Owner Risk Averse and Enterprise Technological Innovation Mode: Focus on Major Equipment Manufacturing Industry

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Abstract

Major equipment manufacturing industry is the strategic industry of national defense construction. In the 1990s, China began implementing the "market for technology" strategy, but the strategy did not achieve the desired results, for the important technology and equipment is still highly dependent on imports. The paper analyses the risk aversion characteristics of the owners to purchase, and points out that the risk aversion characteristics comes from the product attributes of important equipment manufacturing industry and asymmetric information. Then it elaborates a dynamic game model to study on the choices of the enterprise's technological innovation modes in the major equipment manufacturing industry. Finally, the paper concludes that under the strong risk aversion constraints, rational companies will choose collaborative innovation instead of independent innovation.

Keywords: risk aversion, major equipment manufacturing, technology innovation, mode

1. Introduction

The major equipment manufacturing industry is a pillar industry in China and a strategic industry for national economic development and military security. It is particularly important to strengthen the study on the model selection of major equipment manufacturing technological innovation.

With respect to the influence of owner risk averse on the market, Eeckhoudtetal concerned the effect of owner risk averse on the decision variable of newspaper boy model (Eeckhoudtetal, 1995). He promoted a comparative static analysis under different prices and costs. Tsay studied that under the circumstances which both supplier and retailer have the character of owner risk averse, buy-back strategy could be used to embed to the arbitrage model (Tsay, 2002). Gan obtained the coordinated contract among parts with owner risk averse in the way of Pareto Optimality (Gan, 2004). Bouakiz.M.and M. J. Sobel considered the issues of inventory collaborations with risk averse (Bouakiz & Sobel, 1992).

The purchaser of major equipment manufacturing products has obvious risk aversion characteristics. The reason is that the product has a long production cycle and large inputs. Once it fails after the owner's purchase, the owner will suffer losses much greater than the inputs' costs of the purchasing products. In the economic sense, Liu Yingzong, Pan Pengcheng, and Xu jiang (2006) think that risk preference is used to explain the behavior of consumers and investors in the case of asymmetric information, showing the reluctant level of individuals to accept high-risk transactions relative to the low-risk but low expected return transactions(Liu Yingzong, Pan Pengcheng, & Xu jiang. 2006). Zhang Guobao, Wang Qianyuan and Zhang Xinjian argued that the technology spillover from transnational corporations helped experience accumulation for self-dependent innovation, and the manufacturing and research of major technological equipment has got a substantive progress (Zhang Guobao, 2006). Wu Weili, Liu Jinshan and Dong Shuli pointed out that technology spillover had low-side and internality characters (Wu Weili, 2006). Because of substitution and squeeze-out effect, most of Chinese major equipment manufacturing corporations barely mastered the core technology and were entrapped into vicious circle of independent R&D.

Considering the costs and benefits of risk reduction, risk aversion purchaser is more inclined to make a low-risk preference. In this case, domestic owners who purchase the major equipment manufacturing products will generally consider past "market performance" as the access condition of the product purchase and purchasing preferences become important factors in deciding technological innovation model. This paper uses owner's risk

aversion characteristics as the starting point to analyze the impact of selection of the major equipment manufacturing innovation model, and tries to build a technological innovation model suitable to the development of Chinese major equipment manufacturing industry, promoting the development of China's equipment manufacturing industry, technological innovation, especially independent innovation.

2. Purchasing Characteristics of Owners under the Constraints of Risk Aversion

The product characteristics of major equipment manufacturing industry and market information asymmetry are two main reasons that form the purchasing characteristics of the owners.

Firstly, the products of major equipment manufacturing industry have the following characteristics: First, major equipment manufacturing products require high development costs and have high development risks. Major equipment manufacturing industry is a strategic industry that matters national livelihood and national security, whose technological relevance and technological requirements are also high. Most links, including design, experiment debugging, production & sales, and maintenance require enterprises to complete independently, with the equipment manufacturing companies bearing all costs and risks in product development and manufacturing. Second, risk is a major factor in purchasing products of equipment manufacturing industry. For buyers, the purchase of major equipment manufacturing products is a major infrastructure investment for the enterprise. Once the product has problems or defects, the company will suffer huge losses. So when the owners purchase major equipment manufacturing products, risk factors have huge impact on their decision. Third, on the demand side, Qiu Ruozhen and Huang Xiaoyuan (2006) show that the number of owners is limited, which results in monopoly, owners and companies' behaviors vary greatly from other industries(Qiu Ruozhen & Huang Xiaoyuan, 2006). Fourth, from the technological structure's perspective, equipment products belong to typical complex product system, the breadth and depth of product innovation and technology required are larger than that of other products, which has the features of technological complexity, small batches, and product customization.

Secondly, for the owners, before making a purchasing decision, due to the asymmetry of information, all kinds of information of equipment products acquired through the information search is limited: First, equipment products are "completely uncertain" products. Product availability and particular functions cannot be foreseen to the transaction parties prior to the transactions; the owners cannot learn them from the appearance and image of the product to determine the quality. Second, the cost for the owners to obtain product information is high, because the environment of production and use of the equipment products cannot be simulated; product practicability can only be verified through on-site operation; besides, the purchase and manufacture are both one-off huge investment, with long production cycle and high costs. If the owners want to get full product information, they need to pay a huge cost. Due to the asymmetry of information, the practicality and reliability are unpredictable to the buyers and sellers before the transactions, so the two sides face huge transaction risks, and asymmetric information causes the market's ineffective allocation of resources, which cannot meet with the utility maximization in economics.

Based on the above two points, the owners have high risk aversion characteristics when purchasing major equipment manufacturing products

(1) The owners do not trust the products manufactured by domestic equipment companies. Currently, many domestic products in equipment manufacturing industry are comparable with foreign products, and even beat foreign products in some parts such as performance, but because the owners do not trust the products of domestic equipment companies, a phenomenon exists in the purchase process: If the imported products have defects, due to the fact that multinational corporations are not subject to the control of our administrative mechanism, the government has no power in the accountability of multinational corporations; if you choose domestic products, the problem will be accountable, various reasons cause domestic equipment products to fall into disadvantage in the procurement bid.

(2) Localization of "the first set" lacks recognition of the owners. Equipment manufacturing industry has features of long construction period, wide work span, heavy capital investment, and high experience requirements, making the recognization and adoption of "the first set" an important part. However, due to fact that domestic enterprises' performances are in a blank in "the first set" market, Sun Xiaohua and Yuan Jijun (2008) show that owners highly value "the first set" so much that to avoid the use of risky products, they develop a variety of harsh conditions, or carefully design tender eligibility threshold in orders and the bidding process to "accurately" shut out domestic enterprises and domestic-brand products with potential innovation capability(Sun Xiaohua & Yuan Jijun, 2008). Not only will domestic enterprises lose market opportunities, but also feel a serious blow to the confidence. Domestic enterprises can only be committed to the reproduction of the sales

cycle for foreign enterprises, and gradually lose their patience on the innovation of products, and their products being eliminated out of the market due to risk aversion characteristics of the owners, further weakening the strength of the domestic equipment companies.

(3) Repeated introduction multi-introduction phenomena still exist. Due to the lack of macro-control in the major equipment manufacturing market, the owners multi-introduce and repeatedly introduce the complete set of equipment, falling into a vicious cycle of introduction - backwardness - the introduction again. Because of the information asymmetry between foreign equipment manufacturing enterprises and domestic enterprises, foreign enterprises maintain the confidentiality of the specific data and equipment parameters of the introduced product, so that domestic enterprises' equipment lags far behind the quota and requirements of owners' needs, not to mention should be market opportunities, the less accumulated experience, the more inadequate innovation power, only to make them become the subsidiary of foreign companies.

(4) Qin Ying, Lei Jiaxiao and Han Miao (2009) think that the owner just pursuit of the advanced nature of the equipment, ignoring the matching of equipment. Major equipment manufacturing industry requires high matching of equipment and environmental adaptability(Qin Ying, Lei Jiaxiao & Han Miao, 2009). Some equipment must be attached to the original machine, and the most advanced equipment may not necessarily achieve the best results, only the most closely matched and most appropriate equipment can achieve the best results. The owners only consider the advanced nature of the equipment, not the best matching, resulting in a waste of product purchasing, and exceed the digestion and absorption capacity of the domestic technical staff.

Although some of the domestic major equipment manufacturing industries have achieved or even surpass foreign products through technological and capital accumulation, the owners still choose products of foreign key equipment manufacturing industry, ignoring the domestic independent innovative product. The key issues in owners' purchase do not lie in the quality and technical level of domestic products' independent device, but in the external factors like "historical performance" and "first set ", which leads to extreme risk aversion caused. This makes some domestic equipment, which has achieved critical progress in key product quality and performance, not recognized by the owners due to the lack of running practical environment. Unable to cross "the first set" condition limitations, the new products cannot get the market's positive affirmation, which seriously impede the technological level of equipment manufacturing industry and development of innovation capability.

3. The Impact of Owners' Risk Aversion on Enterprise Technological Innovation Model Selection

3.1 Basic Assumptions

Currently, typical industry represented by the major technological equipment remains highly dependent on imports; multinational monopoly power has been formed. Domestic enterprises are eager to get rid of dependence on foreign technology through improving technological innovation model and relying on our own strength to carry out the technical innovation.

Assuming there is duopoly in the equipment manufacturing market, domestic equipment manufacturing enterprise A and foreign equipment manufacturing enterprise B. Domestic buyer of major equipment manufacturing industry is made up by a limited number of owners, forming approximate purchasing monopoly, so the decisions of the owners have a huge impact on the product suppliers.

To facilitate the analysis of the model, this paper makes the following assumptions when building a dynamic game model of enterprises' technological innovation model selection:

(1) Interests driving force is the main motivation of enterprises' technological innovation, under which, the enterprises have self-conscious requirement of technological innovation. The primary determinant of what kind of technological innovation model to choose is the utility that innovation brings to the enterprise. When the utility brought by the technological innovation is negative, the enterprises have no motives to carry out technological innovation; different models of technological innovation can bring different utilities, so companies will make a rational choice based on the principle of utility maximization.

(2) In order to secure the comprehensiveness of model's strategic content analysis, we assume that in the current market, influenced by historical performance and technical ability, foreign firm B has value P on local market, but needs further development on key technologies. Estimate that successful development can bring π revenue for enterprise B. Company A does not have this technology, in order to gain a competitive advantage and profit increase, needs this technology, so they have the possibility of cooperation and innovation.

(3) Assume that company A is the first decision-makers, firm B know the decision-making action of company A, while company A knows that their own actions will be observed, so both sides mutually understand and benefit.

3.2 Game Process of Technological Innovation Model Selection

In a game model, the two companies constitute a sequential game tree model. Domestic equipment manufacturing company A wants to change the unfavorable situation of the existing market through technological innovation model. To carry out technological innovation, there are three technological innovation strategy: independent innovation model, a model that cooperates with foreign enterprise B in innovation, through the introduction of absorbing foreign enterprise B's technology to imitate the innovation model.

In this game model, A as the first policy-maker, if chooses the independent innovation, then game ends; if company A selects to cooperate with enterprise B in innovation, in this case, if firm B agrees, the two sides will cooperate and allocate the profit of innovation pro rata, if firm B disagrees, then company A will conduct independent innovation: if firm A chooses to imitate the innovation, foreign enterprise B will decide whether to sell its technology to company A to allow it to imitate the innovation, if   it agrees, then both sides will negotiate through the introduction of technological prices, if not, then company A will use independent innovation to get the technology, which put an end to the game. As is shown in Figure 1.

When domestic enterprise A carries out independent innovation, its probability of success is p_1, which represents its own innovation ability and gains profit π. Assume that domestic enterprise Podolny, J (1998) show that A's independent innovation success can successfully break the technological monopoly of foreign manufacturers(Podolny, 1998), while both cooperative innovation and imitative innovation can't, according to Podolny's theory on independent innovation, independent innovation's success can bring in an additional market share profit V. If assume that without taking the risk aversion factor of the owners into account, there is $V = \pi$, considering the impact of owners' purchasing decision, introduce the owners 'risk aversion parameter number $\rho(0 < \rho < 1)$ in additional market profit share, the greater the ρ, the stronger the owners' risk aversion characteristics, the more inclined to buy good "market performance" products. Under the given condition of successful technological innovation, the higher the risk aversion of the owners, the less additional profit acquired by enterprise A due to lack of good market performance. From the analytical framework by Suzanne Fogel (2004) the revenue function of enterprise A after successfully achieved independent innovation is(Suzanne Fogel, 2004):

$$\pi_1 = p_1\pi + V \tag{1}$$

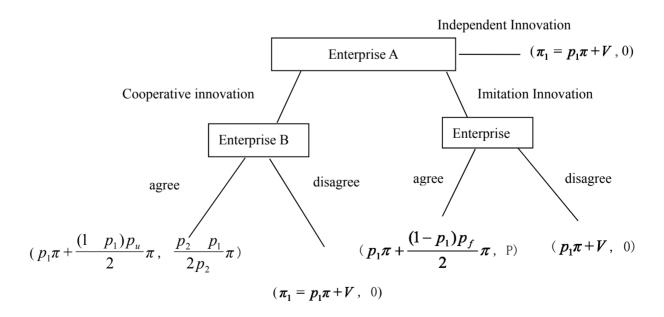Here, V depends on whether to consider the owner's risk aversion characteristics.

Figure 1. The game chart of the enterprise technological innovation model selection

When enterprise A chooses enterprise B for cooperative innovation, if enterprise B agrees, assuming that enterprise B innovates independently and the probability of its success is p_u, so the probability of enterprise A's

cooperative innovation is:

$$p_2 = p_1 + p_u - p_1 p_u \tag{2}$$

Through university-industry collaboration, enterprise can accumulate more technical resources, so cooperative innovation is more likely to succeed than independent innovation, obviously $p_2 \geq p_1$, the benefit allocation proportion after cooperative innovation succeeds is α. The process of benefit allocation is affected by enterprise A's own innovative ability, that is, is threatened by enterprise A's own innovative ability.

When enterprise A chooses enterprise B for imitate innovation, if enterprise B agrees, enterprise A have to pay technology introduction fee P. Suppose enterprise A goes on a secondary development based on foreign technology and the probability of success is p_f, besides, foreign enterprise B have market share and other advantages, so $p_f \leq p_u$. So the probability of imitate innovation for enterprise A is:

$$p_3 = p_1 + p_f - p_1 p_f \tag{3}$$

Enterprise purchases foreign advanced technology, greatly improves the success rate of innovation, so $p_3 \geq p_1$.

To solve the problems of benefit allocation and technology introduction fee, we use comparative Nash negotiations solution, the result is $\alpha = \dfrac{p_1 + p_2}{2p_2}$, $P = \dfrac{(p_3 - p_1)\pi}{2}$.

This shows:

When enterprise A chooses to innovate independently, their benefits are($p_1\pi$,0); When enterprise A chooses cooperative innovation, and enterprise B agrees, the benefit allocation proportion after cooperative innovation succeeds is α, their benefits($p_1\pi + \dfrac{(1-p_1)p_u}{2}\pi$, $\dfrac{p_2 + p_1}{2p_2}\pi$); When enterprise A chooses imitate innovation, if enterprise B agrees, and enterprise A pays the technology introduction fee P, their benefits are($p_1\pi + \dfrac{(1-p_1)p_f}{2}\pi$, P).

We can get the benefits brought by the comparative advantage of independent innovation and cooperative innovation, that is:

$$\pi_1 - \pi_2 = V - \frac{(1-p_1)p_u}{2}\pi \tag{4}$$

And the benefits brought by the comparative advantage of independent innovation and imitate innovation is:

$$\pi_1 - \pi_2 = V - \frac{(1-p_1)p_f}{2}\pi \tag{5}$$

So, the benefits brought by the comparative advantage of cooperative innovation and imitate innovation is:

$$\pi_2 - \pi_3 = \frac{(1-p_1)(p_u - p_f)}{2}\pi \tag{6}$$

We get conclusions as follows, when domestic enterprises choose technological innovation model, they will consider the value of V, $\dfrac{(1-p_1)p_u}{2}\pi$ and $\dfrac{(1-p_1)p_f}{2}\pi$.

When we don't consider the purchase decision of owner and enterprise B's benefits, $V = \pi$, because $p_1, p_u \leq 1$, we can get that: $\dfrac{(1-p_1)p_u}{2} \leq 1$, so $V > \dfrac{(1-p_1)p_u}{2}\pi$. Independent innovation can bring more benefits than cooperative innovation: Domestic enterprise A owns new products and technology depending on its own strength, or uses technology in universities for technology integration, thus builds its own core technical ability and technology advantage. And it seizes the market, forms its own advantages in competition, changes the adverse situation of present market.

In this game, the enterprise A is the first decision maker, the decision-making power is in the enterprise A's hand, the enterprise A's best choice is independent innovation. By selecting the independent innovation pattern,

enterprise A can optimize the industrial structure of the equipment manufacturing industry, promote the center part of industrial upgrading, get rid of the independence on foreign technology by technology import and imitation, break the technology monopoly of foreign enterprises, grasp the initiative of innovation core link, grasp the ownership of core technology, and improve international competitiveness of the products, rely on independent innovation to form his own first-class brand and product, change current negative situation of the equipment manufacturing industry, further change the export trade structure of domestic equipment manufacturing industry.

3.3 Technological Innovation Model Choice under Owner Risk Averse

When considering the demand, the owner's purchase choice has close relationship with its risk aversion characteristics. When the domestic enterprise innovates successfully, the profit function of enterprise A after independent innovation is $V = \pi - \rho\pi$ (here, ρ is the risk aversion parameter of owner). As mentioned above, the owner will have an influence on market share through his purchase decision, the risk aversion makes enterprise A's innovation may have two situations:

(1) When the owner's risk aversion degree is low, the owner only considers the price and performance of the products in equipment manufacturing industry at home and abroad, but doesn't consider product "performance" and other brand effects. Economically speaking, in order to realize the resource allocation optimization, the owner will act as a rational economic man and only compare the price with the benefits brought by buying the product, previous purchase experience and the product evaluation will not have a great effect on the next product purchase decision.

After independent innovation succeeds, enterprise A will get $V = \pi - \rho\pi$, when the owner risk aversion degree ρ is low, $1-\rho$ will get higher, we can get $1-\rho > \dfrac{(1-p_1)p_u}{2}$, and $\pi_1 - \pi_2 = V - \dfrac{(1-p_1)p_u}{2}\pi$, so $V > \dfrac{(1-p_1)p_f}{2}\pi$, $\pi_1 > \pi_2$; and $\dfrac{(1-p_1)p_u}{2} > \dfrac{(1-p_1)p_f}{2}$, so $\pi_1 > \pi_3$. When domestic enterprise A compares the benefits of independent innovation with cooperative innovation and imitation innovation, if enterprise has the inherent demand of technological innovation, it will choose independent innovation model. Choosing this kind of innovation model, the domestic enterprise with excellent independent design innovation ability, is expected to break foreign technology blockade, and forms his own first-class products and brands, changes the current domestic adverse equipment manufacturing industry market.

(2) When the owner's risk aversion degree is high, he takes the brand effects and other previous purchasing factors into consideration first, such as the performance of the products, while purchasing the products in equipment manufacturing industry, largely because the products from major equipment manufacturing industry are one-off purchased and consumed. Under the high risk aversion, the risk aversion parameter ρ becomes larger, and $1-\rho$ smaller, resulting in $1-\rho < \dfrac{(1-p_1)p_u}{2}$. As $\pi_1 - \pi_2 = V - \dfrac{(1-p_1)p_u}{2}\pi$, we can draw that $V < \dfrac{(1-p_1)p_f}{2}\pi$, $\pi_1 < \pi_2$. The extra benefits from company A's independent innovation are fewer than that from company A's cooperative innovation. Based on "rational agent" decision, company A will choose cooperative innovation model rather than the independent innovation model. Even when the owner is highly risk averse, the risk aversion parameter ρ becomes large enough, and $1-\rho$ extremely small, resulting in $V < \dfrac{(1-p_1)p_u}{2}\pi$. The benefits from independent innovation are even fewer than that from imitation innovation.

Based on "rational agent" decision, Chinese companies have no motivation to choose the independent innovation, and probably they will just take advantages of foreign companies' technological advantages and choose cooperative innovation model. But this cooperative innovation model cannot change Chinese companies' independent innovation capabilities, because foreign companies still possess the core technology and key technology of the equipments, and Chinese enterprises are only involved in some peripheral technological work. At the same time, foreign countries exert the monopoly power to export the low-end equipments without advanced technology, making the technological gap between Chinese enterprises and foreign companies even wider. Thus, Chinese enterprises in equipment manufacturing industry have never changed the disadvantaged position even if they choose the cooperative innovation model.

In conclusion, the choice of innovation model by the owner is influenced by his risk aversion. When the owner's risk aversion degree is low, ρ is small and $1-\rho$ is large, resulting in extra benefits V from independent innovation larger than that from cooperative innovation and imitation innovation. Driven by the interests, company A has the demand for independent innovation. However, the reality is the owner is highly risk-averse, ρ is large enough, and $1-\rho$ extremely small, resulting in $V < \dfrac{(1-p_1)p_u}{2}\pi$, so company A will choose the cooperative innovation model. Independent innovation will increase company A's benefits in theory, and change its current market share, But even if Chinese company A succeeds in independent innovation, and possesses new products whose performance is better than that of foreign companies' products and the price is lower, purchasing risk is still the most important factor that the owner takes into consideration. Balancing the reduction in risks and increase in benefits, if a Chinese company hasn't good performance before, the owner will show on interest in the new products developed through innovation. Based on the "rational person" decision, Chinese company A first considers the loss resulted from the risk aversion to the new products, and then chooses the cooperative innovation model. Although the benefits from cooperative innovation are fewer than that from independent innovation in theory, and foreign countries want a share in the total profit. But only with the foreign advanced technology, foreign companies' performance and brand effects, Chinese products are marketable.

4. Conclusion and Policy Recommendations

Currently, the technological level in Chinese equipment manufacturing industry still remains low, Chinese companies imitate a lot, depend greatly on foreign technology and equipments, and haven't developed their own independent innovation capabilities. To change the situation where Chinese major equipment manufacturing market is monopolized by foreign companies, Chinese companies must innovate independently. The priority is to reduce the owner's risk aversion degree, and on the demand side, to create more practice and innovation opportunities for Chinese enterprises. If the owner's risk aversion degree cannot be reduced, on one hand, the owner will choose the products manufactured by multinational companies at first, which will influence his purchasing decision continually in a period; on the other hand, even if Chinese companies succeed in independent innovation, no one buy their products, so without the benefits from the independent innovation, the host country's technological development will be blocked, leading to that Chinese companies and research institutes have no initiative to innovate independently.

When resources cannot be allocated effectively through market mechanism, government is needed to be involved in, becoming the third body. Government can reduce the owner's risk aversion degree through government purchasing and taxation system.

Through government purchasing, "the first set" can be easily sold out. On one hand, government purchasing requires the owner enterprise to purchase domestic technology and equipment first, solving the "first product selling" problem. On the other hand, the risks of manufacturing equipments in major equipment manufacturing industry are shared by the government, reducing the owner's risk aversion degree. The labs and engineering practice opportunities provided by the government create a convenient environment for companies' independent innovation. On the demand side, it guides the way for companies' independent innovation: performance and standard of purchased products are specified in the purchasing process, and general conditions like performance-to-price ratio are emphasized. Auxiliary measures are also needed to give full play of the government's role.

Taxation system is another way to reduce the owner's risk aversion degree. Taxation, as a safeguard for independent innovation strategy should focus on reform and improvement of taxation system, thus laying a financial foundation for independent innovation. To the owners in major equipment manufacturing industry, preferential policies for importing foreign equipments need adjusting, which accelerates technological equipments' depreciation, accelerates the pace the technological progress and promotes the product updating and technological upgrading in equipment manufacturing industry.

From the macroeconomic level, government purchasing and taxation system adjustment act as policy orientation and innovation incentives, reducing the owner's risk to the largest degree with the other auxiliary measures. The implementation of two means also changes the previous purchasing decisions dependent on "performance" and "the first set", enhances the Chinese companies' motivation to innovate independently, promotes the product updating and technological upgrading in equipment manufacturing industry and boosts the development of this industry.

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