Research on Catch-up Oriented Industrial Technological Capabilities Growth in Developing Countries*

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Abstract This paper takes for that the realization of economic catch-up strategy of developing countries should depend on technological catch-up, but the successful technological catch-up requires the fast enhancement of industrial technological capabilities. The paper points out four characters that the catch-up oriented industrial technological capabilities growth process should possess, and presents a framework of the catch-up oriented industrial technological capabilities growth in developing countries. This study reveals that the growth framework of industrial technological capabilities in developing countries is a synergistic development mechanism consists of the technological efforts at industry-level, firm-level, and national-project-level.

Key words Catch-up; Developing countries; Technological capabilities; Growth

1 Introduction

Since 19th Century, the most important problem for developing countries is how to achieve industrialization and catch up with developed countries. With the acceleration of economic globalization, the uniform tendency of markets, and the limited resources, the comparative advantage of developing countries which based on cheap and abundant resources in economic development will be gradually lost. So the realization of developing countries' economic catch-up strategy should depend on mastery of advanced technology. The international economic development experience over half a century has shown that the acquired technological assets become more and more important for economic development, and the strategy that only relies on "comparative advantage" will make developing countries even further behind. How quickly and effectively enhance the industrial technological capabilities has become the focus for the implementation of catch-up strategy of developing countries. This paper studies the growth framework of industrial technological capabilities to point out the striving directions of industrial technology capabilities enhancement, and to provide references for developing countries to develop a more reasonable industrial and technological policies and to carry out effective practice of industrial technological capabilities enhancement.

2 Characteristics of Catch-up Oriented Industrial Technological Capabilities Growth

Technological catch-up is a process to reduce or eliminate the industrial technological gap between developing and developed countries. The realization of industrial technological catch-up strategy depends on the continuous enhancement of technological capabilities in developing countries. However, the catch-up oriented industrial technological capabilities growth process or mechanism should have the following characteristics.

2.1 Accelerate enhancement

Industrial technological capabilities in developing countries requires accelerated enhancement under technological catch-up strategy. On the one hand the developed countries have been developed for a period of time in the initial stage of industry in developing countries, and the developing countries generally have to depend on the introduction of mature or outdated technology to develop, and there is a huge gap in industrial technological capability in the initial stage of industry in developing countries. On the other hand, the industrial technological capabilities in developed countries also develop rapidly, and the industrial technology upgrade led by developed countries becomes more and more quickly. Therefore, no matter take what kind of technological catch-up strategy mode, developing countries must accelerate the development of local industrial technological capabilities through their own technological

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efforts, in order to reduce the technological gap and keep up with the pace of global scientific and technological progress. The accelerated enhancement of industrial technological capabilities of developing countries expresses in two dimensions: the development of technological capabilities in developing countries starts from technology introduction, and after some development phases, it can achieve self-development(or self-innovation); developing countries must depend on their own technical efforts to accelerate development of their industrial technological capabilities, thus substantially reducing the transformation time of technology from one generation to the next and improving their technical level as soon as possible to participate in the competition with technology leaders.

2.2 Aim for independent innovation

Technology introduction is an inevitable choice for developing countries in the initial stage of industry, but the development of industrial technology should not be regarded as an easy and quick enhancement process through technology introduction. It requires conscious technological efforts to finally achieve the independent innovation. Historically, the development of technological capabilities in lots of developing countries fell into a vicious circle of "backward —introduction …… backward again — introduction again". As time goes by and world technology progress, the technological capabilities development of developing countries will only changes in quantity but not in quality. Only aiming for the realization of independent innovation, breaking the path-dependence predicament of technology introduction, the development of developing countries' industrial technological capabilities will ultimately realization qualitative leap on the basis of quantitative change. With the lapse of time and the upgrade of technology, the development of industrial technological capabilities in developing countries under catch-up strategy should show a path of "backward — introduction …… adaptation and improvement …… independent development — leading — independent innovation". Only realization of technology leapfrogging from introduction to independent innovation, the developing countries can achieve the industrial technological catch-up with developed countries.

2.3 Take leaders as reference

Most of the existing researches on industrial technological capabilities development issues of developing countries take the history of their own as a reference dimension and do a vertical comparison. After a period of industrial development, developing countries achieve the transformation from technology introduction to improvement and then to independent innovation, and finally realize the breakthrough from production capacity to innovative ability. However, the vertical comparison of developing countries' industrial technological capabilities development is not enough for the requirement of technological catch-up strategy, so it must also do a horizontal comparison that take developed countries as reference dimension to enhance technological capabilities. In order to achieve technological catch-up, the development of industrial technological capabilities in developing countries must take international technological leaders as reference and measure their development of technological capabilities by the yardstick of the gap with technology leaders. The only way to achieve technological catch-up for developing countries is through improving technological capabilities to reduce the gap with technology leader.

2.4 Coordinated development of system

The industry is not composed of a single activity, but linked by lots of activities. These series of industrial activities carried out around a specific product or service links with each other and form a complete industrial chain. Each node in industrial chain is supported by a particular technology, and these particular technologies constitute the technological chain system. Industrial system is an organic system composed of all nodes of the industry chain, and the industrial technological capabilities refer to the capabilities of a country to lead the development of industrial technology system, rather than a simple accumulation of the technological capabilities of all the enterprises within the industry. The technological catch-up with developed countries requires the enhancement of industrial technological capabilities of developing countries not only limited in some nodes of the low-end of technological chain, but also realization of coordinated development of technological capabilities in all nodes of the industrial technological chain system (especially the key nodes).

3 The Framework of Catch-up Oriented Industrial Technological Capabilities Growth

In the global competitive market, technology life cycle becomes much shorter, and the international industrial development is under the pressure of constantly update technology to ensure the competitive advantage. In this trend, the process of industrial development in developing countries faces greater

challenges which contain not only the shortage of their own technical scarcity and industrial backward, but also the fierce competition and the technological blockade or suppression from developed countries. How to effectively enhance the industrial technological capabilities to ensure the realization of technological catch-up has become a challenge for developing countries. So, developing countries should consider the synergistic development of all levels of industrial development to improve industrial technological capabilities, rather than limited to a certain level of technological efforts. In the study of product innovation platform, Hu and Wang divide product innovation platform into public innovation platform, industry innovation platform and enterprise innovation platform. Similarly, this paper considers that the efforts to enhance industrial technological capabilities of developing countries should be considered at industry-level, firm-level and the national-project-level.

3.1 Industry-level

At the industry-level, the most important issue of the development of industrial technology and the enhancement of competitive ability in developing countries is how to change the actuality of the industrial chain incompletion and the key technologies absence.

The characteristics of industry in developing countries in initial stage are low technological capabilities and simple production activities. Usually through introduction of mature technologies from developed countries, developing countries begin their industrial activities from the terminal products assembly process, and then develop mostly rely on the comparative advantage of their cheap and abundant labor resources, raw materials and other resources endowment. However, depending on technology introduction and the comparative advantage of resource endowment to take industrial activities in the low-end of global industrial chain can't promote the fast enhancement of technological capabilities and the formation of long-term competitive advantage. The path-dependence of technology introduction and only at the low-end of the global industrial chain will inevitably form the key technologies absence state. The key technologies absence refers to lack of advanced and core technologies, which becomes one of the major bottlenecks in the process of industrial development and technological catch-up in most developing countries.

In order to achieve the fast growth of industrial technological capabilities to ensure the realization of technological catch-up, developing countries must change the situation of the key technologies absence. Therefore, at industry-level, the catch-up oriented industrial technological capabilities growth in developing countries requires changing the status of missing industrial core technology and advanced technology through a series of industry activities, such as industry planning, policy supports, practical endeavors. And the catch-up oriented industrial technological capabilities growth mechanism in developing countries is shown in Figure 1.

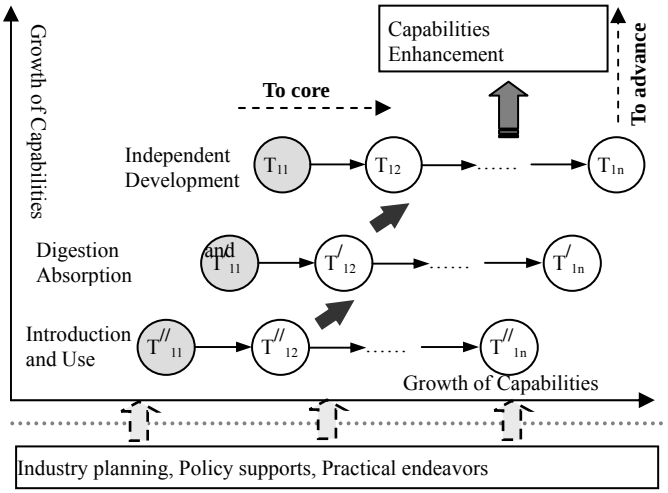

Figure 1 Catch-up Oriented Industrial Technological Capabilities Growth Mechanism at Industry-level

At industry-level, the catch-up oriented industrial technological capabilities growth will include two trends: core trend and advanced trend. The core trend requires the industry of developing countries can not only be limited to possess the peripheral or low-end technology (T_{11}), but also extend to possess the core and high-end technology ($T_{12}…T_{1n}$). Thus enables all kinds of industrial technologies (from the periphery to the core, from the low-end to the high-end) to obtain coordinated development and to

achieve the evolvement from initial introduction and use (T''_{11}, T''_{12}……T''_{1n}) to self-development (T_{11}, T_{12}……T_{1n}). The formation of cooperated development of various types of technologies and self-development capabilities is the basis of the industrial technology upgrading (T_{2i}), and finally, achieve the advanced trend of industrial technology and catch up the leading technologies through industrial technology upgrading.

3.2 Firm-level

Firms are the most important technical actors, so the successful construction of technological capabilities at firm-level determines the successful development of industry. In the initial period, firms in developing countries begin to operate based on the required technology obtained from other countries, and they even lack of the most basic technological capabilities. In order to be competitive and catch up with technology leaders, the first thing that firms in developing countries must consider is establishing and upgrading their technological capabilities. But the acquisition process of technological capabilities is unpredictable, and there are considerable risks in capability investment and the result is also uncertain. Thus, firms in developing countries will not take too many efforts in the process of technological capabilities enhancement, especially in the great R&D activity. Taking the proportion of R&D expenditures in the GDP for example, the ratio of high-income countries in 2003 reached 2.46%, whereas the middle-income countries' was only 0.85%. Especially in China, the situation of R&D expenditures is even more pessimistic: in 2006, the ratio of firms which carried on R&D activities in large and medium industrial firms was only 24%; the firms owned research institutions accounted for only 23.2%, and the proportion of expenditures on R&D in main business income of large and medium industrial firms was only 0.77%. For technological catch-up, such a situation of insufficient investment in the process of technology improvement must be changed urgently. At the firm-level, there are two aspects to consider the investment and activities of catch-up oriented industrial technological capabilities growth.

(1) Internal efforts of firms. Generally firms in developing countries depend on the introduction of mature technologies of developed countries to engage in industrial activities. But for firms in developing countries under catch-up strategy, the introduction and use of foreign technology is not their end. In order to become more competitiveness and catch-up with technology leaders, they must establish their own technological capabilities to realize independent-innovation. The creation and development of technological capabilities requires a key element of technological efforts, refers to a process of investing time, capital and other resources with a purpose on technological learning activities to enhance technological capabilities. The effective internal efforts of firms to establish and enhance technological capabilities mainly include continued improvement of new technologies to adapt to the special local environment and production conditions, depending on the firms' own investment in R&D, human resources and skill development, etc.

(2) External supports. As firms can not be operated in the "vacuum", the internal efforts will be affected by external factors such as industrial policy orientation, and the technology behaviors of a firm can be regarded as a series of responses to all kinds of stimulations from the surroundings. The development of technological capabilities in developing countries requires the government playing an active role through providing suitable policies, and a major task of technology policy in developing countries is to provide institutional and organizational structure to allow a wide range of participants in the process of development interacting on a sustainable supply-demand relationship. The major sources of the formation of technological capabilities including: internal methods in firms, external institutional facilities, interaction with other firms, public areas and international sources, so the fast enhancement of technological capabilities in developing countries requires the external supports by government through technology policy. However, there is an important issue that firms are the key part of effective technology accumulation is not realized in the technology policy in many developing countries, thus most of R&D developed by public sectors. External support does not mean external substitution; therefore the focus of government policy is promoting firms to develop the internal efforts to enhance technological capabilities.

3.3 National-project-level

There are some technologies which have the following characteristics: great comprehensiveness, involving a number of technological fields, requiring a long cycle of R&D and a huge investment, and a great risks in technological development, but they play an important role in industry development and upgrading, such as some generic technologies, core technologies and complex technologies (products), etc. The R&D of these technologies is very difficult for an individual firm to achieve the desired objective. Thus the national R&D will be considered to play a prominent role, in the condition that

individual firm can not obtain the competitive advantage. Especially in developing countries, the national-project is particularly important in the process of industrial technological capabilities enhancement.

Enhancing technological capabilities through national-project to achieve technological catch-up mainly display in two aspects: realization of the independent-development of industrial key technology (such as some generic technologies, core technologies and complex technologies, etc.), and approaching to the international advanced level.

(1) Realization of the independent-development. The industrial key technologies are great important for the upgrade of industry and the acquisition of competitive advantage. Now, these technologies mainly depend on introduction from advanced countries in the process of industry development in developing countries. Therefore, enhancing investment on those key technologies' R&D activities which relating to industry development trend to achieve fast enhancement of technological capabilities from "introduction and use" to "independent-development" is an important object of national-project. For example, the main task of national science and technology program of China is enhancing the original scientific and technological innovation capability, the development capabilities of industrial core technologies, etc.

(2) Approaching to the international advanced level. Technological backwardness is the main reason for the low competitiveness of industries and firms of developing countries, especially some core technologies in the process of industrial development of developing countries often lag behind the developed countries with a generation or even several generations gap. Such as South Korea, although it has already reached the international leading level in semiconductor industry of 256M DRAM in the mid-1990s, but in the early 1980s, when South Korea began to enter the 64K DRAM R&D activities, its technology level was greatly behind that of United States and Japan (United States and Japan have already achieved the development of 256K DRAM, and started the R&D of 1M DRAM). The technological efforts at national-project-level, which aim at quickly enhancing the technological capabilities to realize technological catch-up, must be took to achieve independent-development of the more advanced technology and to reduce the gap with the international advanced level.

3.4 Integrated framework

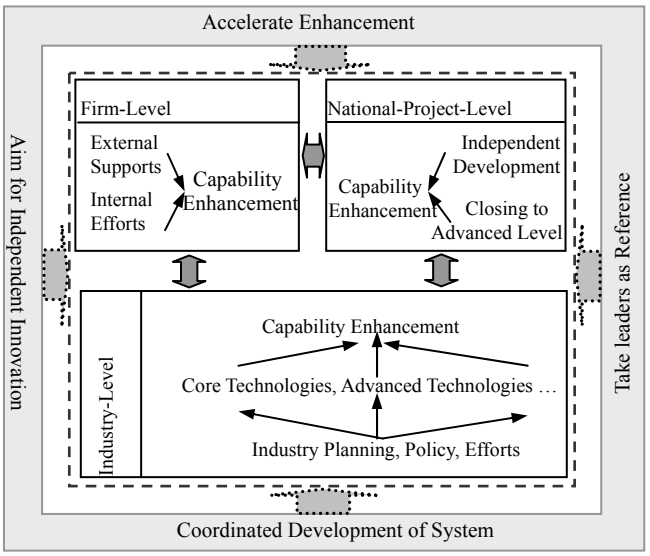

Figure 2 The Growth Framework of Catch-Up Oriented Industrial Technological Capabilities in Developing Countries

In conclusion, the enhancement of industrial technological capabilities in developing countries requires a comprehensive consideration in three aspects of industry-level, firm-level and national-project-level. The "industry—firm—national-project" framework of catch-up oriented industrial technological capabilities enhancement in developing countries is shown in Figure 2. At industry-level, the situation of key technologies absence in developing countries will be changed through designed industrial activities of industry planning, policy supports and practical efforts. So that, the industrial technologies will be developed to the core technology nodes, and the fast upgrade of

industrial technology will be achieved through coordinated development of technologies in all nodes. At firm-level, the leapfrogging from production capacity to innovation ability and the breakthrough from technology introduction to independent-development in developing countries will be achieved mainly through internal technological efforts combined with the creation of external supports which promote the internal efforts. And at national-project-level, the object is realizing independent-development and closing to the international advanced level in the important technological fields of industrial key technologies which the firms in developing countries can not independently break through. Although it is required to take efforts at respectively at industry-level, firm-level and national-project-level to enhance industrial technological capabilities, but the three aspects are interrelated.

4 Conclusions

Technological capabilities is the main determinant factors of industrial competitiveness, the realization of catch-up strategy of developing countries under the globalization background has to depend on the enhancement of industrial technological capabilities. In order to achieve fast technological catch-up, the growth of industrial technological capabilities in developing countries should have the characteristics of acceleration enhancement, aiming at independent innovation, referring to the leaders and coordinated development of systems. Based on this, the enhancement of industrial technological capabilities in developing countries should take the synergistic development of all levels into consideration, the efforts of catch-up oriented industrial technological capabilities in developing countries should be considered at three interrelated levels: industry-level, firm-level and national-project-level. None but the integration of the technological efforts at industry-level, firm-level and national-project-level, may enhance industrial technological capabilities of developing countries for technological catch-up.

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