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Innovation Mechanism Study Based On The Technological Convergence: Implications For IT Enterprises

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Abstract

Based on redefining the concept of technological convergence, this paper analyzes market demand of convergent products according to the characteristics of technological convergence in IT industry. We define market power as the function of product price and the improvement of convergent product's performance. We also assume the original technology is symbiotic. Based on the above analysis, the paper modifies the Bass Model and the hypotheses of related models, builds a demand growth model of technological convergent products, and uses this model to analyze and estimate the demand growing of converged products. At last, we discuss the conditions that technological convergence will be successful.

Keywords: *IT Enterprises; Technological Convergence; Innovation Mechanism*

1. Introduction

In IT industry, technological innovation takes place every day, the update cycle of products and technologies speed up, and the time cycle that the technology required from the successful of RandD to the first commercialization significantly shortened. But the technology has its own laws, with the continuous advancement of IT technology, the development space of the track of specific technology will become smaller and smaller, the technology opportunity gradually move toward exhaustion. The progressive innovation will be more and more difficult at the same track and even can't achieve. However, the multiple technological of different fields converge can bring new opportunities [1].In IT industry, technology convergence is becoming a common phenomenon and important trends. However, why some project of technology convergence success when some have failed, what are the reasons?

Theorists often use the theories and models of diffusion to describe the growth of new products in the market. The innovative products formed by technological convergence, is also facing a market demand of new-born, and thus the diffusion of convergent products also follow the general law. In the description of the demand diffusion situation for innovative products, the more representative is the Bass model. Bass(1969)[2] thought that the demand for new products is caused by the behavior of innovation and imitation. Where the innovation behavior of consumer is influenced by external conditions such as the mass media (such as advertising). The imitational behavior of consumers is influenced by oral communication of people, and the major impact caused by some of the intrinsic properties of new products, which cannot be identified, such as product reliability, durability, ease of use and so on. The Bass model and other related models have described the situation that the growth of new products was stable in the long term, but they have neglected the reality that the market and the main elements of product are changing. In these models, market power has been set to a constant volume. Later, many scholars gave amendments on the Bass model. Kalish(1985)[3] modifies the function of gross actual

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demanders by introduce reservation price that people would be willing to pay for. People would become actual demander if only the actual price is below the individual's reservation price. Kalish and Sen(1986)[4] pointed out that the price should be an important variable which can affect the total quantity of the actual demanders. Later Jain and Rao(1990)[5] defined the gross of the actual demanders as the function of price, but this function did not reflect how the price affect the choice behavior of potential demanders. Xie and Sirbu(1995)[6] constructed an dynamic model in which market power is the function of network externality and price. Liu Qinglin(2006)[7] introduced the conception of willingness to pay, assumed the number of the actual demanders equal to the potential demanders whose utility exceed the firms' fixed price, and gradually set up a modified diffusion model network externality according to the network externality that consumer' s real perception price decreases while the accumulated number of users increases. In addition, Swami and Pankaj(2003)[8], Van den Bulte and Stremersch(2004)[9],[11], Wang Peng(2004)[10], Feng Nan-ping, and Zhan Li-zhen(2014) [12]have studied the diffusion of new products thoroughly for the more complex conditions or restrictions on consumer behavior.

The convergent products are innovative products of convergence, and also are mixed products from different technologies fields. It integrates different functions of a variety of original products and become a innovative product with new feature. Generally the convergent product is directly caused by consumer demand, so its function is very clear. Due to the unique nature of technological convergence, it is different from the demand diffusion of the general innovative products. Therefore, at first we redefine the concept of technological convergence and analyze market demand of convergent products in IT enterprise. Based on modifying the Bass model and the hypotheses of related models, this article constructs diffusion models of convergent technology in IT industry. Using these models, we get the demand growing law and the demand growing uptrend of converged products, and also get the condition which judge whether technological convergence is successful.

The innovation of the present paper is fourfold. First, based on technological innovation and symbiosis theory, we redefine the concept of technological convergence. Second, we seek to fill the gap in the literature by studying market selection mechanism of technological convergence of IT enterprise. In this article, we analyze the diffusion of technological convergent products and the conditions that technological convergence will be successful. Third, compared to previous innovation diffusion mode, we amend the diffusion model in two aspects. One is that market power is defined as the function of product price and the improvement of convergent product’s performance, and the other is that we take the nature which the original technologies are coexisted into the model. Fourth, we consider the growing demand of the converged-innovative products contains two aspects. The first is that the converged products substitute the original market demanding, and the second is of creating the new market demanding.

The rest of the paper is organized as follows. In Section 2 we redefine the technological convergence and in Section 3 analyze demand of convergent product in IT industry. In Section 4 we present the model of technological convergence diffusion. In Section 5 we construct model to analyze the condition to judge whether technological convergence is successful .We conclude in Section 6.

2. Theory and Literature

To understand the influence of technological convergence to innovation mode of IT enterprises, first to break through the narrow perspective of the technology itself to understand the essence of technological convergence, discusses the connotation of technological convergence. Therefore, it is necessary to investigate the background of technological convergence, and its relationships with related concepts defined. Therefore

we can identify the status of technological convergence in technology innovation activities, and correctly handle the relationship between technological convergence and every other aspect.

2.1. Connotation of Technological Convergence

In discussing the connotation of technological convergence, most scholars according to their own research content defines it, and currently there has no consensus of opinion.

Concept of technology convergence, as can be traced back to the United States to learn Rosenberg (1976) [13]for the study of America's machine tool industry evolution, he believed in the middle of the 19th century when similar technology was applied in different industries, had given rise to independent machinery industry, and this process was known as technology convergence. Stieglitz (2003) [14] proposed that technology convergence can be divided into alternative convergence and complementary convergence. Alternative convergence was referred to the diffusion of innovation and new technology, instead of different technology, made the previously unrelated industry from a technical perspective became relevant, and promoted the emergence of a new industry. Complementary technology convergence was accompanied by the emergence of new technology, combined with the existing technology in different industries through integration of complementary and promoted the emergence of a new industry.

Domestic scholars about the definition of technology convergence: Wenxian Tang (2006) [15] put forward technology convergence prolong the life cycle of the original technology of technology diffusion process based on supply and social economy demand for power. Lei Liao (2009) [16] analyzed it based on the technology of IT companies under the background of the fusion technology integration. Technology convergence was defined as enterprises with the purpose of introducing themselves and the technology had strong complementarily, compatibility with gap of other technology in the field of advanced technology, and put IT with its own core technology mutual penetration, absorption, reference, study, and combined to produce a integrated more than the original technology of different function and become a kind of new technology with new functions, and to the spread of the continuous process.

From the domestic and foreign scholars about the definition of technology convergence, foreign scholars emphasize technology convergence is across industries or different technologies in the field of technology, or similar technology diffusion, between different industries and eventually lead to the birth of a new industry or new technology process, emphasizes the evolution of technology development. Domestic scholars tend to define technology convergence for enterprises to introduce across the industry in the field of technology, and digestion, absorption, to create, to produce a new technology process, emphasizes the technology convergence is a kind of enterprise innovation behavior.

This paper argues that the introduction of technological convergence is the enterprise have a purpose and its technology has strong complementarity, compatibility with other advanced technologies in the field of technology gap, and put it with its own core technology mutual penetration, absorption, reference, study, and combined to produce a integrated more than the original technology of different function and become a kind of new technology with new functions, and to the spread of the continuous process. Technological convergence is essentially a kind of technology innovation, to participate in the fusion technology in the fusion process constitute a symbiotic relationship, be short of one cannot, must be used, to merge into the new technology.

2.2. Innovation Mode of IT Enterprises

General innovation mechanism has independent innovation, cooperative innovation and imitation innovation. And based on the integration of technology innovation, is the enterprise's core technology and has a technology gap between outside major technology

mutual confluence, so different from the general technological innovation. In IT industry, technology penetrating into each other in different fields as a result, the destruction of the industry boundary, fuzzy, technology integration has increasingly become a trend which cannot be ignored. Barriers between industries, enterprises, departments, gradually disappear, integration and globalization, collaborative, network, authorization, cooperation, strategic alliance, and dynamic network is increasingly becoming a common phenomenon in the IT enterprises. In this paper, innovation mechanism of IT enterprises is defined as: core technology sharing alliances, mergers and acquisitions, technology licensing.

Core technology sharing alliance refers to the IT enterprises which are technically complementary companies forming a strategic alliance, the core competence of sharing one or more parties, as a core element of the alliance, and to incorporate these core technologies of an innovative way. Enterprise and technology convergence, the first stage of independent research and development activities, but companies reached an agreement in advance, sharing knowledge and technology research and development activities. Core competence is scarce and difficult to imitate and substitute, and through the formation of strategic alliance, enterprises can realize the core competence of complementary, fusion, and create new skills. Core technology sharing, however, have a certain risk, because IT technology has a strong spillover, sharing can lead to be copied enterprise core competence, so that the core capacity loss and depreciation.

Technology acquisition: with complementary technology companies merged into one enterprise, promote the convergence of complementary technology, and shall be conducted by the technology of enterprise after the merger integration innovation management. Mergers and acquisitions is the enterprise directly access to external resources and capabilities of a way, this way can be directly in the merger and acquisition of enterprises or research and development institutions of all resources in enterprise organization system, at the same time to obtain the core of enterprise external technical knowledge and ability. Although technology costs and risks of mergers and acquisitions is higher, but it can make the enterprise resources you will need to obtain fusion technology as soon as possible and ability. In addition, because technology mergers and acquisitions will fusion convergent products which need to be focus within a company, is advantageous to the fusion technology research and development.

Technology licensing is an important way for IT enterprises to import technology and integration innovation. Technology licensing is a contractual agreement, make the organization of the licensee by a technical license or licensed individual organizations or individual rights of proprietary technology. The current IT enterprise convergent products contained in the technology, more and more convergent product innovation requires enterprise to complete all related technology development, the technological development ability of enterprises put forward very high requirements, such as the vast majority of specialization, the core of the IT enterprises can't reach this level. At this time, the business license may be able to buy from other business: convergent products required for other techniques. Technology licensing can make the enterprise in a short period of time to obtain their own lack of technology, or other resources or ability quickly which have to obtain external technology integration innovation, and then merge with its own technology, the development of new products and occupy the market.

Convergent products generally are caused directly by the consumer demand, functions more clearly. Convergent products tend to merge different techniques in the field of product function. But for a certain industry, enterprise is usually difficult to have the required knowledge and technical resources for convergent product research. Therefore IT enterprises should choose a different access to outside technology development strategy according to the actual conditions, in view of the different types of convergent products.

3. Demand Analysis of Convergent Product

When integrating their technologies, the enterprises should take the market needs of their products into full consideration. The convergent products, which integrate different functions of many original products in different technological fields, have their own new functions. Therefore, the need of a new convergent product, is determined not only by the market of new convergent product substituting the original products, but also by the new market which is caused by the changes of functions and price of the new product. We should take both of them into consideration. In the theoretical field, diffusion theory and modes are used to describe the growth process of new products in the market. Convergent products confront the nascent market needs; so they also follow the general rules in the diffusion of new products. At the same time, the innovation in technological convergence can change the features of market needs and bring to new market needs for the original products.

According to the characteristics of technological convergence, we propound the following assumptions:

(A.1)There are two aspects in the growing demand of the converged-innovative products. The first is that the converged products substitute the original market demanding, and the second is of creating the new market demanding.

(A.2)The alternative consumption is caused by the easily identifiable external factors (such as advertising, appearance, function and performance of other external factors, etc.) and the role of human imitation behavior. The innovative consumption is only caused by the price and the changes of the effectiveness of convergent product.

(A.3)The convergent product is faced with a linear markets demand curve, and its price depends on market demand and product function.

In order to simplify the model, we assume that the convergent product required two kinds of technology which came from different department or technical field of IT industry.

3.1. Alternative Consumption

Kalish (1985) [3] modifies the function of gross actual demanders by introducing reservation price that people would be willing to pay for. People would become actual demanders if only the actual price is below the individual's reservation price. In this article the actual demand (or more simply the dynamic demand) for the monopolist's product is as below:

$$N(p) = N_0 \int_{\omega > p} g_\omega(\omega) dv \qquad (1)$$

Where $N(p)$ is the gross of actual demanders, N_0 is the gross of actual demanders when the price equals to 0,(that is, the so-called potential demand referred in this article), p is the price of the products, ω denotes the utility of potential demanders, $g_\omega(\omega)$ denotes the utility function of potential demanders.

Following Liu Qinglin(2004)[7] ,the function of the actual total demand (market size) is defined as:

$$\overline{N}(t) = (1 - p) m(t) \qquad (2)$$

Where $m(t)$ is the gross of potential demanders at time t , $1 - p$ is the ratio of actual demanders.

Assumed the utility functions of original products are respectively $f(x_1)$, $f(x_2)$, the function of convergent products is $f(x_1, x_2)$ .Where x_1, x_2 are respectively the technical content of original products 1 and 2.

When the convergent products appear in the product market 1, if consumer abandon the original product, and purchase the technological convergent product, when the reservation effectiveness of potential consumers will increase $f(x_1, x_2) - f(x_1)$, which equals to the price to decrease $\gamma[f(x_1, x_2) - f(x_1)]$, where γ is a discount factor implied in function of product. Hence, the revised demand function of original product market 1 is as below:

$$\overline{N}_1 = [1 - p + \gamma(f(x_1, x_2) - f(x_1))]m, \quad (3)$$

Similarly in the product market 2, if consumer abandon the original product, and purchase the technological convergent product, when the reservation effectiveness of potential consumers will increase $f(x_1, x_2) - f(x_2)$, which equals to the price to decrease $\gamma[f(x_1, x_2) - f(x_2)]$. Hence, the revised demand function of original product market 2 is as below:

$$\overline{N}_2 = [1 - p + \gamma(f(x_1, x_2) - f(x_2))]m \quad (4)$$

Where p is the external influence coefficient, which mainly depends on features, appearance, quality, and advertising of the convergent products. q is the imitation coefficient, which mainly depends on the extent that the imitation behavior gives impact on consumer. Here $p \geq \gamma(f(x_1, x_2) - f(x_1))$, $p \geq \gamma(f(x_1, x_2) - f(x_2))$.

3.2. Innovation Consumption

According to the definition of technological convergence, the consumption of convergent products in addition to containing alternative consumption to the original products, there is demand of a new market which is neither the original market 1 nor market 2.

According to the foregoing assumptions, the demand curve of convergent products is

$$Q(t) = a - bP + c\omega \quad (5)$$

Where ω denotes the utility of consumers caused by convergent product.

The relationship between innovative consumption and prices, the effectiveness of the products can be expressed as

$$\Delta W_t = -m\Delta P_t + n\Delta\omega \quad (6)$$

According to the expression (5), yields

$$\Delta Q(t) = -b\Delta p + c\Delta\omega \quad (7)$$

Based on the assumption of linear demand function, here we introduce an innovative coefficient γ $(0 \leq \gamma \leq 1)$, and let $b = \frac{m}{\gamma}, c = \frac{n}{\gamma}$, yields

$$\Delta W_t = \gamma Q(t) \quad (8)$$

The meaning of innovative coefficient γ could be understood as the ratio that innovative consumption of convergent products at time t accounted for the incremental consumption at time t.

4. The Diffusion Model of Convergent Innovation

Bass (1969) [2] thought that the demand for new products is caused by the behavior of innovation and imitation. Where the innovation behavior of consumer is influenced by external conditions such as the mass media (such as advertising). The imitational behavior of consumers is influenced by oral communication of people, and the impact major caused by some of the intrinsic properties cannot be identified of new products, such as product reliability, durability, ease of use and so on. The following model was established:

$$\frac{f(t)}{[1-F(t)]} = p + qF(t) \tag{9}$$

$$\begin{aligned} Q(t) = \frac{dN(t)}{dt} &= p[\bar{N}(t) - N(t-1)] \\ &+ qN(t-1)[\bar{N}(t) - N(t-1)] \end{aligned} \tag{10}$$

The alternative consumption of convergent products to original product 1 and original product 2 are as follows:

$$\begin{aligned} \Delta S_1 &= [p + \frac{q}{\bar{N}_1} N_1(t) + q_{21} N_2(t)] \\ &[[1 - p + \gamma(f(x_1, x_2) - f(x_1))]m - N_1(t)] \end{aligned} \tag{11}$$

$$\begin{aligned} \Delta S_2 &= [p + \frac{q}{\bar{N}_2} q N_2(t) + q_{12} N_1(t)] \\ &[[1 - p + \gamma(f(x_1, x_2) - f(x_1))]m - N_2(t)] \end{aligned} \tag{12}$$

Where $N(t)$ is the cumulative amount that the consumers of original products transfer to the consumption of convergent product, that is the reductive accumulation of the original market demand, q_{21} is the impact coefficient which reflects the impact of consumers of product 2 on the ones of product 1, q_{12} is the impact coefficient that consumer of product 1 impact on the one of product 2.

With the foregoing assumptions, we can see that the total consumption of convergent products is

$$\begin{aligned} \Delta Q(t) = &\frac{1}{1-\gamma}[p + \frac{q}{\bar{N}_1} N_1(t) + q_{21} N_2(t)][\bar{N}_1 - N_1(t)] \\ &+ \frac{1}{1-\gamma}[p + \frac{q}{\bar{N}_2} N_2(t) + q_{12} N_1(t)][\bar{N}_2 - N_2(t)] \end{aligned} \tag{13}$$

(1) When $\lambda = 0$, the consumption of convergent products are all alternative consumption, which means the convergent product is the upgrade of the original product's features, performance and value, not create new features, and thus it did not open up new markets.

(2) When $\lambda = 1$, the convergent products can't replace the original products at all. That means the products formed by technical convergence, are different with original products in features and applied scope of the products, and thus here technological convergence open up a new market demand.

5. The Judgment to the Success or Failure of Technological Convergence

The success of technological convergence innovation not only means that this new technology converge successfully, but also means that the convergent technology can diffuse and be accepted by the market. If consumers (those impacted by imitating acts mainly) found that the performance, quality and usable range of the convergent product cannot meet requirements and cannot give them more satisfaction, they will give up spending on convergent products, and then return to the former consumption. We make the following assumptions:

(A.4) Returning to the former consumption for consumers is possible after they consume convergent products.

(A.5) It is primarily influenced by internal factors that consumers purchase the convergent products, so imitation act plays a major role for convergent products.

(A.6) The number of consumers that transfer to convergent product consumption who spent on the original technology market 1 and market 2 is proportional to the number of consumers keeping convergent product consumption and the potential market capacity of the original market, and the ration is called imitation diffusion coefficient k. The number of consumers that returned to the former consumption from convergent product consumption is proportional to the number of consumers keeping the former consumption, and the ratio is called recovery coefficient l.

$x(t)$ represents the amount of consumers keeping the former consumption in time. $y_1(t)$ represents the amount of consumers that transfer to convergent product consumption from the consumption in market 1, $y_2(t)$ represents the amount of consumers that transfer to convergent product consumption from the consumption in market 2, $z(t)$ represents the amount of consumers that return to former consumption from the convergent product consumption.

$$x(t) + y_1(t) + y_2(t) - z(t) = Q \tag{14}$$

$$\begin{cases} \dfrac{dy_1(t)}{dt} = k[m_1 - y_1(t)]x(t) \\ \dfrac{dy_2(t)}{dt} = k[m_2 - y_2(t)]x(t) \\ \dfrac{dz(t)}{dt} = l \bullet x(t) \\ Q = x(t) + y_1(t) + y_2(t) - z(t) \\ z(0) = 0, y_1(0) = y_1, y_2(0) = y_2 \end{cases} \tag{15}$$

Yields $y_1(t) = m_1 - (m_1 - y_1)e^{-\frac{k}{l}z(t)}$ (16)

$$y_2(t) = m_2 - (m_2 - y_2)e^{-\frac{k}{l}z(t)} \tag{17}$$

$$\lim_{t\to\infty} z(t) = \frac{a_2 + n}{-2a_3} \approx \frac{-a_2}{a_3} = \frac{2l}{k} - \frac{2l^2}{k^2}\frac{1}{m_1 + m_2 - y_1 - y_2} \tag{18}$$

We can see from the formula above. If y_1 , y_2 are very small, which means that the fewer consumers transfer to convergent product initially, the more consumers return to former product consumption. If the convergent product's consumption transferring initially is smaller than a certain limit, the demand of convergent product cannot diffuse.

For successful technology convergence, the fundamental condition must be met that are the acceptability of convergent product for consumers must reach the boundary in initial stage of technology convergence. Otherwise the convergent technology is difficult to diffuse because the demand don't grow or grow slowly. The meaning of their practice as follows: producers or investors must consider firstly the acceptability of market demand of convergent product in introductory phase; if the convergent product is difficult to be accepted by consumers at the beginning of convergent product entering market, or most of consumers accepting the convergent product return to the former consumption or transfer to other consumption, the producer or investor should consider the problems existing in convergence and the feasibility of technology convergence.

6. Conclusions

In this paper, on the basis of redefining the technological convergence, we studied the market selection mechanism of technological innovation in IT enterprises under technological convergence. By establishing diffusion model of technical convergent product, we revealed the diffusion law of convergent products in IT enterprise, which is the market demand of convergent products. In addition, we analyzed the conditions which determine the success or failure of technological convergence by establishing the corresponding model. The results show that the condition of technological convergence's success is that the acceptance degree of consumer to the convergent product must reach certain limit in the initial stage of technological convergence. Otherwise, as a result of no growth or slow growth in demand, the diffusion of technology convergence will be difficult. This study provide a preliminary theoretical analysis basis for the scholars who studied the related policies of technology convergence.

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