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INNOVATION STRATEGY FOR BUILDING INDIGENOUS TECHNOLOGICAL INNOVATION CAPABILITY IN CHINA*

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Abstract: Indigenous technological innovation capability-building has emerged in recent years as a new development agenda and the critical problem in China. This paper, based on 5-year empirical research on Chinese firms and theoretical analysis, presents and details the contents of a "3-I innovation strategy," and finally shows the industrial difference of such strategy.

Key words: indigenous innovation, strategy, firm
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INTRODUCTION

It is very important for China to achieve sustainable development because of the primary role of China as the advocate of peace in the world and especially in the Asia-Pacific region. Over the past several decades China has increasingly come to realize the Technological Innovation (TI) may hold the key to sustainable development. International technology flow has become a massive world-wide circulation of economic resources, and may be perceived as a means for rationalizing the international division of labor in the area of science and technology, and for less developed economies to catch up with technologically more advanced economies. Hence technological upgrading requires a mix of technology acquisition, adaptation and innovation if a country or firm is to reach technological frontiers in production(Alice, 1989).

Indigenous technological innovation capability-building has emerged in recent years as a new development agenda. It is recognized that the critical problem in China is not how more science and technology can be borrowed. Rather, emphasis is now placed on how science and technology can be made an integral part of development, society and culture(Xue et al., 1997).

Because of the weak technological capabilities affecting the development process, panacea or not, foreign technology is expected to make a large contribution to science and technology development. But, generally, the indigenous technological capability necessary to effectively select, assimilate and improve the imported technology is insufficient (Alice et al., 1989), China's indigenous technology has not benefited much from the imported technology: the ratio of complete sets of equipment in technology acquisition was higher and higher (from 89% in the 1950s, 91% in the 1960s to 95% in the 1980s); and from 1981 to 1990 data showed that among the 3878 imported technology projects costing 20.383 billion US$, 48.17% were equipment importing costing around 15 billion US$. Investigation on 200 large technology acquisition projects also showed that only 10% of the imported technologies had been improved partially. So the vicious circle of "acquisition-lag-reacquisition-relag" is the problem faced by industrial development in China, where the indigenous technological innovation capability has not been highly improved (Xu et al., 1997) (Table 1).

Nowadays, many new and exciting avenues of research on technological innovation and the improvement of indigenous technological innovation capability have opened. Since the advocation of the concept of technological innovation by Schumpeter(1990), the Western views such as the demand-pull theory of Prof. Schmookler (1985), the technology paradigm of Dosi(1988), 'learning by using' concept of Rosenberg(1976), innovation policy of Rothwell(1986) and others give a

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Table 1 Technological capability: Sino-Japan comparison(Liao, 1991)

ITEM	Year 1950		Year 1980	
	Japan	China	Japan	China
1. Technical Selection Capability	4	0	5	1
2. Hardware Importing-Production Capability	5	2	5	5
3. Software Importing-Application Capability	3	0	5	2
4. Incremental Innovation Capability	2	0	5	2
5. Incremental Innovation Capability	1	0	5	2

good impact and inspiration for Chinese researchers. In the meantime, some scholars in developing countries initiated exploratory research on technological development. Dr. Linsu Kim in South Korea pointed out that the development of human resource, acquisition of foreign technology and self R&D (Research and Development), are the key factors for national derelopment. Dr. Hyung Sup Choi thought that integration of technology and entrepreneurship, emphasis on the in-house R&D and human resource development are the critical issues for self-reliant technology in developing countries(Hyang, 1988).

However research on improving indigenous technological innovation capability and achieving sustainable development in developing countries, especially in China, are difficult and challenging. It is difficult because the process of technological innovation in China is inherently more complex and the development stage in China is quite different from that of developed countries (Takeshi, 1990). The theory and methodology of technological innovation and the paths and policies on the improvement of technological capability by Western and Newly Industrialized Countries (NICs) scholars may not be really suitable for China. The viewpoints of Chinese scholars need to be tested. It is challenging because the finding of suitable paths and policies of improving indigenous technological innovation capability does promote the sustainable development of society, economy, science and technology and environment in China.

As indigenous technological innovation capability is related to many complex factors, capability-improving is no doubt a multidimensional concept (William, 1991; Raghu et al., 1994). Thus, improving the innovation capability requires consideration of both internal and external conditions. Here, it is shown that the external conditions are very important. By this logic, we provide a new framework for indigenous technological innovation capability-improving for Chinese enterprises (Fig. 1).

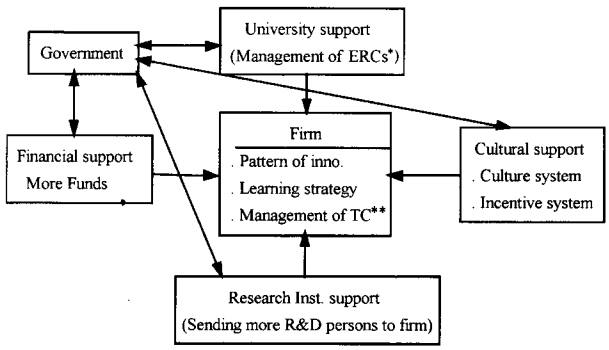

Fig. 1 Framework for indigenous TI capability improving

* ERC-Engineering Research Center; ** TC-Technology Center

According to our investigations and theoretical analysis, the choice of innovation strategy does affect the improvement of indigenous technological innovation capability.

TECHNOLOGICAL INNOVATION STRATEGY FOR CAPABILITY BUILDING

Due to the differences in political institution, education system, national resources endowment, as well as technological infrastructure, the character and strategy of technological innovation in developing countries are very different from those in developed countries. For the developed countries, innovation often result from basic research, applied research and experimental development, but for developing countries in the Asia-Pacific rim, even including early Japan, innovation often originates from imitation of imported technology to improvement. Such an innovation strategy in Chinese firms is called " 3-I Strategy", an acronym for imitation and improvement and innovation(Xu et al., 1997).

The first step of the "3-I Strategy" is imitation, the typical example of such a technology management strategy was the Shanghai Machine Tool Works, a manufacturer of universal machine tools. In 1953, universal machine tools saturated

the market, and new products were expected to be developed. After extensive and careful market survey and investigation around the country, the Shanghai Machine Tools Works decided to conduct research and development studies on precision plane machine tools. They did not imitate the former Soviet Union's products but tried to imitate the precision gear machine tool products of a Swiss firm, and finally correctly chose ideal products to imitate and became very successful. After this, the Shanghai Machine Tools Works produced new products at low cost and in less time.

The benefit from imitation of imported technology is large, because the low level self-design and development here could not be more competitive than those in higher level technology acquisition as technology capability in China then was far lower than the state-of-the-art of the more advanced countries (William, 1991). Aware of this, China has, since the 1980s, stressed technology acquisition, characterized by (1) Large scale and heavy investments for technology importation; (2) Multi-dimensional technology acquisition in both heavy industry and light industry; (3) Technology acquisition with strategic purpose of import-substitution and promoting export.

After the large-scale technology acquisition stage, China turned its attention from imitation to improvement and innovation because of the following reasons:

1. As a learning process, imitation leads to technology improvement, and innovative persons (leveraging up their capability and enlarging their knowledge base), just as the case of the Shanghai Machine Tool Works revealed. Because of long time imitation, the Research and Development (R&D) personnel in the Shanghai Machine Tool Works accumulated much technological knowledge, skill and experiences, and so, were able to successfully improve the feed box of the grinding machine and reduced components from 47 to 17. The fewer but more efficient components led to better performance. As a result, the problem of oil leakage was solved.

2. R&D is the necessary step for transformative capacity from imitation to innovation(Raghu et al., 1994). The ability to maintain internally developed technology over time is important for economic vitality, and is called transformative capacity. The key elements of transformative capacity are: (1) The choice of technology, including gathering information, choosing difficult-to-create knowledge, identifying technologies for shelving, and developing criteria for evaluating technological options, etc.; (2) The maintenance of a technological knowledge base, including developing avenues for researchers to share information, permitting 'underground' research and development activity, providing incentives for maintaining currently unwanted technologies, retaining key personnel who possess tacit knowledge etc.; (3) The reactivation and synthesis of knowledge, including encouraging scientists, technologists and engineers to move around among product groups and research lab, periodically reviewing the catalog of shelved technologies etc.

All of the above factors depend on R&D because R&D provide more project-on-shelf and knowledge, which form the basis for technology choice, maintenance and reactivation and synthesis(Fransman et al., 1984).

In short, the imitation-improvement-innovation process can be divided into the following stages (Xu et al., 1997):

1. Acquisition stage: the main tasks are investigation, feasibility analysis and obtaining the embodied technology;

2. Imitation stage: the key issue of this stage is to master the operation technology.

3. Adaptation stage: a localization process which make technology suitable to the firm's environment;

4. Improvement stage: high-level technological capacity to be formed on imported technology at this stage;

5. Generating stage: the critical event is the innovation of products and processes which are state-of-the-art in the world.

Several Chinese firms grasped this mainstream, and developed their technology by the recommended steps of the above-mentioned five stages of innovation, with emphasis on the process innovation first. As a result, they spent less time and cost to keep abreast of state-of-the-art of advanced technology. The Hangzhou Oxygen-making Machine Plant (HOMP) is a typical case. Up to now they have developed 6th generation air separators based on the technology acquired from the former Soviet Union and West Germany, HOMP was successful at imitation, adaptation, improvement and generation, and dominated the market for large capacity air separators in China, while

many original license manufacturers found it difficult to enter China's market(Xu et al., 1998).

FRAMEWORK OF INNOVATION STRATEGY FOR CHINA

After analyzing the common features of innovation strategy, we also pay attention to the influence of industrial difference. Hence, the three enterprises, which belong to labor intensive, capital intensive and technology intensive industry correspondingly, are analyzed further. The index of profit focus, development strategy as well as reform strategy, were analyzed.

Table 2 shows that industrial difference has an underpinning influence on the operations of a state enterprise's reform and development. For example, the labor intensive firm has weak motivation to reform the R&D system while the other two kinds of firms pay more attention to it.

Table 2 Industrial difference of innovation strategy in China

Factor	Enterprise	Labor intensive	Capital intensive	Technology intensive
Profiting focus		Price	Quality/Market	New market
	Business Strategy	Retain market share	Focus	Joint venture and market exploration
Innovation strategy focus	Competitive strategy	Low cost	Diversification	Timing
	Technology strategy	Technology. acquisition and joint development	Self-Innovation based on cooperation	Self-Innovation based on joint venture
Market mechanism	Internal market to decrease cost	Internal market to give incentive, resource optimization	Internal market to quick response, resource qptimization	
Reform strategy	Firm organization	Stable	Strategic business unit (SBU)	SBU
	R&D organization	Stable	R&D institute entering SBU	R&D institute entering SBU, Setting up Tech. center

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