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Research on the Phase of Capability Rising of China's Advanced Manufacturing Enterprises

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Abstract

Based on the perspective of technological catch-up, this paper explores the stage characteristics and division of the technological capabilities of China's advanced manufacturing enterprises. An exploratory vertical single case study method is used to analyze the technological catch-up process and stages of technological capabilities of Huawei Technologies Co., Ltd. The enlightenment of the phase division of the advanced technological capabilities of China's advanced manufacturing enterprises. The research found that the technological capabilities of China's advanced manufacturing enterprises can be divided into four stages in order: experience learning, exploration and research, independent research and development, and technological leadership. Each stage can be leaped step by step or can be stepped across. This article provides development ideas for the technological catch-up of Chinese enterprises, and enriches the connotation of the technological catch-up theory of enterprises in the developing economies.

Keywords

Advanced manufacturing enterprises; technological catch-up; leap in technical capabilities; vertical single case.

1. Introduction

The asynchronous development of the global economy and technology has made catching up and surpassing an important topic that has received widespread attention [1]. From a long-term perspective, late-developing companies rely on late-moving advantages such as low cost, low risk, and high flexibility It is a relatively common phenomenon to achieve technological catch-up of leading companies in the industry [2,3]. From the perspective of micro-technology catch-up, technology catch-up often goes through three stages: strategy and resource preparation, rapid catch-up and surpassing [4]. In the transcendence stage, the technology of the late-developing companies is close to the international frontier, but the marginal rate of convergence of the late-developing advantages and the gap in the technology gap have dropped significantly, and technology catch-up has fallen into a bottleneck period [5]. In order to explore the possible path to break through this bottleneck, some researchers have explored from an industry perspective whether different attributes of industrial technology characteristics provide different transcendence spaces or longer time windows for catching up, and find that when transcendence occurs in the dominant design Immature industries with high uncertainties in technology development trajectories such as advanced manufacturing [6], catch-up enterprises can better achieve technological catch-up of leading enterprises in the industry through the phased leap of technological capabilities [7]. In fact, China ’s high-speed rail, Hikvision, Huawei and other advanced manufacturing companies are precisely because they have seized the window of opportunity in the non-linear industrial technology iteration [8], fully applying the technical discontinuity and the interactive drive of institutional markets Efforts have been made to improve the technological capabilities of enterprises to get rid of the

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low-end lock-in of global value chains [9], and jumped out of the "technology catch-up trap" of "introduction-backward-re-introduction-then backward" [10].

In fact, many studies have noticed that advanced manufacturing may be one of the best choices for Chinese companies to achieve technological catch-up under the circumstance of technological transcendence, and the enterprise resource base, innovation strategy, and business model of advanced manufacturing under the constraints of the catch-up mission The interaction of such factors as how to promote the convergence of technological capabilities to the international frontier has been discussed in depth [7]. These studies have found that the technological capabilities of advanced manufacturing companies have leapt. At the same time, it is pointed out that this leap in capabilities may be an important promoter for companies to achieve market breakthroughs and value chain climbs. It is also a key condition for their advanced layout of high-level technology and creation of catch-up paths]. Most studies have given positive answers to the question of whether the leap in technological capabilities can help advanced manufacturing companies break through the technological catch-up bottleneck. They believe that the leap in technological capabilities of enterprises can provide them with strong internal motivation and positive external conditions. Then promote the realization of enterprise technology catch-up [11,12]. However, there are no clear conclusions on issues such as the recognition of the phase characteristics of Chinese advanced manufacturing enterprises in their technological catch-up. Based on this, this article selects Huawei as a sub-sample of a vertical single-case analysis, traces the complete process of the company's technological catch-up, and summarizes the four stages of its technological capability development, as well as the technological capabilities of the company in each stage of production, investment, and The specific performance in three dimensions of innovation leads to the fact that the technological capabilities of enterprises in China's advanced manufacturing industries may undergo similar stages of leaps and provide theoretical support and practical suggestions for companies and governments to formulate relevant development strategies and guiding policies.

2. Theoretical Basis

The leap in technological capability of advanced manufacturing enterprises has certain stage characteristics. How to identify the technological capability stage of an enterprise through its specific performance in various dimensions is an important part of an enterprise's technological catch-up [12]. In response to this problem, some scholars have divided the three stages of experience, search, and research in turn according to the specific performance of the company's technological capabilities in the three dimensions of production, investment, and innovation [13]. The process from low to high stages is Leap for the technological capabilities of enterprises [14]. Some scholars also summarized the experience of China's high-speed rail technology catch-up process, and divided its technical capabilities into experimental exploration stages based on independent research and development, independent innovation-oriented technology introduction stages, positive design capability formation stages, and independent intellectual property rights and China's high-speed rail standards. The construction phase [15]. However, this division only takes the development trajectory of China's high-speed rail industry as the object of discussion, and the explanation of the leap in technological capabilities of the entire advanced manufacturing industry is not convincing enough. Coupled with the imbalanced development of advanced manufacturing enterprises in China, the technological capability stages of different enterprises are quite different. It is of great practical significance to incorporate this difference into mathematical models for specific and classified discussions. Therefore, based on the review of the technological capability evolution literature of late-developing enterprises in recent years, this article uses Huawei Technologies Co., Ltd. as a case object, analyzes its technological catch-up process in depth, and

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concludes the various stages of the enterprise's technological capability leaps. The leap-forward mechanism and path selection of technological capabilities of advanced manufacturing companies provide realistic evidence.

3. Research Methods

The vertical single case analysis method is most suitable for situations that have not been fully understood, and when "contextualization, vivid description, dynamic construction, and human values" have a significant impact on research [16]. The purpose of this article is to explore the periodical changes and leap-forward mechanisms of the technological capabilities of China's advanced manufacturing enterprises. Whether this evolution phenomenon exists and how it behaves is affected by many endogenous factors and external environment. In order to sort out the logical direction, we need vivid and concrete case presentation to guide the research ideas and enrich the construction of subsequent models. Therefore, the vertical single case analysis method has strong applicability.

4. Case Selection and Analysis

4.1. Case Object Selection

Based on theoretical requirements, this article selects Huawei Technologies Co., Ltd. as the sample enterprise. On the one hand, China is the main manufacturer of communication equipment and related services. It ranks sixth among the top 500 global electronic technology companies. It is a leading company in the new-generation information technology industry in the China Made 2025 plan and a representative of China's advanced manufacturing industry. On the one hand, Huawei ’s late catch-up process is complete and it has finally achieved technological catch-up [17]. Its technological capabilities have undergone significant changes in stages, which better fits the research theme of this article.

4.2. Case Analysis and Findings

4.2.1. Huawei's Technology Overtaking Process

(1) Accumulate original resources and promote technological progress (1988-1997). Since its founding in Shenzhen, Guangdong, in 1987, Huawei has started as a sales agent for a Hong Kong company that manufactures private branch exchanges (PBXs). After facing the huge domestic market, it was disadvantaged by several major companies such as Ericsson, Nokia, and Panasonic Under the circumstances, began to develop and launch rural digital exchange solutions. This low-cost and low-price strategy to surround the city on the one hand helps Huawei to quickly seize the market and expand the company's size. It opens the door of Asian, African, and Latin American developing countries at low prices and gradually penetrates into the markets of developed countries. The accumulation of its original resource elements has laid a solid technical foundation for subsequent rapid catch-up;

(2) Exploring core technologies to help catch up quickly (1998-2007). Huawei has hired IBM consultants to carry out process transformation projects for the company since 1998. Through a series of changes, standardization of work processes and modules has been implemented to improve the company's technical capabilities.It has also been established in Bangalore, India, Stockholm, Sweden, and Silicon Valley 12 R & D centers to make full use of the global talent and technology resource platform. During this period, cooperate with 3Com, Siemens, Global Marine, Symantec and other companies to establish joint ventures to comprehensively promote enterprise data network solutions, TD-SCDMA solutions, submarine cable end-to-end network solutions, storage and security products Exploration of core technologies such as solutions. During the ten years from 1998 to 2007, Huawei's sales revenue grew at an average annual rate of 41.79%, achieving rapid catch-up of leading companies;

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(3) Adhere to independent research and development to achieve technological catch-up (2008-2013). The company submitted 1,737 PCT patent applications in 2008, ranking first in the list of patent application companies (persons) published by the World Intellectual Property Organization. In terms of R & D investment, Huawei has always insisted on investing in research and development at a cost of not less than 10% of sales revenue, and used 10% of R & D investment for research on cutting-edge technologies, core technologies and basic technologies. Since 2008, the company has increased The input of R & D personnel has gradually maintained at a high level of 45%; in terms of sales revenue, Huawei surpassed Ericsson for the first time in 2013 with US $ 39.5 billion to become the world's largest communications equipment manufacturer, to a certain extent, it has achieved international leadership Technology catches up. However, it is worth noting that from the change in the year-on-year growth rate of corporate sales revenue in Figure 1 below, it can be seen that due to the constraints of multiple factors such as markets, technology, standards, and trade barriers, the company's sales revenue growth rate has started from 2008 Began to slow down significantly. Until 2013, with the significant increase in the proportion of corporate R & D investment, the establishment of global R & D centers and joint innovation centers, and the accumulation of top-notch talents such as independent R & D, the sales revenue growth rate has gradually picked up. It also confirmed from the side that continuous independent research and development is an important means and way to achieve technological catch-up;

(4) Increase technological innovation and lead the 5G era (2014-present). In 2014, Huawei established 5G innovation research centers in 9 countries around the world, and ranked first in the 2015 corporate patent application rankings with 3,898 applications. The company continues to carry out continuous, stable and high-level R & D investment. As of January 2019, Huawei has joined more than 400 standards organizations, industry alliances and open source communities, and actively participated in and supported the formulation of mainstream standards to lead industrial technology innovation. At the same time, the company is also committed to investing in basic education to help cultivate local ICT talents. As of the end of 2018, Huawei 's flagship corporate social responsibility project "Seeds of the Future" has sowed seeds of hope in 108 countries and regions. Excellent university students from all over the country came to visit and study at Huawei headquarters. It is this forward-looking and sensitive perspective that lays out the future in advance, and unswervingly adheres to active technological innovation, which enables Huawei to withstand the huge pressure of survival to adapt to the complex and changing external environment, and finally achieve the late catch-up and technology leadership.

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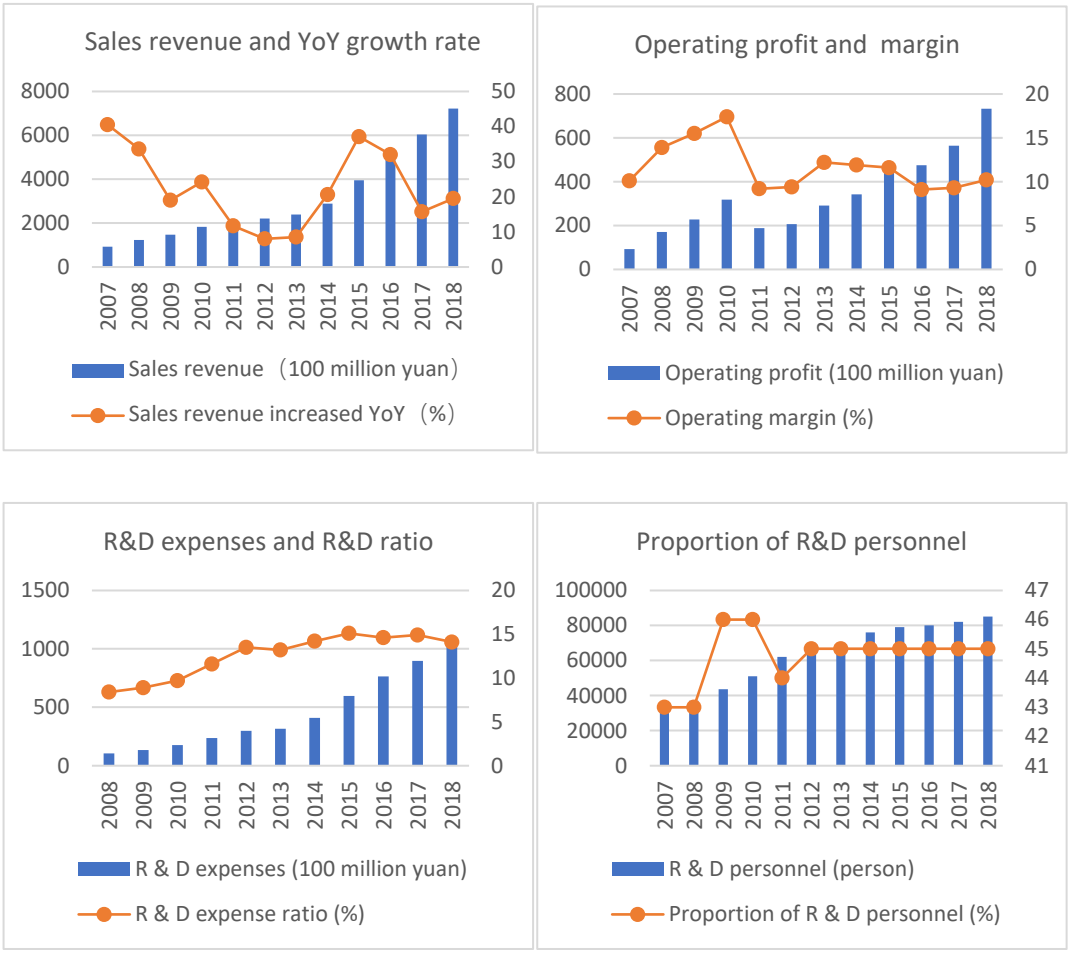

Figure 1. Huawei Technologies Co., Ltd.'s sales revenue and R & D investment from 2007 to 2018

4.2.2. Huawei's Technical Capability Phase

According to the above-mentioned Huawei Technologies Co., Ltd.'s technological catch-up process and the company's specific performance in three aspects of production performance, investment capacity, and innovation results, we explore the progress track and phase change of its technological capabilities. We find that it can be mainly divided into experience learning , Exploration research, independent research and development and technology leadership, of which the first three stages are consistent with the existing research on the three-stage division of the evolution of technological capabilities of enterprises. However, it is worth noting that the transition to independent research and development through active innovation and the subsequent overtaking of leading foreign companies is not the final destination of Huawei's technological capability development. After entering the "no man's land", Huawei is committed to Independent research and development and innovation of core key technologies in the industry, and continued to increase research and development costs and personnel investment, helping its technical capabilities leap to a higher level of technology leadership.

(1) Experience learning (1988-1997). The latecomer disadvantage of catching up with companies makes technology introduction the main way to improve their technical capabilities in the early stages of catching up, and based on this, imitation and experience learning. During this stage, the company introduced a large number of mature foreign products, equipment and technical personnel as its The accumulation of original resources and technologies. Huawei's early product research and development system, sales system, supply chain system, financial system, human resources system, and organizational structure system were mostly designed by foreign leading companies such as IBM, Hay Group, Mercer, etc. This introduction of learning

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enables companies to quickly adapt to the industry Develop and acquire common technologies at lower cost. At this time, Huawei's production scale is small, and most of its employees are ordinary technical workers. It is urgent to introduce high-quality comprehensive technical talents through the partner program, and encourage the company's local employees to attract high-caliber personnel in daily production activities. Learn advanced technology to enrich the accumulation of technical knowledge of enterprises.

(2) Exploration and research (1998-2007). With the rapid development of late-developing economies and the deepening of the internationalization of enterprises, empirical learning will be difficult to sustain the economic growth momentum of late-developing enterprises, so that they will fall into a "technology catch-up trap" similar to the "middle-income trap" and step into the level of technological capabilities. In the exploration and research phase, open innovation has become a powerful weapon for breaking technological isolation. After completing preliminary common technical experience learning and the accumulation of original resources and knowledge elements, Huawei actively expanded the size of the company and set up R & D and training centers around the world in order to improve the technical competence of employees through technology spillover effects. At the same time, the company began to use its existing resources to explore the core key technologies of the industry in advance, and made a large number of patent technology applications;

(3) Independent research and development (2008-2013). Global innovation activities have led to a leap in technological capabilities, and the nature of enterprise technological capabilities has shifted from exploratory innovation that relies on technology introduction to completely independent and independent research and development. Huawei has established joint innovation centers around the world, continued to increase research and development costs and investment in research and development personnel, and used the technical advantages of big data and cloud computing to develop the industry's first 400G DWDM optical transmission system and build a 70,000-scale global The largest desktop cloud service platform breaks through the market monopoly of leading companies and its core key technology bottlenecks with completely independent technology research and development.

(4) Technology leadership (2014-present). After the independent development of the leading companies in the industry, Huawei did not stop taking the initiative to innovate, relying on the establishment of 5G innovation research centers in 9 countries around the world to deploy cloud-based commercialization and next-generation artificial intelligence in advance to achieve ICT Comprehensive catch-up and technical leadership in the field. At this stage, the company established Huawei University to train local professional and technical personnel. At the same time, relying on the popularization of 4G technology and mastery of 5G technology, Huawei's consumer terminal business has developed rapidly. In 2018, Huawei's global shipments of mobile phones (including Honor) exceeded 200 million, ranking first in the world.

4.2.3. Enlightenment from Huawei's Technology Catch-up

From the above discussion of Huawei's technological catch-up process and development stages of technical capabilities, we found that this four-stage technological capability development process including technology leadership or industry standard formulation and the experimental exploration, introduction learning, and forward design of China's high-speed rail There are great similarities with the four-stage technology catch-up experience of the standard system construction. Therefore, by discussing the growth and evolution of Huawei's technological capabilities, it can be imagined that the development of China's advanced manufacturing enterprises' technological capabilities may also go through similar stages. Provide a strong realistic basis for the subsequent model construction and simulation. However, it is worth noting that different types of enterprises in advanced manufacturing may be at different stages of technological capabilities, so the development trajectory of technological

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capabilities and the required incentives and means will be different, so we will consider this situation Incorporate to construct the following hidden Markov model.

5. Conclusions and Outlook

Based on the perspective of technological catch-up, this paper discusses the basic elements and characteristics of China's advanced manufacturing companies' technological capabilities and their phase changes. Taking Huawei Technologies Co., Ltd. as a case study, it is found that: ① The technological capabilities of enterprises can be divided into experience learning, exploration research, Independent research and development and technology lead the four stages. Among them, the division of the first three stages supports the existing research results on the technological capability evolution of Chinese enterprises. The latter stage is based on the case analysis of Huawei's technological catch-up process. New enlightenment obtained; ② Low-level enterprises should accumulate technical resource elements through basic production imitation, and absorb advanced technology and high-quality talents through investment and introduction. At the same time, they can also deploy technological innovation strategies in advance to achieve a staged leap in technological capabilities. ③ Enterprises at the advanced stage should insist on continuous R & D investment and carry out continuous deep core technology innovation and key technology exploration.

This paper still has deficiencies in the following aspects, which need further research and in-depth discussion: ① When measuring the technological capabilities of enterprises, three broad types of indicators, such as production performance, investment capabilities, and innovation results, are used, which limits the research to a certain extent. Breadth and depth. In the subsequent research, we can try to subdivide or expand these three types of indicators. ② This article uses an exploratory vertical single case study method. In the future, we can try to add multiple cases to enhance the universality of the research conclusions.

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