

Review on the technical catch-up paradigm

Xinyu Zheng

School of Economics and Management, Guangxi Normal University, Guilin, China

Abstract

Technological innovation plays an increasingly prominent role in the process of economic development, and it should be based on technological innovation in developing the catch-up strategy. On the basis of sorting out the existing technology catch-up path, and according to some cases of domestic and foreign technology catch-up, the general mode of late-development enterprises and countries in the process of catch-up technology catch-up, that is, early jump-middle follow-later creation. The whole catch-up process should take learning, digesting and introducing technology, improving technical ability and enhancing independent innovation ability as the main line. Whether the path jumping, path following or path creation technology catch-up path can only become part of the whole catch-up process.

Keywords

Later-developing countries; Catch-up strategy; technical innovation.

1. Introduction

With the deepening development of economic globalization, the economic ties of the world are increasingly close, and the production place and market are increasingly unified. Therefore, developing countries gradually lose their comparative advantages of labor force and raw materials in the process of economic development. Throughout the economic development of developed countries and the development experience of leading enterprises, the position of technology is increasingly prominent in the process of economic development. Therefore, the latecomer countries and enterprises should also change their development strategies and take mastering cutting-edge technology as the focus of catching up. Based on this, this paper summarizes the backwardness countries and enterprises in the process of catching up with common pursued strategy of general law and applicable conditions, and puts forward the early jump-follow-late-creation or early follow-jump-late-creation after path, in order to provide reference for backwardness countries pursued strategy formulation and adjustment.

2. Concept definition

2.1. The concept of technological innovation

In his early book on innovation economics, *The Theory of Economic Development*, Schumpeter defined innovation as a new product or process, a new organization, a new source of raw material, or the commercialization or industrial application of a new product. According to Schumpeter's point of view about innovation, the rise of the early European workshop handicraft industry is a kind of product production process innovation, the product production process based on the division of labor, through the responsible for each process production of workers set in a fixed place, shorten the distance of each process in space, save the transportation time, improve the production efficiency.

The "Technology window" refers to the emergence of new technologies or fundamental innovations. From the perspective of the concept of "technology window", technology innovation, technological innovation can be regarded as a technological invention from zero to

1, from nothing to some. The steam engine invented by Watt in the first industrial revolution and the invention of electric power in the second industrial revolution can all be regarded as a fundamental innovation.

3. Research and review of the impact of technological innovation on enterprises and countries' catch-up

The starting enterprise and the starting country are divided from the perspective of a certain product or technology, and have obtained a certain market position. The enterprise that develops a certain technology or product and occupies the market is the first enterprise; adopting a certain economic development mode or creating an economic development, promoting the economic development and surpassing other countries are the first country. The pioneer enterprise or country is often the first developer of a certain product or technology paradigm, but the latecomer enterprise or country may also develop a new technology track and produce a new product to catch up with the pioneer. Generally speaking, the pioneer of the pioneer often follow the three path, one is the following of the pioneer technology track, through the introduction, learning, digestion, innovation, master the core technology, speed up the process; the second is to open up a new technology track, develop a new economic development model, realize the pioneer of the path of the technology catch-up model, that is, through the introduction of foreign advanced technology, skip some technology development stage, speed up the process. When the technical limit of the starter appears, it is more desirable for the catch-up to use the second path to catch up, but it also challenges the technical basis of the starter, especially when the technology in the catch-up technology field is highly cumulative. At present, there is relatively little research on the pioneers, most of which focuses on the catch-up, in part because the first mover still occupy a solid market position, and the industrial base has been relatively perfect, and it is relatively difficult to create a new industrial field; however, it is also necessary for us to summarize the successful experience of the first mover and the lessons of being successfully overtaken by the latecomers.

Generally speaking, the success of technical catch-up is the result of the combination of internal and external factors. Miao et al. (2018) summarized external factors into policy environment and technical system; internal factors mainly include the financial system of enterprises, corporate governance structure and collaboration of affiliated enterprises (Nam, 2015). In the process of technology catch-up, late-comer enterprises should not only pay attention to their own independent innovation ability and improve the intensity of independent research and development, but also fully realize the influence of external factors such as foreign technology transfer, transnational flow of technical talents and cooperation among multinational companies.

The development of enterprises that survive the fierce market competition will go through a stage from weak to strong, so it is not to surpass other enterprises in the industry overnight, but needs to go through a long process. In terms of innovation itself, technological innovation is not achieved overnight, but a continuous process, and the innovation of different technical difficulties requires different inputs and risks. Therefore, enterprises need to correctly view technological innovation, in different stages of development, according to their own actual situation to develop innovation strategies in line with the actual situation of enterprises.

3.1. Impact of technological innovation on preemptive enterprises and preemptive countries

In the field of high and new technology, whether an enterprise can achieve a breakthrough in the core technology of product development will directly affect the survival of the enterprise. When the competition in a certain field of technology becomes more and more fierce, the impact

of technological innovation on the market share of preemptive enterprises becomes more significant."In order to take the lead in technology development to achieve economic returns, the market must take the lead in development. Only when the results of technology development are commercialized as soon as possible and introduced to the market as soon as possible, can we prevent followers from seizing the market and bring practical benefits to enterprises." For the first-mover enterprises in a certain high-tech field, these enterprises have more or less occupied a certain market share, so this can lay the market foundation for the technology development of enterprises in the later stage. As long as the existing enterprises make key technological breakthroughs, which can better meet the needs of consumers and win the favor of consumers, it will promote the rapid application of the technology in the already occupied commodity market, and then expand the market share and catch up with the existing enterprises.

For the pioneers, the challenge they face is that because they are the first developers of a certain technology or product, they often have no product production plan and technology development experience for them to learn from before, which tests the independent innovation ability of the pioneer enterprises, and is accompanied by certain risks. Successful pioneers tend to attract competitors and become pursued in their technology fields. For the first enterprises, it is extremely important to improve the ability to predict the technical limit, when the technical limit appears, get rid of the dependence on the existing technical track and open up a new technical paradigm. Because, when the pioneer technology occupies a certain market position, the leader may ignore the potential threat brought by the new technology and resist the introduction of new technology, and tend to tinker with the original technology. If the emergence of the technology occurs, the pioneer will face the threat of being overtaken by the latecomers.

3.2. Technology catch-up path of latecomer enterprises and latecomer countries

In the process of technological innovation and economic development, the preemptive enterprises and the preemptive countries not only provide successful experience for the latecomers, but also summarize the lessons of failure. It is extremely important to learn and summarize these lessons for the latecomers.

"In the early stage of catching up, high-tech enterprises should generally choose to imitate innovation strategies first." First, because the high-tech enterprises have limited capital, lack of professional technical development team, so the ability to resist risk is weak; and imitation innovation is a gradual process, covering the introduction, digestion, absorption, innovation four links, more conducive to solve the start-up in the high-tech field. In addition, in the introduction link of imitation and innovation, the late-development enterprises can selectively skip some stages of technological development, reduce the investment in outdated technologies, and speed up the process of catching up. With the continuous development and integration of technology, the technological, industrial and scientific foundations needed to create new industries have become more complex, which further precludes the possibility that the underdeveloped countries can catch up by creating new industries before they master the existing technologies. Therefore, for the contemporary developing countries after World War II, learning from existing technology becomes an overwhelming content of technology catch-up. Therefore, for late-developing enterprises, the first step in learning existing technology is often to directly introduce an advanced technology achievement. This could reduce corporate investment in outdated technologies, ease financial pressure, and speed up the catch-up process. In the early stage of reform and opening up, in order to improve the backward state of communication equipment, China introduced the most advanced digital programmer switch, and successfully developed the HJD 040,000 digital programmer switch. Moreover, "the

successful catch-up of the communication equipment manufacturing industry shows that the weak cumulative technology track is easy to leapfrog. And the cumulative technology track is suitable for gradual innovation, and the latecomer is very difficult to surpass." Therefore, when choosing the high-tech industry they want to enter, they should fully consider the strength of the cumulative accumulation of technological products in the industry, that is, the size of the technical difficulty. The greater the technical difficulty, that is, the stronger the technology accumulation of industries, the higher the entry barrier of the latecomer enterprises, and the greater the difficulty to catch up in the later stage. Cohen and Levintha (1990) also believe that the size of the technology gap is inversely proportional to the possibility of catching up, and that it is too big to catch up. However, there are options if latecomers or some developing countries are determined or have to enter some industries with strong technology accumulation. "Korea's rapid and successful catch-up in D-RAM technology also takes advantage of the late developing enterprises, skipping some stages of technological development through the "technological transition", reduces the investment in backward technologies, and directly introduces the cutting-edge technologies of the first countries, so as to achieve rapid catch-up." Therefore, whether it is a strong cumulative industry or a weak cumulative industry, "technology transition" is a good catch-up path for some latecomer enterprises or developing countries. However, this catch-up is still on the same technical track, at least in the early stage. Moreover, "the premise of adopting the path-jump is that the leading enterprises does not mind technology transfer". Because once blocked by foreign technology, through the "technology transition" to speed up the catch-up of the path will be blocked, at this time we have to find a new path to catch-up. On the one hand, the South Korean government successfully developed the CDMA system without the high-intensity independent innovation of South Korea, and also benefited from the core technology introduced from Qualcomm company in the United States in 1991. Moreover, before South Korea successfully developed MSM chips in 1997, the MSM electronic chips all relied on imports. Therefore, while the introduction of technology, it is more necessary to strengthen the learning and absorption of technology, improve the ability of independent innovation, and avoid the generation of technology dependence, so as to prevent the negative impact brought by the blockade of the technology of the late starter.

When the latecomer enterprises choose to imitate the strategy in the early stage of catch-up, if they do not pay attention to the learning and digestion of the introduced technology in the later stage of pursuit, form their own technical ability and improve their own technical foundation, it is easy to rely on the introduced technology and fall into a vicious circle of "backward-introduction-re-backward-reintroduction". And studies by Perez (1997), Kokko (1994a, 1996b), Lapan and Bardhan have shown that the ability of later developing countries to absorb advanced technologies from developed regions is affected by the accumulation of past technologies. They believe that the effectiveness of imitation strategies will be influenced by the technical foundation, technology accumulation and the technical ability to learn to imitate advanced technologies. Therefore, latecomer enterprises or countries should pay attention to technology accumulation and improve their own technical ability from the first introduction and imitation of the introduction of technology.

Late-comer enterprises in the process of chasing can not only adopt follow type or jump up strategy, should fully consider the internal and external factors, consider the early follow-jump-late creation or early jump-middle-late creation catch up strategy, a series of catch up case has proved the feasibility of the two patterns. Because following is a process of learning, digesting and forming their own technical ability, if only following, the late mover will never catch up, and if the creative path is adopted in the early stage, the technical difficulty is high for the risk, especially when the existing technology is far from reaching the technical limit; and the adoption of the jump catch-up path needs to consider the availability of external technology. After jumping through some stages of development, it often takes some time to learn and digest

the introduced technology, rather than immediately over-reaching the later creative stage. In addition, Lall (1985) and others believe that the technology spillover in production and processing technology is relatively obvious, but there are reservations in deeper technology transfer. In other words, the developing enterprises will not transfer the most core and most advanced technology to the later developing countries for the need of self-protection, which means that the leaping catch-up path is still limited. Both the early jump-middle follow-late-creation or early follow-middle jump-late creation, or Lee route creation, jumping or route, follow and jump are only part of the whole process, rather than all, and could not be the whole process, and, "Lee and Lim stage leapfrog pursued is essentially a special form of path after" Because these two models are still on the same technical track as the pursued person. Therefore, neither follow nor leapfrog can be the last step in a successful catch-up. Therefore, it can be concluded that whether the independent innovation ability can be cultivated in the whole process becomes the key to determine the success or failure of the later catch-up. It can be seen from the CDMA mobile phone system independently developed by South Korea, in the whole process, there are both the introduction of core technologies from Qualcomm companies in the United States, and also the implementation of independent innovation. Perez and Soete (1992) showed that for the catch-ups, introducing the technology during its infancy and maturity is the most suitable opportunity to catch up.

"Technological progress can be roughly divided into continuous technological progress and discontinuous technological progress. The continuous technological progress is still limited to the original technological paradigm, and the technical principle is still improved on the original technological track, while the discontinuous technological progress breaks through the original technological paradigm and opens up a new technological track." The continuous technological progress prefers the continuous self-improvement on the basis of the original technology, which can be understood that from 1 to 100, a process from imperfect to perfect, from simple to complex; and the discontinuous technological progress is a revolutionary breakthrough for the continuous technological progress, which breaks through the original technological track and eliminates the original technical paradigm, from 0 to 1, from nothing. In the technical paradigm of non-smartphone, the continuous improvement of non-smartphone operating system can be regarded as a continuous technological progress, and the continuous technological progress is just a new technological track different from non-smartphones. The change of smartphone technology paradigm compared with non-smartphone is a discontinuous technological progress. Any kind of technology is continuous development and continuous improvement, but "the technological progress of any technological track will be limited by the laws of nature, which makes the ultimate limit of technological development appear. In other words, there are technological limits in the development of technological tracks." The emergence of a technological limit is a threat to the enterprises using this process. First, the emergence of technology limit will lead to the emergence of the development bottleneck of high-tech enterprises; second, those high-tech enterprises are limited by the technology track, due to the technology dependence, which will create favorable entry opportunities for the enterprises. The entry of latecomer enterprises is to take advantage of the discontinuity of technological progress. If the late-development enterprises can timely explore the emergence of the limits of technology, open up a new technology track, and develop a new technology products, they can occupy the advantage. The elimination of smartphones from non-smartphones is the result of competition between two different technology tracks. MOTOROLA and Nokia were eliminated not because they made mistakes in their own development process, but because the latecomer enterprises opened up a new technology track, produced smartphones that can better meet people's needs, and seized new development opportunities, which led to the decline of the former.

The landmark inventions in the first industrial revolution, such as steam locomotive and Jenny spinning machine, were all masterpieces of the peak of the development of craftsman technology. The craftsman technology under the apprenticeship became the most advanced technology in the world at that time, and Britain also became the world overlord with its advanced craftsman technology. In the second Industrial Revolution, the discovery and wide application of electricity broke through the limit of craftsman technology in the first industrial Revolution and became the most advanced productive force in the world at that time. Therefore, the United States and Germany surpassed the United Kingdom. Craftsman technology and science can be regarded as two different technological tracks, and virtue's catching up with Britain is in essence the science's catching up with craftsman technology. Therefore, the limit of technology determines the limit of productivity. The third Industrial Revolution once again promoted the great development of the world economy with the invention and application of atomic energy, electronic computers, space technology and biological engineering. Facts have proved that all those countries that seized the opportunity of the industrial revolution have achieved catching up with other countries in economy and achieved remarkable achievements. From a macro point of view, the development route of the three industrial revolutions is three different technological tracks, and these three technological tracks present a progressive step relationship. Therefore, "in the new era of the technological and economic model, all countries are new players, which creates opportunities for backward countries to catch up." Although the emergence of a new technological and economic model will provide opportunities for the latecomers to catch up, if the technical foundation of the latecomers is very weak, the latecomers are also difficult to seize the favorable opportunity to catch up. Similarly, when the pioneers who have accumulated a strong technical foundation seize the opportunities brought by the new technical model, they will widen the gap with the laggards. The third technological revolution occurred in the United States, rather than in some countries in Asia, Africa and South America, largely because the United States, as one of the initiators of the second Industrial Revolution.

In the 1960s, when South American countries' disposable income was more than twice as much as South Korea, studies found that they paid special attention to the cultivation of technological innovation ability and investment in education. Since 2000, the number of patent applications in South Korea has reached more than 5,000, and the R & D expenditure accounts for more than 2.5% of GDP, far exceeding the hundreds of patent applications of South American countries every year. The high intensity of R & D investment in South Korea has rapidly boosted the country's economy. Therefore, the technological innovation achievements brought by high intensity R&D investment are extremely important for the catch-up of the later countries, which should increase the investment in education and lay a talent foundation for technological innovation.

4. Technological innovation and catch-up of China's chip industry under the state of technology blockade

In the process of catching up with leaders, late-comer enterprises will be affected by many factors, which can be summarized as the technology window, demand window and system window in the "window of opportunity" theory. In the last century, the United States, Japan, South Korea, Europe and Taiwan in the semiconductor chip field have proved that the success of the latecomers to the leaders is often the result of the coordination of three factors: technology, demand and system. Moreover, the higher the technical difficulty of the catch-up field, the greater the challenge to the collaboration between government and business.

4.1. Make full use of the demand window created by the super-large market

At present, the United States is the world's strongest science and technology innovation center, while China is the world's largest market. If any technology product loses the market, it will lead to the rupture of the capital chain, which will cause the shortage of R&D funds, restricting further technological innovation. The US high-pressure policy on Chinese technology will make the US lose the irreplaceable huge market of China. Once it loses the Chinese market and finds no new market in the short term, the high-intensity R&D expenditure of the US will not be sustainable, and it will be difficult to maintain its technological advantage for a long time. Therefore, although the United States technology blockade policy in the short term will make the normal operation of Chinese enterprises in trouble, but also to the development of domestic technology to create market opportunities, may improve market share and income, make more money back to research and development, into the "market-development-iteration, greater market" of the virtuous circle, finally achieve domestic alternative. Also because of this, we must reduce the dependence on foreign markets, actively explore the domestic market, give full play to the size of our large market advantage, for the development of key industries in our country to win market opportunities, to minimize the foreign technology blockade policy adverse impact on our country enterprises, make more money can be used to improve the independent innovation ability. The reason for actively developing the domestic market is also because our technical level limits our opportunities to enter the foreign market.

4.2. National industrial policies will help to open the institutional window

The US technology blockade of China in the chip manufacturing technology in the short term, because the technology accumulation of chip manufacturing technology is very high, and before that, China relied excessively on chip imports, and the technical foundation of chip manufacturing is very weak. In the face of this situation, China's chip manufacturing enterprises need to start from imitation innovation on the one hand, on the other hand to improve the ability of independent innovation. "To this end, we can learn from the successful experience of South Korea in CDMA mobile phone system innovation. In 1989, the South Korean government listed the CDMA system as a national development project, and in 1991, it introduced the core technology from Qualcomm company in the United States to develop its own system. Under the efforts of the South Korean government, CDMA was officially listed as a national telecommunications standard in 1993, and through a series of innovative efforts, most of the core chips of CDMA mobile phone were basically realized in 1999. The reason why the South Korean government chose a different path of technological innovation is that it realized that with the ready-made European TDMA (GSM) system, South Korea would never catch up with the leaders, and the gap would only widen." his and our country in mobile phone chip development technology problems are similar, if our country enterprises have been relying on mobile phone chip imports, adopt the European and American countries telecommunications standards, do not develop their own telecom standards, we will never be able to narrow the gap with Europe and the United States technology, and our country faces in mobile phone core chip technology blockade, only through independent innovation to narrow the gap with the technology leader and the United States. While chip manufacturing technology has strong accumulation, high development cost and high risk, it is too difficult to achieve technological breakthrough by a single enterprise. Therefore, in the field of chip manufacturing, we can vigorously promote the merger of enterprises to form a group of large enterprises with high technology level and strong innovation ability, so as to improve the efficiency of resource utilization.

5. Summary and outlook

This paper summarizes the concept of technological innovation, on the basis of the previous latecomers pursued case summarized more in line with the actual pursued mode, namely early jump-mid-follow-late creation or early follow-middle jump-late creation technology pursued path, and for the difficulties in the chip technology combined with opportunity window theory gives practical Suggestions. Only by accurately defining the concept of technological innovation, clarifying the mechanism of technological innovation in the process of catch-up and the conditions needed to be met, can a practical catch-up strategy be formulated.

Technical catch-up is a complex process, but it presents certain rules. Exploring and following these rules is an extremely necessary work for the latecomers to formulate the catch-up strategy. Starting from the characteristics of the technology itself, it is extremely important for both the first mover and the pursuers, to realize the limitation of the technical track, strengthen the technical early warning, and improve the cognitive ability of the technology to the technical limit.[4]However, the successful catch-up should not only consider the regularity of the development of the technology itself, but also fully realize what the latecomer countries and enterprises should do in the process of catch-up.

References

- [1] Hong Yong, Su Jingqin. Research on industrial technology catch-up mode in late-developing countries, *Science and Science and Technology Management*, Vol. 29 (2008) No.12, p.18-23.
- [2] Jen Fagberg, David C. Morley, and Richard R. Nelson: *The Oxford Handbook of Innovation*, Oriental Publishing Center, (2021), p.296-298.
- [3] Chen Liu, Zhang Nianhua. Summary of the theory and practice of catch-up countries, *Discussion on Modern Economy*, Vol. 481 (2022) No. 01, p.26-34.
- [4] Yang Delin, Chen Chunbao. Imitation innovation independent innovation and high-tech enterprise growth, *Soft Science of China*, (1997) No. 08, p.105-110.
- [5] Amsden A: *The Rise of "the Rest": Challenges to the West from Late-Industrializing Economics*, Oxford University Press, (2001).
- [6] Lin Min, Wu Guisheng, Xiong Hongru. Research on the enlightenment of technical orbit theory for latecomer catch-up, *China Science and Technology Forum*, Vol. 209(2013) No. 09, p.13-19.
- [7] Cohen, Levinthal. Absorptive capability: a new perspective on learning and innovation. *Administrative Science Quarterly*, (1990) No. 35, p.128-152.
- [8] Lei Xiaomiao, Li Yang. Technology catch-up and leap-forward development of high-tech industry- Literature review and research outlook, *Industrial technology and economy*, Vol. 38(2019) No.02, p.145-152.
- [9] Lall, S. *Multinational, Technology and Exports*, Macmillan, (1985) p. 53-66.
- [10] Zhang Jing. *Theoretical analysis and model discussion of technology leap-Also-On the practice of technology leap in China*, Fudan University, (2004).
- [11] Li Gen, *Golden Chrysanthemum*, Park Guanghai. Catch-up, surpassing, backwardness and Asian development model of Asian countries, *Foreign Social Sciences*, Vol. 313 (2016) No. 01, p.114-122.
- [12] Lan Xiaohuan. "In the Inside." , *Trade Union Expo*, Vol. 876 (2022) No. 03, p.52.
- [13] Jia Jia, Ji Dengke, Wei Guoping. Research on the Korean technical catch-up paradigm and its reference in China, *Scientific Management Research*, (2006) NO. 01, p. 117-120.