# THE TECHNOLOGICAL STRATEGY OF SMES BASED ON THE SYSTEMATIC ARCHITECTURE OF THE ABILITY OF TECHNOLOGICAL INNOVATION

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**Abstract:** The ability of technological innovation is a systematic set of a Series of complementary abilities, such as research and development capabilities, capabilities of developing supporting products, market expanding capabilities, brand building and maintenance capabilities, after-sales service capabilities, adaptive learning abilities, self- improvement abilities, cooperative abilities and abilities to mobilize social resources. If there exiting defective capabilities in the firm, it must face high risk in keeping the ability of technological innovation sooner or later. But SMEs just have many defective capabilities. In order to explore the ways of getting these capabilities, a strategic consideration was made in this paper.

**Key words**: Ability of Technological Innovation, Technological Paradigm, Technological strategy

## 1. INTRODUCTION

Technology innovation is the whole process of activities from a new technological composition to research and development further to business application. It should create economic and social effectiveness. So technological invent isn't technological innovation. Only when technology was used and created value can it be called technological innovation. This means the ability of technological innovation not only includes the inventing ability of technological components and the integrative ability of technological architecture but also includes marketing ability and a series of complementary abilities. The ability of technological innovation is a systematic set of such complementary abilities. Usually, the failure of technological innovation of SMEs (small and medium enterprises) was not originated from the technological reasons but from their deficiency in other complementary abilities. It has definitely the same situation to most developing countries which were in the positions of technical following. This

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paper will analyze the systematic characteristics of the ability of technological innovation and its influencing mechanism to the success of technological innovation and also its enlightenment to technological strategy of SMEs.

## 2. SYSTEMATIC CHARACTERISTICS OF THE ABILITY OF TECHNOLOGICAL INNOVATION AND ITS MECHANISM

The competition among technological products is different from that among ordinary products. To the ordinary products, different products with similar natures can coexist in the same market for a long time. But to the technological products, only the products which controlling the main technological paradigm can exist, the products in other technological paradigms will eliminate in the market sooner or later. If the company didn't keep pace with the main technological paradigm, they will get eliminated or could only become second agents or manufacturers of the core technology holders. If then, their value creating capability will be very limited.

### 2.1 The Complementary Abilities Needed for Seizing the Main Technological Paradigm

The competition in technology market is similar to the natural choice mechanism. Only the kind of technology that supplying the most combined values to consumers in the shortest time could be selected by market and survive. The values that technology gives consumers are not only including the value of technology itself but also including the value of network externality from market share and supporting products. The technological value is the value from technological function, aesthetical feeling and its convenience, this part of value can't increase as the expanding of market share. But the value created by market share and supporting products of the technology will increase as its market share, just like the snowball effect. Therefore, the combined value of technology will increase as the exponential function following the expanding of market share. If use the description way of Melissa A. Schilling(2005), this process can be expressed as figure 1.

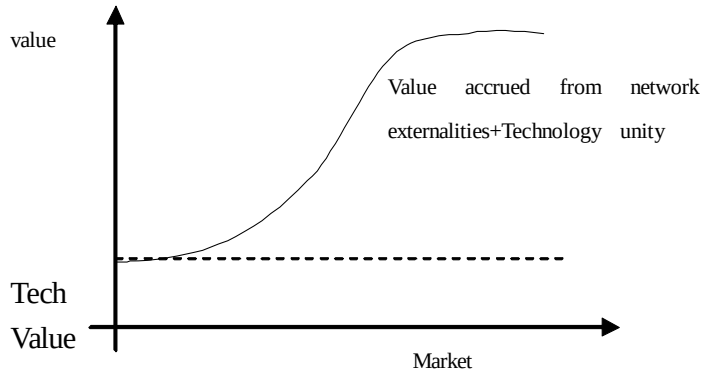


**Figure 1. Combined Value of Technology**

The competition among technological products is really the competition of objective and subjective combined values supplied by technologies to consumers. The products with the same technological utility will give consumers more combined values when market share becoming larger; they will give consumers less combined values when market share becoming smaller. Therefore, the technology which first reaches the critical point of combined values and makes its combined values bigger than other technologies in the same market will win the competition for design dominance and become the final and only winner of the market. This process can be expressed by the change of marginal rates of substitution

in indifference curves. For simplification, assuming that there were only two kinds of technological paradigm in some technology market, they had the same technological values, and they entered into the market in the same time, and the utility of them had the characteristics of the normal goods with diminishing marginal utility, their indifference curves firstly is like U in figure 2. Now the market share of A is increasing and that of B is decreasing, the utility of A will be bigger than that of B to consumers with the same qualities of A. Then to the same qualities of A, the marginal rate of substitution of A to B will increase, and the indifference curve will become $U_1$. If the market share of A increased furthermore and finally owned the whole market, the indifference curve would become $U_2$. The marginal rate of substitution of A to B would become infinity.

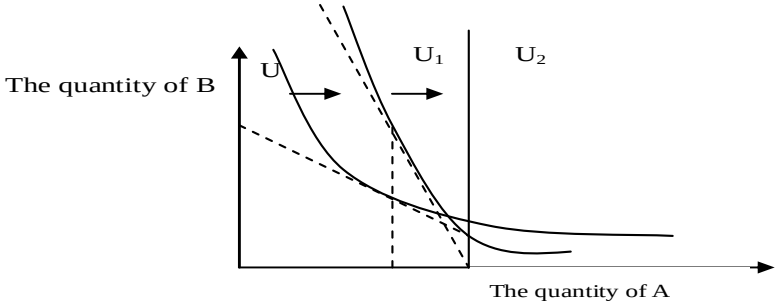


**Figure 2. The Change of Indifference Curves of A and B**

To most SMEs, they have advantages on discerning new technology path and doing invention, because they get less influence from their original technology path and organizational inertia. But it's difficult for them to be success in technological innovation for their lacking the other complementary abilities for technological innovation. In the fields of difficult to protect intellectual property rights, the technological inventions of SMEs may even become "public goods" that can be imitated cheaply by the monopoly enterprises. For example, a small company named Symphony was the first to introduce a new kind of air conditioner into the Indian market, its products had many charming characteristics——movable, plastic modeled and convenient to use. But a large company named Videocon imitated this creativity, and developed the same kind of agile air conditioner. Videocon not only got a great deal of benefits from the creativity but also was regarded as the inventor of this creativity (Naushad Forbes，David Wield , 2005). A Chinese company named WanYan is another typical example. In Chinese market of electrical appliances, WanYan is a small firm with limited capital and productivity. But it developed VCD at first, and had to advertise strongly and also had to produce disks, the supporting product. So WanYan soon made itself into an awkward predicament of serious lack in productivity and marketing capabilities. It couldn't get rid of this predicament finally and was purchased by another company. Thus it can be seen that although WanYan opened up the VCD market in China, he couldn't get many benefits from it even became the "stepping stone" of other large companies. The competition between IE and Netscape is another example with the same characteristics.

Therefore, in the competition for design dominance, it is not enough for companies to hold the abilities of R&D in technology, they must also simultaneously hold the developing capabilities of supporting products to build the whole technology architecture, the strong capabilities of manufacture to supply the expanding market, the marketing capabilities and excellent brand resources to increase the market share rapidly, the post-sale service abilities to increase the satisfaction degree of customers and to get more demands. All these capabilities are complementary mutually, this means that the defect in any kind of capability will obstruct the success of technological innovation, but the increase in abilities of technological innovation will need the increase of all of them simultaneously. If some kind of ability is shorter than the other abilities, it will become the restriction for increasing the whole ability of technological innovation. So in the case of lacking the other abilities, if SMEs using the leadership strategy and commercializing their technological invention, they will has the extremely possibility to become the "little pig" in the "Boxed Pigs" Game, and been eliminated by the market.

## 2.2 The Complementary Abilities Needed for Following the Design Dominance of Technology.

In the view of life cycle of technology, the design dominance of technology nowadays all has the possibility of being substituted by another new technological paradigm. It is the same whether to component technology or to architectural technology. But to the companies holding the design dominance, their core capabilities accumulated formerly would become the inertia of cognition and bring huge transactional costs for their exploring new technological paradigm. Because the function of new technology in its stage of appearance is inferior to the old one and its future is not clear, but the old technology is the main source of the profits of the company, many companies in the old technological paradigm usually missed the opportunities in the situation of transformation of technological path and became the followers from the leaders. Therefore, the path transformation of the design dominance is risky to the leaders of technology. There are many examples of this kind of change. The architecture of rigid disk of computers had changed from 14 inch to 8 inch, 5.25 inch and 3 inch, but in every transformation of the technological path, the leaders of the market had also changed correspondingly. Similar to the substitutions in the market of rigid disk of computers, photolithographic alignment equipment also experienced four generations of architecture technology which are proximity aligner, scanning projection, first-generation stepper and second-generation stepper, accompanying to the substitution of technology, the leaders of the market are also changed from Cobilit and Kasper to Cannon，Perkin-Elmer，GCA and Nikon (Rebecca M.Henderson, Kim B.Clark, 1990).

Therefore, a company must coordinate carefully the equilibrium between exploiting the current technology and exploring the future technology. In the turbulent environment of technology and market, if a company wanted to remain its long term performance, the set of abilities of technological innovation should include strong learning abilities and self-improving abilities. Just as the emphasizing of evolutionary economists', on one hand, individuals will be eliminated or selected by the mechanism of natural selection on the standards of the system, on the other hand, individuals are guessing the selecting standards of the system and are learning and improving adaptively. After the evolution in a period of time, only the one who had guessed rightly what the selection standard of the system really is and its adaptive learning ability is the strongest can survive finally.

This kind of learning ability and self-improving ability are the ties from a set of capabilities to another set of capabilities for the evolution of companies. When a company realized the direction of the transformation in technological path, it must reconstruct its set of capabilities according to this new direction. But the connotation of the capabilities in the new direction is different from that of the old one, and it is complementary relationships for all kinds of capabilities in the same way. Nevertheless, whether a company can reconstruct this set of capabilities is determined by its learning ability and self-improving ability. The process of the evolution in the set of capabilities is expressed as figure 3.

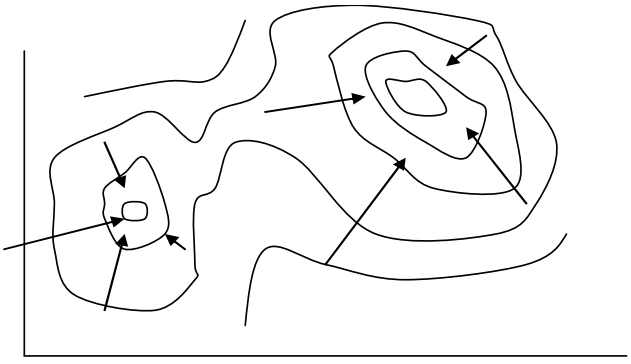

**Figure 3. The evolution in the set of capabilities**

When the transformation of design dominance is occurring in the market, as influenced by the accumulated inertia of the former capabilities, it's difficult for the monopolistic corporations in the old

technological paradigm to reconstruct the set of complementary capabilities in time although they usually could judge rightly the direction of technology. But to most SMEs, they rarely hampered by the former capabilities, and thus are easy to construct the set of capabilities around the new technological direction. Therefore, it's more possible for SMEs to create even higher combined values. Once the combined values exceeded the critical point, the new technological paradigm will substitute the old one and become the design dominance; then the followers will exceed the former monopolistic corporations and become a new leader in the new technological paradigm. Therefore, there are leaping opportunities for SMEs in the period of transformation of technological path but they are risks for leaders in the market now. It is just because of discerning and capturing rightly the opportunities of transformation of technological path in the period of budding that many corporations became the leaders in nowadays market, just like the companies of Sony，Microsoft，Nokia and Google.

### 2.3 The Complementary Abilities Needed to Control the Transformation of Design Dominance

If a company wanted to maintain its abilities of technological innovation, it must predict the future design dominance and control the evolution of technology path. It is the key generic technology that determined the transformation of technology path in the market. The key generic technology has a serious of developing prospects in many fields; its life cycle is the embracing curve of life cycle's curve of all kinds of products developed by it (Gregory Tassey, 2002). The main characteristics of generic technology are: (1) they are the technologies before commercialization which are highly uncertain in technological prospect and market prospect and facing huge risk in the early stage of investment, and this risk exceeded the limits of the capabilities that a single company can sustain. (2) Generic technology is near to the basic technology and has the characteristics of public goods. The benefits from its development will spill over generally so that companies would never have enough motivation to supply. (3) The development of generic technology is belonging to the systematic innovation which must be supported by other kinds of technologies and other profit units. But the motivation for the cooperation is not enough, for everyone only considers their own benefits but not the whole benefits of them (Li jizhen, 2004). Such characteristics for the development of generic technology thus determined that companies would never have enough motivation and capabilities to supply generic technology so that the supply of generic technology must fall into market failure if government not giving intervening.

The supplying mode of generic technology in developed countries mainly had two kinds which are the American mode (leaded by market and guided by government) and the Japanese and Korea mode (leaded by government). But there are common characteristics of them: there are some special organizations to set up researching projects (these projects are about the technologies that before the step of competition and not the technologies in the step of products, they must be international frontier, general basic, huge resource consuming and need the cooperation of different profit units); setting up special organizations to coordinate these different cooperative units; government allotting special researching funds to support the development the project in their early stage (Li jizhen, 2004). Therefore, the predicting abilities and supporting abilities for key generic technologies will be the key of the problems. In such cases, the cooperative capabilities and mobilizing capabilities for social resources will be very important for companies.

The success of Silicon Valley is a good example for utilizing the opportunities and evading the risks in the transformation in technology path. The companies in Silicon Valley had grasped successfully four main transformations in technological paradigm which are defense, integrated circuit, personal computer and internet. Now they are developing in the direction of ICT and nanotechnology (Jarunee Wonglimpiyarat, 2006). In the process of the transformation, a large number of SMEs developed and became the giants that controlling the design dominance. The cooperative capabilities and mobilizing capabilities for social resources in Silicon Valley for controlling the technological path were mainly originated from its perfect technological innovation networks consisted of enterprises, universities, finance institutions, technological intermediaries and so on. Every cooperators were motivated by the government polices and regional culture to form a kind of relationships of close cooperation and trust

(Jarunee Wonglimpiyarat, 2006). Because the design dominance of high technologies in the whole world are mainly controlled by the transnational corporations with strong monopoly concentrated in Silicon Valley, Silicon Valley was thus becoming the core cluster that can construct its production networks around the world wild. From the developing experience in Silicon Valley, we can see that the cooperative capabilities and mobilizing capabilities for social resources are really relative to the institutional environment and cultural environment that the enterprises were in. If the SMEs wanted to make use of the opportunities of the transformation in technology path, they must fuse into the environment with the kind of institution and culture that motivating cooperative innovation so that SMEs can obtain the abilities they didn't have through cooperation and borrowing power.

In a word, the abilities of technological innovation is a systematic set of many complementary capabilities, which mainly consisted of the R&D capabilities, developing capabilities of supporting, capabilities of manufacture ,marketing capabilities, capabilities for brand construction, post-sale service abilities, adaptive learning abilities, self-improving abilities, cooperative capabilities and mobilizing capabilities for social resources. These capabilities must increase simultaneously, once there exiting some deficiency in one kind of capability, there will have great risk in maintaining the abilities of technological innovation sooner or later.

## 3. THE STRATEGIC CHOICE FOR THE TECHNOLOGICAL INNOVATION OF SMES

If the SMEs wanted to get success in technological innovation, they must overcome their shortcomings and develop their advantages. In the view of the systematic characteristics of the ability of technological innovation, the disadvantages of the abilities of SMEs are mainly in developing capabilities of supporting products, capabilities of manufacture, marketing capabilities, capabilities for brand construction, post-sale service abilities and mobilizing capabilities for social resources. But the advantages of the abilities of SMEs are mainly in adaptive learning abilities and self-improving abilities. If their cooperative capabilities ware strong enough, the SMEs would get their lacking abilities rapidly through cooperation or they would develop such lacking abilities first and then innovated independently. According the theoretical analysis and the experience of successful enterprises, the technological strategy of SMEs can be considered as follows.

### 3.1 Market expanding and brand constructing first, then independent innovation

The success of Galanz , a Chinese company in electrical appliances, is a good example. Galanz firstly expanded its market share through OEM and price reducing and then improved the qualities of its products. Influenced by the effect of scale economics, there appearing a mutual promoting situation of cost decreasing and market share increasing. But before completing this stage goal, Galanz didn't invest more in independent innovation. Just as Yu raochang the creator of the company said: "we can't digest the investment in R&D only if we have enough scale. Nokia can invest billions of dollars in R&D, but Galanz can only invest nearly four hundred million RMB in R&D". When the company finally became the biggest manufacturing base of microwave oven in China and even in the world, it hence had the capability to invest a large number of resources into the technological innovation and developed high-end products. In the year of 2005, it had more than 500 patents and specialized techniques, and Galanz had also become an international famous brand. The developing way of Galanz is from process promotion to product promotion and then to function promotion. The promotion way of Acer was similar to this. Acer was also improving its learning abilities first through OEM, and then built its world level productivity and capabilities of manufacturing, further established its world level design capabilities. It only entered into one frontier field each time, and expanded steadily (Zhang yuming,2005).

### 3.2 Fusing into the regional innovational networks

Cooperation with other enterprises, universities, researching institutes and other social organizations is an effective way for SMEs to overcome their shortages in market share and anti-risk abilities. It's also beneficial for them to discover and grasp the opportunities of innovation. Hsinchu is an example. There exiting such kind of regional division and cooperation networks in Hsinchu where the enterprises had close linkages with universities and built the center-satellite system by the help of regional government. This system is to encourage large central enterprises (suppliers in the upstream, integrators in the final-end, large trading companies) to build long close linkages with other satellite enterprises. The purpose of their cooperation is mainly including such intentions like that capturing common core technology, getting financial resources of the holding companies, learning knowledge of the industry, increasing market share and acquiring technology scanning abilities, constructing common brands. In this system, large companies became a kind of important source of technological innovation of SMEs, SMEs could make use of the market power of large enterprises to promote the commercialization of its innovations (Paolo Guerrieri, Carlo Pietrobelli, 2004). Silicon Valley is also a typical example that regional innovation networks promoting the improvement of innovative abilities of high-tech industry successfully，but the characteristics of the network is that there neither any organization nor any institutes to manage the innovations in it, the operation of the network is completely by the market mechanism and the close cooperation among different benefit counterparts (Jarunee Wonglimpiyarat,2006). Therefore, SMEs should fuse into the cooperative innovation networks to get complementary abilities for their growth.

### 3.3 Cooperating with large corporations, borrowing power to grow up

It is complementary relationship between large enterprises and SMEs in resources and capabilities that the advantages of SMEs mainly exit in some specialized technologies but the advantages of large corporations are mainly market power and brand. Cooperation or binding are beneficial to both parts. Microsoft is a successful case of borrowing power to grow up. In the early stage, Microsoft had borrowed power from IBM the blue giant to bind its Microsoft DOS to cover the market. When DOS became the technical standard of the operating system in PC, Microsoft then almost monopolized the market. After the success of DOS, the Windows series were bound to it, and then IE. In another word, the success of Microsoft is due to its series of strategies of technical compatibility and bindings to a great extent.

However, whether a company can realize close trust or stable cooperation is not determined by the subjective whishes of their own but by the institutional environment and cultural environment of the region they exiting (David A. Walfe,2000). Therefore, in order to prevent from falling into the game of "prisoner's dilemma" for cooperation, many kinds of policies had been made by the governments of various countries to motive cooperation and built the cooperative platform. As referred above, though Silicon Valley was operated mainly by market mechanism, the government policies also played very important roles for cooperation in the early stages of commercialization of technologies where it's hard to enter for venture investments. But these polices are to remedy the defects of market not to substitute the market.

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