For China's enterprises, it is a great chance to develop imitated medicine and enter the global pharmaceutical market.

3.2.1 Step on the imitation road with China's characteristics

Beginning from imitated innovation, China's pharmaceutical enterprises should insist on the combination of imitation and innovation, and aim at manufacturing products with "higher technologies, better curative effects, higher added values, and new forms", and decreasing the costs of products. Emphasize the high-tech research and the new-form research of imitated medicine, which can consume less material and possess higher quality, being safe and effective. China's pharmaceutical enterprises should take references from foreign countries' advanced experiences, speeding up the development of the self-innovation by developing "me too" medicine, which is a shortcut from imitation to innovation. Continuous and small-scope process innovation, such as the improvement of techniques, has higher maneuverability no matter what it is cost or technology. Besides, they can develop their own technologies by tracing some products with invalid patent and energetic vitality and steering clear of a series of crafts and technologies with valid patents (Jie Tan. & Yan Cheng, 2006, p104-107).

Meanwhile, China's pharmaceutical enterprise should focus their advantage strengths on several most profitable products, instead of "wide farm, less income". According to the increasing effect of scale economy, enterprises should perform best in a few kinds of products. Collect enterprises' advantage resources to drive the sales of several

products, realizing the leap from quantity accumulation to quality improvement. The increase of sales can enlarge the production scale, decrease production cost, and gain more spaces for benefits, which can improve the economic effect and increase the investment in research and development.

3.2.2 Problems that should be noticed

(1) Construct a perfect information management system and obtain useful information timely and rightly. Affordable pharmaceutical enterprises should build up an information net system for technological research and development that can help to collect information from relevant researching programs, fruits, and institutions, and relevant regulations, laws, and patent materials in other countries. Construct a perfect information net system that can collect, process, analyze, transfer, and communicate information and an effective feedback mechanism for evaluation of innovation, what can provide with information support for the whole process of enterprises' technological innovation. Besides, pharmaceutical enterprises should be good at using exterior strengths to obtain information, such as obtaining needed information through relevant special consulting agency and information service institution. Especially for small pharmaceutical enterprises that are not capable of constructing their own information net system, they can sign special or long-term contracts for information provision with special consulting agency and information service institution, which can ensure that enterprises can obtain sorts of latest trends and specialized knowledge that relate with technological innovation.

(2) Deal with the relationship between imitation and copy properly. Pharmaceutical enterprises' imitated innovation is to absorb others' successful experiences and lessons by learning from their innovative thoughts and activities, introduce and interpret the core technologies and technological secrets, and make improvement. Input main strengths in middle- and later-production rings, such as art design, quality control, cost control, and marketing and produce more competitive products, gaining more spaces in market. In contrast, copy is to take others' technologies and products directly, without any improvement in products' forms, production crafts, and even marketing channels, which is an invasion to others' knowledge property.

3.3 Cooperative innovation ------ merge and purchase

No matter what it is self-innovation or imitated innovation, the two kinds of innovation can be realized by merge and purchase. Merge and purchase mean the investors, such as enterprises and financial institutions, obtain other enterprises' part or all stocks or assets by certain channels and payment ways in order to achieve certain goals, which can make investors practically control or completely control other enterprises' business management (Xingmin Yin, 1999). Merge and purchase is a main way for cooperative innovation. In the long run, the cooperation after pharmaceutical enterprises' merge and purchase will undoubtedly inspire innovation. According to Henderson's investigation on 25% of world new medicine in middle 90s in last century (Henderson, 1996, p32-59), large pharmaceutical enterprises possess more advantages in research and development. The efficiency of R&D programs in large pharmaceutical enterprises is higher than that in small pharmaceutical enterprises. The advantage of large pharmaceutical enterprises comes from the economy of scale. Large pharmaceutical enterprises can make best use of exterior resources and interior accumulated knowledge capitals with higher efficiency. And the economy of scale makes large pharmaceutical enterprises greater specialization under the same cost.

Data show that the number of enterprises' merge and purchase activities has increased from 73 in 2003 to 84 in 2004, once every week in average (Hai Huang. & Zhifeng Wang, 2007, p1117-1120). To occupy advantage resources is the goal of enterprises' merge and purchase activity. Enterprises invest more time and energy in advantage resources.

3.3.1 The form of merge and purchase

(1) Horizontally merge and purchase. Enterprises in one merge and purchase action belong to one industry and produce similar products. The important economic meaning of horizontally merge and purchase is the economy of scale. Marshall defined the so-called economy of scale as a decrease of production cost and a increase of return per unit in certain enterprise due to enlarging production scale (Yi Wang, 2001). Merge and purchase and reengineering can bring about the obvious effects caused by the economy of scale and together with specialization and advantage complement, what can generate scale benefits in production, marketing, and R&D accordingly. By merge and purchase, enterprises can complement and adjust their assets in order to meet the requirement of optimal scale economy and minimize the business costs. Besides, enterprises can realize the deepening production, use uniform production procedure, reduce the intervals between production rings, and make best use of productivity, as they sustain their general product structure. At present, China has thousands of pharmaceutical enterprises. And most of them are small- and medium-enterprises. Only 300 of them are large enterprises. Although the concentration rate CR_4 of China's pharmaceutical industry increases from 7.2 percent in 1998 to 9.5 percent in 2003, it is lower comparing with that of foreign countries. In 1983, the concentration rate CR_4 of England's pharmaceutical industry is 35 percent, and in 1991 the number of Germany's pharmaceutical industry is 28 percent (Diquan Cao. & Ke

Chang, 2002, p14). Therefore, China's pharmaceutical industry has a wider space to increase the concentration rate. Enterprises' merge and purchase and reengineering can help to obtain the sustainable scale benefits, especially in fields of marketing, brands, and R&D, what is an excellent way to get rid of the position of "small pig" in game.

(2) Vertically merge and purchase. Enterprises in one merge and purchase action locate in different stages of production and circulation. They connect with each other by materials' production, supply, processing, and sale. By means of vertically merge and purchase, large enterprises can completely control all stages of materials' production and sale. It is an essential way for large enterprises to construct a vertically control system. The aim is to decrease the transaction costs in market and enhance the monopoly over market (Yi Wang, 2001). That is why most pharmaceutical enterprises prefer to the vertically merge and purchase strategy.

(3) Mixed merge and purchase. The horizontally merge and purchase, and the vertically merge and purchase happen at one action. Or enterprises in one merge and purchase action belong to different and non-related industries. This action generally happens as enterprises in one industry try to enter other profitable industry. And mixed merge and purchase usually relates with enterprises' multiple strategy. In fact, the profitable pharmaceutical industry has become an ideal investment field for many powerful investors.

3.3.2 Problems that should be noticed

(1) The boundary of enterprises' size. Many problems should be noticed in merge and purchase process. One of problems that deserve more attentions is the size of enterprise that is reached by merge and purchase and is most effective. According to the concept of scale economy discussed in classic theories of economics, the enterprise has an optimal size, namely the critical point of scale economy and non-scale economy. Only when the enterprise is on the critical point, can it gain profits by enlarging the size. Otherwise, it can not gain profits by enlarging the size. Therefore, it is necessary to consider the boundary of enterprise size. The boundary of enterprise size is the balance point between the transaction cost in market and the exchange cost in enterprise. According to the three dimension of transaction and the three contract backgrounds advanced by Williamson, an economist, three factors determines the boundary of enterprise size, namely the frequency of transaction, the asset specificity, and the contract environment. The three factors determine the transaction costs of different economic organizations. By comparing the costs and the benefits, we can theoretically get the optimal size of enterprise, which can help the enterprise to achieve its optimal size by merge and purchase (Shuzhen Chu, 2004, p156). Therefore, pharmaceutical entperises should control their boundaries of size in merge and purchase, avoiding the non-scale economy caused by too-large size.

(2) Construct modern enterprise system. After the merge and purchase action, enterprises should construct a uniform management system for organizational management, employees' performance evaluation, finance management, products' research and development, marketing and sales, and customer service, in order to guarantee the general management and operation in enterprises.

(3) Invest more in research and development after the merge and purchase action. The government can drive enterprises to invest more in medicine research and development by taxation policy. The national taxation should permit enterprises to take expenses in research and development as costs, what can reduce the new medicine's value-added tax and income tax after entering the market. Pharmaceutical enterprises should emphasize more on the cultivation of scientific and technological talents after the merge and purchase action by forming a "research and development alliance" with science & technology research institutions and colleges (Hai Huang. & Zhifeng Wang, 2007, 1117-1120).

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Table 1. Won matrix.

Small pig / Big pig	Press button	Wait
Press button	5, 1	4, 4
Wait	9, -1	0,0

(In every decision, the first number stands for the won of big pig and the second the won of small pig.)