

# COMPARISONS OF CATCHING-UP AMONG DEVELOPED NATIONS AND DEVELOPING COUNTRIES

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## ABSTRACT

Although interest in the catching-up strategy of developing countries has increased during recent years, this line of research is focused on national analysis from the beginning, using developed nations as benchmark for productive lagging-behind countries, which need to be reviewed. Accordingly, we utilize literature analysis method to distinguish the difference among developing and developed countries of the catching-up process. Based on our analysis, we state that the lagging-behind countries have late-coming advantages. In the short term, the developing countries are able to achieve technical imitation by catching-up with the technology. However, in the long run, imitation innovation is always based on the main concepts of developed countries, and does not really integrate the actual situation and social resources with the economic situation of developing countries. Consequently, it is essential for developing countries to find an innovative way to fulfill the transformation.

**Keywords:** Technology catch-up, Technical imitation, Lagging-behind country, Innovation, Industry 4.0

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## INTRODUCTION

Most advanced nations, such as Germany, Britain, and United States, have realized catching-up in their early period, which was experienced during the Industrial Revolution (Lin, 2010). So, they have harvested advanced knowledge and technology that lagging-behind countries pursue to catching-up. From the beginning, latecomers imitate leaders, and then

after learning and absorbing knowledge from leaders, they begin to innovate themselves based on their resources and actual situation (Ou and Sheng, 2008). Established studies show that some developing countries have latecomer advantages (Lin, 2010), but we are not sure how they accomplish catching-up (Malerba and Nelson, 2011). Therefore, we intend to review previous research and identify the factors which make developed countries' catching-up

successful, and then promote developing countries' catching-up. In addition, there is no denying that "Industry 4.0" is a novel strategy for many countries to try their best to accomplish, however, it is a tough process for not only developing nations but also developed countries to achieve "Industry 4.0" (Schumacher, Erol and Sihm, 2016). The goal for the "Industry 4.0" is to make industry more intelligent and autonomous. Nevertheless, most industries still need humans to test the veracity of machines. So here is the question: What factors promote developing countries' catching-up at the national level?

### THEORETICAL BACKGROUND

From historical experience, the last 30 years of the 19th century were the beginning of the second industrial revolution, which is a period of great technological innovation and industrial development (Broadberry, 1994; Lin, 2010). But in the mid-19th century no one was able to anticipate the relative decline of Britain. Indeed, when the British industrial advantage seemed to be difficult to challenge, the United States and Germany seized the industrial advantage, which was a decisive factor in their ability to rise rapidly through their technological innovation, catch-up and surpassing Britain and other industrialized countries (Nelson, 1996).

First of all, we focus on Germany: until the eve of the First World War, Germany had established a complete industrial system on the basis of the latest technology, becoming the first industrial power in Europe (Bell and Pavitt, 1993). In the second industrial revolution period, the emergence of a new type of economic organization, monopoly organizations, was also closely related to national innovation and development. During this period, The United States enhanced its productivity. By 1894, the United States' industrial output value was ranked first in the world. As a series of new industrial sectors developed rapidly, the United States jumped from lagging the European industry and imitators to industrial leaders (Lin, 2010).

Next is Japan, the most developed country in Asia: there is no denying that Japan has a more advanced awareness than other Asian countries, and a better strategy for technological innovation development (Odagiri and Goto, 1993). In addition, its efforts to build the basis of independent technology development,

led to the introduction of technology, not just staying in the application phase, but by building self-development capacity after absorbing and assimilating foreign technology (Hobday, 1995). Third, the introduction of technology is carefully expanded, mainly through acquiring technology patents (such as the patents granted in the USA), thus strengthening understanding, absorption and innovation, and gaining access to new international patents (Malerba and Nelson, 2011).

In the world economic system, in addition to developed countries, developing countries are also playing a very important role in the economic cycle. Once developed countries have achieved their own economic development through technological innovation, many developing countries try to imitate the leader's technology for the sake of achieving catching-up (Guo, 2012; Guo and Wang, 2004). However, for the late-coming countries, achieving catching-up is not easy (Furman and Hayes, 2004). They first need some basic conditions or resources for the purpose of catching-up. The success of the attainment of the catching-up is the need for certain conditions, such as strategic opportunities or government policy (Hou, 2003), which are vital to catching-up. Some scholars have pointed out that developing countries, through the introduction of advanced technology in developed countries, have narrowed the gap between the lagging countries and developed countries, as well as the level of economic development (Mu and Lee, 2005). By imitating the introduction of technology, the less developed country is able to, in the short-term, obtain economic growth, but in the long run, it can only rely on imitation (Kim, 1997). Less developed countries cannot achieve real technology catching-up, to achieve the expected economic growth. Therefore, most countries are in the early stages of imitating the advanced technology of developed countries in order to realize their own economic growth. But these countries are caught in the vicious cycle of slow economic growth and no independent innovation consciousness, which hinders the innovation and development of the country (Lee, 2005). Historically, there are only a few countries and regions (such as South Korea, Taiwan etc.), which have achieved the desired results (Amsden, 1989). Actually, South Korea and Taiwan have been acknowledged in the literature as having experienced rapid industrialization and technological upgrading

and can thus be considered as typical catching-up economies (Amsden, 1989; Kim, 1997).

At present, the economy in China has manifested in the economic development which is growing from high speed growth. Its growing economy will be more focused on innovation, in particular the endogenous innovation in technology side (Fan, 2006). Therefore, the transformation and upgrading aiming innovation will become an important factor in China's new stage of economic development (Jin, Lu and Deng, 2011). And the development of production industries in China takes Industry 4.0 as an opportunity to benchmark with.

In fact, the term "Industrial 4.0" was first proposed at the 2011 Hannover, Germany, with the aim of improving the German manufacturing level through new technologies such as the application of the Internet of Objects (Lee, Bagheri and Kao, 2015). Many companies and associations in Germany supported this concept. In 2013, "Industrial 4.0" project into the German government in July 2010 announced the "High Technology Strategy 2020" to determine one of the top ten projects, and this project also driven by the German Federal Ministry of Education and the Federal Ministry of Economics and Technology. Accordingly, government plans to invest 200 million euros in funds, the purpose is to support a new generation of industrial technology in the field of R&D and innovation, to maintain Germany's international competitiveness, for the sake of ensuring the future of German manufacturing).

Industry 4.0 is based on the Information Physics System (CPS), through the CPS network to achieve real-time connectivity, mutual recognition and effective communication among people, devices and products (Anderl, 2014). In addition, building highly flexible and personalized products and services intelligent manufacturing model. The traditional industry boundaries will disappear and produce new forms of activity and forms of cooperation, and the process of creating new values is changing.

German academia and industry practitioners believe that the concept of industry 4.0 is the fourth industrial revolution dominating by intelligent manufacturing, with the aim of making full use of information and communication technologies and cyberspace virtual systems, namely, information systems (CPS) (Schumacher et al., 2016). As a consequence, design, manufacture, sales, service

and other information data, even intelligence, and finally to achieve fast, effective, personalized, customized product supply.

On the basis of the above considerations, scholars have pointed out that we can see the technology development practice from the latecomer countries (Jin, Dai and Zhang, 2013). One reason is that the industrial technology of latecomer country is weak, while the lack of relatively sound institutional environment, their technological progress is basically from the introduction of technology. Such process was fulfilled through the advanced countries that has succeeded in experiencing technology to imitate to improve its own country's technology. Experts also pointed out that the technology of advanced countries has been very comprehensive (Kim, 1997). Moreover, there is no application of the technology development and transformation of such technology into the countries only focus on training the basic operational capacity of the relevant workers. In response to this problem, the experts put forward some solutions, such as strengthening the protection of intellectual property rights, the state to implement new incentives policy (Malerba and Nelson, 2011). However, we think that doing so can only solve some problems in the short run. In the long term, the essential problem of catching-up inefficient remains. What we should pay attention to the core of technological catching-up is the technology per se, rather than imitating the technology. It also requires that the technology to acquire to fit the situation of the latecomer countries, in accordance with national conditions of technological innovation. Therefore, a real challenge for China is how to enhance their own technology in order to achieve the improvements of capabilities. As a consequence, such capabilities can benefit the latecomer countries to compete with advanced countries, by catching-up with the technology. In short, this study plans to analyze the latecomer countries which use the imitation innovation to implement technology catching-up. Moreover, we highlight the importance of capability building for developing countries and latecomer nations which would like to succeed in technological catching-up.

## METHODOLOGY

### Literature analysis

The method of literature analysis refers to the

research of the literature by collecting, identifying and sorting out the relevant literature of a research topic, and systematically, objectively and quantitatively analysing the literature to obtain information, and then form a scientific understanding of the facts method (Glass, 1976). The literature, especially the journal literature, is essentially a carrier of research activities. It can indirectly reflect the development of the field by analysing the literature contained in a technical field for a period of time. Document analysis is mainly based on bibliometrics, content analysis theory and method (Bowen, 2009). The general process of the literature analysis method includes determining the object, the literature collection, the statistical analysis, and the conclusion of the four steps. Document analysis is to carry out research work, the overall grasp of previous research results, to understand the status quo, to find the crux of the problem lies in an effective research method. In order to find the literature related to the problem to be studied more efficiently, we classify and collate the literature words according to the Chinese and English keywords, and lock the literature into published paper documents published by academic journals: academic journals, books and newspaper, CNKI database and so on.

Data sources and descriptive statistics in this paper (that is, the literature collected) mainly comes from the knowledge of China, through the two categories of key words: the first category (technological catching-up, catching-up theory, latecomer advantages, industrial upgrading, and the second category (literature, literature analysis, literature, literature statistics, literature review) combined to search, such as "technological catching-up plus literature analysis." After the search results were obtained, the literature was screened by reading the title, abstract, key words and main contents. Finally, 33 papers were published in the literature from 1962 to 2015, of which 24 were based on the factor of research, 9 of them are based on the process of research; according to the theme of research is divided into two categories: the technological innovation of developed countries, the technological catching-up of latecomer countries.

In the post-technological catching-up the theme, this article will be further divided into three sub-themes, that is, the background of the country, to South Korea and Taiwan as the representative of the newly industrialized

nations and the BRIC countries as the representative of the developing countries or emerging economies. After screening, we received a total of 23 sample documents.

In the first place, Guo and Wang (2004), Lu and Wei (2005) and Yang (2006) used the synthesis method to show their research results for the theme of the technological catching-up. The former two analyzes the backwardness of the technology of the backward countries' technology and the economic development strategies of the developing countries, and systematically analyzes the late-developing advantages of the late-developing countries. In addition to analyzing the catching-up policies in Southeast Asia, the latter also sums up three suggestions about recommendations of the country: first, based on the market mechanism. second, the implementation of balanced development of large and medium-sized enterprises in the industrial policy, the establishment of scale and competition-compatible market institutions. Third, to improve the ability of independent innovation.

In addition, there are eight studies on the success of South Korea and China (Zhang, Yi and Liu, 2006). Based on the literatures of the main periodicals in China, the authors have carried on the thorough inducement and the process analysis to the successful technology catching in South Korea and Taiwan. They pointed out that the insufficiency of the current literature is that the research is not close enough to Chinese national conditions, an empirical study on the effect of research and independent innovation. Localization research as an important part of national strategic management, independent innovation is also one of the main contents of strategic management.

Thirdly, after taking China as an example, the BRIC countries are the third sub-theme. A total of 12 on the four countries and catching-up has been identified. In this paper, we discuss the current research situation and future research direction by literature analysis method. In the end, the literature analysis of the theory of catching-up has also received some attention, especially on the imitation of the study of the latecomer countries. It is worth noting that we have not found the "analysis of how developing countries really achieve technological innovation" by searching. And in view of the importance of independent innovation to the development of a country's technology, it may

be a future research direction.

## FINDINGS

China has plenty of domestic scholars studied the theory of catching-up at national level. And there are also many international scholars from the 20th century, such as 1960s, or even earlier stage, beginning to study how to utilize latecomers advantages to achieve catching-up with the country.

Policy is a very fundamental element to promote countries catching-up, no matter developed nations or developing countries. Some scholars (Yang, 2006; Zhang, 2011; Jia, 2014) have employed theoretical and empirical analysis and pointed out that when the industry or firms plan to develop, government support is positively affect them. Moreover, the policy they made for industry or firms help them enlarge operation market, attract more resources and even promote them to innovate their own technology. Other scholars (Odagiri and Goto, 1993; Fagerberg and Godinho, 2004) conducted empirical analysis to state that the government implement effective policy interventions can help to keep track of future technological trends and promote coordination between industrial and research institutions. And there is no doubt that the government's export-oriented strategy has played a key role in catching-up. Finally, to speed up the improvement of the policy system to encourage innovation to create a national industrial value chain high-end part as the core of the global value chain.

Technology is also an essential element in catching-up process. It is a comprehensive factor which include transfer, absorption, digestion knowledge from others, and then develop own skills. Some scholars (Guo and Wang, 2004; Sheng, 2009; Zhang, 2012) examined the cases of Japan, South Korea and others, holds the view that technology is the first productive force for lagging-behind countries. After technology development, market has opportunity to be extended, and the system updating will improve the efficiency of production. And others (such as Gerschenkron, 1962; Cavallaro and Mulino, 2007) hold the view that that the more the country can absorb foreign knowledge, at the same time rely on foreign technology to improve their own capability, the more the competitive ability to receive goods, as well as long-term revenue growth rate they can obtain. Some other

scholars (such as Park and Lee, 2006) analyzed the technology from Taiwan and South Korea through patent data. These authors summarized that catching-up is more likely to occur in those technologies with short technical cycles. Moreover, the actual speed of catching-up depends on whether the technology is exclusive and whether the knowledge is available.

Apart from policy and technology, resources play an important role in countries catching-up. For instance, human capital, assets, location are all included in resources. Some Chinese authors (such as Zou and Dai, 2003; Lee, 2005; Sun and Gao, 2010) state that wage level as well as location has the ability to attract human labour. Zhang (2012) points out that the implementation of strict intellectual property protection policy is more conducive to technological progress. Lin (2010) shows that the establishment of the growth track is directly related to the new environment in which the development strategy of high growth is pursued. Wang and Wang (2015) studies the national innovation and development strategy in global economic relations. This author advises that there are four aspects that need to be considered when innovation is a national strategy: the international environment, the dominant organization, the capital, and the social support.

Developing countries consider the developed countries as the standard to develop their own countries' policy about catching-up. It starts with the introduction of technology from developed countries, and then do absorption after the imitation and diffusion analysis. We can understand that the latecomer countries or regions have a strong late advantage. As a result, it is very important for latecomers to use their own resources, through learning ability and absorptive capacity to cultivate their own technical capacity to achieve technical and economic catching.

To sum up, although in stable economic relations, the latecomer countries such as China, it is not easy for them to undertake catching-up strategy. But it is easier for the backward countries than many advanced countries to progress in the innovation system and innovation technology. In the short term, the imitation of technology does improve the backwardness of the technology base in lagging-behind countries. However, from the long-term development, the simple imitation is not

enough to support a continuous technological upgrading and social progress of a country. As a consequence, if we would like to achieve truly technological catching-up, we must digest and absorb the technology from advanced countries. And then based on our domestic conditions and social resources, latecomer countries can create the endogenous innovation capacities.

### DISCUSSION

This study reviews prior research about catching-up strategy in developed countries and developing countries. Based on the review analysis, we find that since developed countries have experienced industry revolution in early stage, they have more knowledge and skills for lagging-behind countries to learn. Policy, technology and resources are three factors, which can promote developing countries to catching-up. By the way, in the early stage, advanced countries also accomplish catching-up by these three factors. In addition, we think there are interrelationship among these three factors that could promote catching-up more efficiency. What's more, it is a necessary condition to achieve innovation leadership, based on national innovation - strengthening policy, financial growth and human resource development (Furman and Hayes, 2004).

### CONCLUSION

This study shows that the vast majority of developing countries have not been able to imitate the development of innovation and access to universal and long-term technological upgrading or economic growth. Because when these developing countries focus on imitating, they ignored the good combination of national conditions, the economy situation and the social resources. In Southeast Asia, South Korea and Taiwan are the areas (in addition to Japan) which have a very successful strategy in technological catching-up. These nations highly focused on building their own innovative capabilities, knowing their own national advantages, and according to their own advantages to catching-up, based on the technology. In contrast to the BRIC countries, the lack of better strategy to catching-up, resulting in the process of catching-up will fall into the "catching-up trap" or even catching-up failure. As a matter of fact, the so-called "appropriate technology", varies from country to country. For instance, the same technology in

the countries such as United States, Germany and Japan, may be appropriate. But for relatively weak technology such as China and India, these technologies may be not appropriate. As a result, the developing countries should be based on national conditions to create their own technology, in order to achieve technological catching-up. In this paper, through literature analysis, we can draw a conclusion that the developing countries should pay attentions to their own advantages and to establish capacities in order to finally succeed in catching-up.

Last but not the least, developing countries should coordinate the overall situations of domestic and international, and adhere to open the door to engage in construction, make full use of domestic resources, markets, systems and other advantages, pay attention to domestic and international economic linkage effect. After all, a healthy and sustainable economy will provide more opportunities for enterprises. In addition, it will also open a new investment space for foreign enterprises to provide new cooperation platform. What's more, insisting "Industry 4.0" as a benchmark for Chinese manufacturing industry is an optimal option to accomplish catching-up.

There are some drawbacks of this study. At present, the literature analysis method has been widely used in the research of management accounting in China. But it is limited to objective conditions. What we did is a in-depth analysis of the literature according to a few selective keywords. Other elements, such as the citation, reference literature and other aspects of analysis, should also be extended from the basic analysis.

Our study also has practical implications. For managers, after the digestion and absorption of advanced technology emerged from developed countries, it is important to know the time and conditions from imitation stage to switch to independent innovation stage. Managers should understand that it is a very difficult but necessary step, in order to successfully transfer to a new stage. Meanwhile, it is very important to improve the level of human resources, develop a strategy that is in line with the national conditions of the country and well utilize the social resources according to the national economic situation.

For policy makers, the government should enter the new stage of technological development. In particular, government officers

should pay attention to build the capabilities aiming innovation. When formulating and implementing government policies, capability building of companies play a vital role in their strategy. Government should improve the existing fiscal policy and financial policy to encourage enterprises to engage in independent innovation and endogenous innovation, and finally go beyond the imitation innovation to the inefficient technological catching-up.

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