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A Review of Innovation in Chinese Firms over the Last 40 Years: Navigating the Winding Road toward Innovation

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Abstract

In this paper, we review the innovation experiences in China from 1978 to 2018 across four unique stages. Our analysis of these four stages allows us to offer suggestions for future innovation in this country. First, we describe the innovation strategy, innovation performance, and limitations during each stage. Innovation in China was initially motivated by a shortage of food and other necessities of life. The transition from a centrally planned economy to a market-oriented economy created learning opportunities to promote innovation based on absorptive capacity. As latecomers, Chinese firms have endeavored to catch up with innovation leaders from developed countries, with some gaining an innovation-based global competitive advantage. However, most Chinese firms are still lacking in core technology.

Second, we summarize the innovation characteristics of Chinese firms over the last 40 years. Despite their increasing innovation capability, they have just begun their journey toward real core innovation. Most Chinese firms are short of core technology. As cost advantage decreases, more firms proactively invest in endogenous innovation to create new advantages.

Third, we provide suggestions for future innovation practices, academic research, and research policy. In the future, Chinese firms should pay more attention to the innovation ecosystem, digital innovation, and business model innovation. Chinese governments at different levels should make more efforts to build a new ecosystem based on socialism with Chinese characteristics. Furthermore, future academic research should emphasize the unique characteristics of innovation in China and the innovation ecosystem.

Keywords

technological innovation; institutional innovation; innovation stage

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1. Introduction

Since 1978, the reform and opening up policy has greatly promoted China's economic growth, which is recognized worldwide as a tremendous achievement. Families are living happily, freed from the past worries about basic living necessities. In this new era, global competition relies more on technological foundations than on rural materials or the labor force. Sustainability poses new demands for the transition of economic growth. With the increasing intensity of technological competition and pressure of sustainability, innovation has become the central focus for future development.

However, Chinese firms are facing new innovation challenges stemming from the new digital environment, the institutional system with Chinese characteristics, and the turbulence caused by globalization. The characteristics of the new digital environment pose new challenges for innovation theory, causing confusion among firms. Most importantly, as the world's most important emerging country, China has a special institutional system. China's market environment differs from those of both market-centered and plan-centered economies. Innovation in this environment is a new challenge. The Chinese government has also been urged to identify opportunities for future reform and building an innovation system with Chinese characteristics.

In this paper, we aim to provide some insights based on a review of the innovation experience of Chinese firms over the last 40 years. Past innovation practices pave the way for future innovation. Thus, reflecting on past successes and failures can help firms reevaluate their innovation performance and identify new opportunities for future development. First, we review Chinese firms' innovation experiences during the last 40 years (with each defined 10-year period representing one stage). For each stage, we describe their innovation focus, strategy, and performance; review their progress in the innovation research field; and summarize the central economic targets, strategies, policies, achievements, innovation limitations, and innovation research. Second, we evaluate Chinese firms' overall innovation performance and future innovation trends. Based on our analysis of the innovation characteristics of each stage, we make conclusions about the innovation stages and predict further innovation trends. Third, we present suggestions for innovation research, innovation practice, and research policy. The central purpose of our review is to make recommendations for firms, the government, and scholars, offering suggestions regarding future innovation filings, directions, and orientations. To help Chinese firms and governments, we also encourage scholars to do more research on innovation in the Chinese context and make new contributions to the development of general innovation theory.

2. Innovation Characteristics of Chinese Firms over the Last 40 Years

The stages of innovation experiences can be defined in many ways. Aiming to provide suggestions for promoting ultimate economic growth, we review the innovation experiences from 1978 to 2018 based on four key transition stages, each lasting for one decade. The first stage (1978 to 1988) began with the Third Plenary Session of the 11th Central Committee of the CPC, marking the initial attempt to generate more necessities of life by launching the reform and opening up program. The second stage (1989 to 1998) revolved around the learning and absorption of knowledge to improve product quality. The third stage (1999 to 2008) was highly focused on endogenous innovation. The fourth stage (2009 to 2018) was centered on innovation-based competition.

2.1. Stage 1 (1978 to 1988): Overcoming shortages

Scarcity was the main drive for the reform and opening up program and innovation practices. When the reform began, people were experiencing deprivation and serious shortages of food and other necessities as a result of low levels of technology and poor management practices. Given the urgent pressure to increase food, clothing, and other necessary supplies, the program aimed to improve production efficiency.

With the mission of economic growth, state-owned firms relied on management innovation and technological innovation to improve production efficiency. Compared with long-term technological innovation, management innovation can more rapidly improve production efficiency. During Stage 1, most management innovation practices were designed to improve production efficiency so as to reduce shortages of food, clothing, and other necessities of life. In addition to promoting management innovation, the government invested heavily in manufacturing technology by purchasing equipment. However, many firms failed to improve product quality because they were unable to run the equipment with their limited manufacturing techniques and skills.

The primary tool used to improve production efficiency was management innovation. During this stage, private firms were scarce in China, with state-owned firms dominating its overall economic growth. Therefore, the government promoted innovation via a top-down approach, which included providing managers with training in overseas management principles. The State Economic Commission introduced 18 foreign management methods to help firms improve their management, enhance their production efficiency, and reduce shortages (Xu and Qin, 1985). As a result, Chinese firms gradually learned Western management practices, particularly those of Japanese firms.

In addition to a lack of management knowledge, a lack of motivation was a crucial reason for low production efficiency. In state-owned firms, managers and workers received orders from the government without any room to leverage their expertise. To overcome this constraint, the government allowed managers to lease state-owned factories and share the possible benefits. In 1984, Ma Shengli, a mid-level manager, took the initiative to rent the factory in which he was working, Shijiazhuang Paper Mill. Ma received the National Medal of May Day for his management innovation model. In an important attempt to cultivate modern firms, this model was accepted and promoted by the Chinese government. Wang Hai, another mid-level manager, stimulated enthusiasm and efficiency with his "renting model", which greatly improved the production efficiency of workers at Qingdao Doublestar, a state-owned shoe factory. Doublestar is now the only state-owned listed tire company in Shandong Province. It has also become an international enterprise group that integrates tire manufacturing, smart equipment, smart logistics (*e.g.*, robots), and the smart cyclic utilization of wasted rubber. However, although the renting model increased production efficiency, it did not resolve agency problems. After winning contracts to run a factory, some managers attempted to maximize their own profits. This caused short-term agency problems, as this management innovation did not change the ownership of state-owned firms. However, although product quality was low, management innovation did greatly increase production efficiency.

In addition to management innovation, firms performed technological innovation during Stage 1 by importing new manufacturing equipment from developed counties. Due to low investment in technology absorption, many new factories went out of business. Furthermore, given the shortage pressure, customers accepted even unqualified products. Therefore, firms focused on production volume rather than quality, with production orientation rather than customer orientation serving as the dominant

strategic logic of Chinese firms. Only entrepreneurial managers highly prioritized quality. One example was Zhang Ruimin of Haier, originally a refrigerator manufacturer importing production technology from Germany. Although the market accepted unqualified products at the time, Zhang organized the on-site smashing of unqualified refrigerators, demonstrating the quality-oriented strategy and wisdom of entrepreneurs during the first stage.

During this period, innovation was not central to policy making because production volume was the fundamental goal of the reform. The government made great efforts to energize market players, change industrial structure, and overcome shortages. For example, in June 1979, the State Council's *Government Work Report* proposed an "eight-character policy" with the objective of carrying out adjustment, reform, rectification, and improvement to advance the national economy (The State Council of The People's Republic of China, 1979). In 1980, four special economic zones, namely Shenzhen, Zhuhai, Shantou, and Xiamen, were officially established to explore the market economy experience (The National People's Congress of the People's Republic of China, 1980). In 1981, pilot work on firm autonomy was officially proposed. Various economic forms and business methods could coexist for a long time, accelerating the maturity of the market players (The State Council of The People's Republic of China, 1981). In 1982, the Central Committee of the CPC officially legitimized the household economy and proposed to develop socialism with Chinese characteristics (The State Council of The People's Republic of China, 1982). In 1984, China opened 14 coastal cities as pilot cities for economic reforms and proposed the establishment of economic and technological development zones to further stimulate the vitality of the domestic economy. In 1985, the "*Decision Concerning the Reform of the Science and Technology Management System*" was promulgated, emphasizing the promotion of economic development based on the progress of science and technology (The State Council of The People's Republic of China, 1985). In 1986, the "Seventh Five-Year Plan" mentioned industrial policy at the national level for the first time and proposed directions for industrial development (The State Council of The People's Republic of China, 1986a). The government also officially initiated the National High-Tech R&D Program (the "863 Program") (The State Council of The People's Republic of China, 1986b). In the same year, the State Council indicated that state-owned enterprises could use various approaches, such as leasing, contracting, and shareholding for system reform (The State Council of The People's Republic of China, 1986a). In 1988, the State Council expanded the coastal economic opening area to 140 cities (The State Council of The People's Republic of China, 1988). China revised its constitution to affirm the legal legitimacy of the private economy, laying a solid institutional foundation for furthering its development (The State Council of The People's Republic of China, 1988).

The market-oriented reforms encouraged firms to use new management methods. Management innovation and incremental technological innovation among state-owned firms improved their production efficiency. However, some practices also had limitations. For example, renting caused agency problems, reducing the innovation power and motivation of state-owned firms. During this stage, innovation was not the central strategy concern. Firms relied on management innovation and technological innovation mainly to improve the volume of production, rather than enhancing product quality.

Innovation research during this stage was scarce. All academic efforts were centered on the introduction of foreign innovation theory and practices. Furthermore, no academic journals in the field existed. The most popular books were *Foreign Economic Management Masterpieces* (Ma, 1980) and *Management Modernization* (Zhu, 1985). Although management practices were being widely introduced, management research was new during this stage.

However, international journals published many research papers on innovation. Scholars in developed countries were conducting extensive research on management innovation and technological innovation. The topics included technological innovation models, innovation strategy, innovation processes, organization design, and how to profit from technological innovation. Management innovation was another hot research topic. Many notable papers were published during this stage. For example, Teece published a paper in *Research Policy* using a novel framework to analyze profits from technological innovation (Teece, 1986). In the international innovation field, much research was conducted on the innovation adoption decision and innovation theory in services. However, related domestic studies had yet to commence. During this stage, production and manufacturing were the central concerns of management journals. Innovation was not a central research topic in general terms. Most innovation papers were published in journals such as *Research Policy, IEEE Transactions on Engineering Management, Academy of Management Journal, Management Science*, and economics journals. No journal focused exclusively on innovation research.

2.2. Stage 2 (1989 to 1998): Innovation based on absorption and learning

Export growth was the main driver of innovation during this stage. Market-driven or export-oriented growth became the central strategy for economic development. The "market for technology" strategy was vital. To accelerate the technological progress of Chinese firms, China decided to leverage its comparative resource advantage. To leverage the cost advantage and thereby promote export growth, Chinese firms invested in technological innovation to improve production efficiency by learning from foreign firms through joint ventures. Export growth in return imported new technology and competition. Although economic shortages still existed, the strategic orientation began to change from a production orientation to a market orientation. Ultimately, this market orientation hastened the innovation process of Chinese firms as they sought to compete for customers.

During this stage, technological innovation was most important. Two famous entrepreneurs of the time were Zhang Ruimin and Liu Chuanzhi. Zhang proposed the idea of market orientation and performed business process reengineering to improve customer satisfaction. Under Zhang's leadership, Haier became the domestic model of business process reengineering. A customer orientation became the core element of its strategy. "The customer is king" was a popular Haier slogan. Haier's customer orientation enabled the company to grow quickly. Similarly, Lenovo became the top computer manufacturer in China's domestic market under Liu's leadership. The company is now a nationwide high-tech brand based on market-oriented innovation. It originated in a research institute and developed a competitive advantage based on the alignment of technological exploitation and marketing.

The increasing intensity of competition, along with the market-oriented economic transition, forced firms to absorb new technology from foreign firms and research institutes. The market-oriented transition changed social ideology, offering more opportunities in the private economy. Private firms were market oriented rather than planning centered. To compete for customers, they paid more attention to market orientation and technological innovation.

Even more importantly, the Internet industry emerged during this stage. NetEase was established in 1997 and launched a free e-mail service in 1998. Zhang Chaoyang also set up Sohu and took venture capital to China in 1998. In the same year, Tencent was established. The penguin, which was originally the headshot of QQ, gradually became the most familiar Internet logo among Chinese people. Internet technology pioneered by the U.S. became the cornerstone of growth for China's big data giants (*i.e.*, Baidu,

Alibaba, and Tencent), making the Internet industry unique and important in this populous country. Internet and digital innovation became the new modes of Chinese innovation, opening new paths for management innovation, business model innovation, technological innovation, and social service innovation.

Beyond technological innovation, state-owned firms continued experimenting with new management innovation practices, tailoring the previous system to meet market demand. To promote efficiency, management innovation in state-owned firms was market oriented. Handan Iron and Steel is a typical example. To improve its competitive advantage, the firm sought to reduce costs through market operation stimulation. It also created the "Hangang mode", an intensive management model focusing on the cost veto method (Wu, 1993). It used this model to create market power and accelerate institutional innovation.

In terms of innovation policy, innovation attracted more attention because the shortages had been mainly resolved. Competition intensity even inspired price wars. As a result, quality became the main target of economic development. Innovation began to play a role in product quality improvement and China began to invest heavily in new and high technology. High-tech policy built a solid foundation for high-tech innovation and the Chinese economy. In 1991, the State Council issued the "*Approval of the National Development Zones for New and High Technology Industries and the Relevant Policies*" (Ministry of Science and Technology of the People's Republic of China, 1991). In 1992, the State Council issued the "*National Medium- and Long-Term Science and Technology Development Program*" (The State Council of The People's Republic of China, 1992). In 1993, China initiated the "Project 211", an endeavor aimed to strengthen approximately 100 higher education institutions and key disciplinary areas as a national priority for the 21st century. With this program, the government aimed to improve the infrastructure of universities, research capability, and the public service system. In 1995, China initiated the "*Decision on Accelerating Scientific and Technological Progress*", which emphasized R&D capabilities. In 1997, it launched the "973 Program", a national program devoted to basic research with the aim of improving universities' fundamental scientific research capabilities.

The most important event was Deng Xiaoping's "south tour talks" in 1992, which ushered in a new era for market-oriented institutional transformation by officially confirming the legitimacy of the market economy. In particular, the "*Company Law of the People's Republic of China*" was issued in 1993. Zhu Rongji, then Chinese premier, promoted the market-oriented reform of state-owned firms in 1994. In March 1996, the National People's Congress approved the "*Ninth Five-Year Plan for National Economic and Social Development and the Outline of the 2010 Vision*." This was the first medium- to long-term plan under the socialist economic condition. One hundred state-owned firms took part in the first reform experimentation. The efforts toward ownership reform paid off for many enterprises, such as Xuzhou Construction Machinery Group Co. Ltd., Shenyang Machine Tool Co. Ltd., and Qinchuan Machine Tool Co. Ltd.

Formal innovation research took its first step, with innovation paradigms based on absorption and state-owned management innovation as the central research topics. Scholars discussed the absorption paradigm in a systematic way (Fu, 1994; Xie, 1994) and reflected on the "exchange market for technology" strategy (Yu and Li, 1997a, 1997b). Even more importantly, some scholars focused on the decision-making process, motivation, and capability related to technological innovation (Li and Wang, 1994; Li, 1994). They explored the key elements of innovation strategy, innovation diffusion, "secondary innovation", and the "second-mover advantage" in the innovation paradigm based on absorption (Wu, 1995a, 1995b). In terms of methodology, most innovation research comprised conceptual rather than formal empirical studies.

During this stage, the most popular theory in the international research field was absorptive capacity theory. This theory focuses on the role of absorptive capacity in promoting innovation. The most important studies on market orientation were also published during this stage. The Product Development and Management Association established the *Journal of Product Innovation Management*, a journal focused on innovation. During this stage, international research explored how to promote innovation and how to benefit from innovation. Christensen also published his popular destructive innovation theory during this stage (Christensen, 1997).

However, the central idea of this line of literature was not introduced to China in a timely fashion. Given the weak influence of the Chinese economy, innovation in China attracted little international research attention. Only a few papers in international journals focused on innovation practices in China. In terms of research methodology, international journals mainly published typical empirical studies rather than papers on conceptual frameworks alone. The research field in China was also at the starting point of internalization.

2.3. Stage 3 (1999 to 2008): "Made in China" and endogenous innovation

Competition intensity and globalization were the main drivers of innovation during this stage. The Asian financial crisis in 1998 increased the intensity of domestic competition. With the government's long-term efforts, China officially joined the World Trade Organization on November 11, 2001, beginning a new era of globalization for Chinese firms (Ministry of Commerce of the People's Republic of China Trade Remedy and Investigation Bureau, 2001). With China's low labor costs and manufacturing system accessibility, "Made in China" entered the global market.

Technological innovation became an important part of China's competitive strategy. Globalization and the internal market-oriented reform significantly increased the competition intensity. In turn, the increased competition intensity urged Chinese firms to catch up with global players through innovation. They acquired state-of-the-art technology through outsourced collaborations, joint ventures, acquisitions, and R&D collaborations with global companies (*e.g.*, the TCL Group's acquisition of Thompson). However, the innovation paradigm based on absorption placed serious limitations on their global competitiveness. A lack of core technology became the crucial barrier to developing a global competitive advantage. Therefore, endogenous innovation became the central focus of innovation orientation.

During this period, government policies focused on endogenous innovation (Xu, 2006a, 2006b). In 1999, the Chinese government issued the "*Decision on Strengthening Technological Innovation, Developing High Technology, and Realizing Industrialization*", which emphasized endogenous innovation in the high-tech industry. In 2006, China made strategic goals, such as "building an innovative country based on endogenous innovation", and issued the "*Outline of the National Program for Long- and Medium-Term Scientific and Technological Development*"(The State Council of The People's Republic of China, 2006). The Chinese government also issued the "*Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements*", the "*Law on Science Popularization*", and the "*Patent Law*" to promote endogenous innovation. It further proposed several major national science and technology projects, including the "973 Program", the National Key Technology R&D Project, the program of National University Science Park, and the Knowledge Innovation Project. These policies laid an institutional foundation for the national innovation system.

Enabled by innovation-oriented policy, many private firms pursued endogenous innovation. Huawei is an outstanding example. To improve its innovation capability, Huawei consulted IBM about

integrated product development (IPD) and building an open innovation system. Alibaba was also a star of innovation in the sense of business model. In 1999, Jack Ma started this company out of a residential apartment in Hangzhou. In addition to technological innovation, the SARS epidemic in 2003 sped up the diffusion of the IT industry and inspired IT-based business model innovation. Taobao was introduced in May 2003 and JD.com launched in 2004, eventually becoming flagships of the Chinese Internet industry. The coevolution of technological innovation and business model innovation promoted economic development. However, business model innovation received criticism for abstracting too many resources away from technological innovation. In particular, more firms found it difficult to compete with just a business model without core technology.

In terms of academic research, endogenous innovation became the hottest topic during Stage 3. We were the first to formally define endogenous innovation in a paper published in an international journal (Li *et al.,* 2008). Recognizing the value of research on endogenous innovation, an increasing number of researchers followed this topic. Scholars started to conduct research on endogenous innovation from perspectives pertaining to innovation strategy, innovation organization, cooperation, industrial clusters, and the national innovation ecosystem. During this stage, open innovation was the most important stream of innovation literature in the international research field. Most importantly, innovation in China attracted extensive international research attention. Chinese scholars also published research in top-tier innovation journals.

2.4. Stage 4 (2009 to 2018): Innovation with Chinese characteristics

The desire for a better life became the fundamental drive for innovation in the new era. Chinese firms spent 30 years to catch up with innovation leaders in developed countries. By 2008, the shortage economy was long gone and Chinese people were living better lives. However, the subprime mortgage crisis posed a serious threat to Chinese manufacturing firms. The great losses incurred urged the government to check the position of Chinese firms in the international innovation network. Recognizing its weak competitive advantage, China sought to transform its factor-driven economy into an innovation-driven economy. In 2010, the then Chinese President Hu Jintao stressed economic restructuring and technological innovation. From 2017 to 2018, China kept a close eye on core technological innovation. Intense industry technological competition urged firms to build new innovation capability systems and innovation ecosystems. For example, as a successful model of innovation-driven development, Huawei surpassed Cisco with its IPD system and became the leading brand in the core router market.

Government policies during this stage had two special characteristics. First, the central component of innovation policy was core technological innovation. In 2010, "*The Decision on Speeding Up the Cultivation and Development of Strategic Emerging Industries*" was issued (The State Council of The People's Republic of China, 2010). In 2015, China proposed a "Made in China 2025" plan to promote core technological innovation. Chinese Premier Li Keqiang proposed "mass entrepreneurship and innovation" in his government work report and Chinese President Xi Jinping stated that "innovation is the first driver of development" (The State Council of The People's Republic of China, 2015a; The State Council of The People's Republic of China, 2015b). In 2016, China further launched the "*Outline of the National Strategy of Innovation-Driven Development*" (The State Council of The People's Republic of China, 2016).

An increasing number of firms began to focus on core technology innovation rather than market-driven innovation. In 2017, "core technology" became the hottest keyword. In the same year, Chinese scientists invented the first single photon quantum computer in the world and China's first self-developed

large passenger plane, the C919, flew successfully. President Xi stressed the urgency and significance of endogenous innovation, intellectual property rights, and core technology at a conference of Chinese Academy of Sciences Members. The relevant laws and policies were further modified to promote core technology breakthroughs. However, Chinese firms continue to compete with market-oriented exploitative innovation rather than exploratory innovation.

Second, the innovation policy during this stage placed more emphasis on Chinese characteristics. Regarding the special organizational structure of the national innovation system, the Chinese government introduced the "*Decision on Deepening Structural Reform on Science and Technology and Accelerating the Construction of Nationa1 Innovation System*" in 2012 to establish an innovation system (The State Council of The People's Republic of China, 2012). Out of concern for the potential population size, the government issued the "*Guideline for Development of Big Data*" and "*Opinions on Deepening Reform of Institutional Mechanism and Accelerating Implementation of Innovation-Driven Strategy*" in 2015 (The State Council of The People's Republic of China, 2015c; The State Council of The People's Republic of China, 2015d). To protect intellectual property, the government strengthened intellectual property protection by refining the "*Patent Law*" and the "*Law on Promoting the Transformation of Scientific and Technological Achievements*" in 2018 (The State Council of The People's Republic of China, 2018a; The State Council of The People's Republic of China, 2018b). Most importantly, the Chinese government paid increasing attention to green endeavors and sustainability.

The focus of academic research shifted from innovation capability to innovation ecosystems, the interaction between business model innovation and technological innovation, and core technology breakthroughs. We conducted extensive research on innovation ecosystems, innovation capability systems, and innovation paradigms with the support of the National Natural Science Foundation an d the Ministry of Education of China (Cao, 2018; Li *et al.,* 2018). Other researchers shifted their focus to the effects of open innovation, innovation networks, and innovation ecosystems on innovation outcomes. With the rise of the Internet, big data, and the artificial intelligence industry, digital innovation became the hottest research topic in the Chinese innovation research field.

In the international research field, the most frequently cited papers during this stage were about business model innovation rather than technological innovation. Over 2,700 papers in the Web of Science database had "China" and "innovation" in their titles. A great number of Chinese scholars published papers in international innovation journals using leading research methodologies. However, the development of unique theories based on the observation of innovation practices in China was limited.

3. Summary

Our review of innovation practices in China over the last 40 years shows that the innovation capability of Chinese firms has greatly improved. However, the real innovation has only just begun. Chinese firms still have a long way to go to achieve a competitive advantage with core technological innovation.

First, Chinese firms have indeed developed their basic innovation capability over the last 40 years. Making great efforts to catch up by learning advanced technology from developed countries, Chinese firms have established their basic R&D capability, marketing capability, and manufacturing capacity. Forty years ago, Chinese firms invested mainly in production systems, rather than R&D activities, and focused on their manufacturing capability rather than innovation capability. With technological development, more Chinese firms have built R&D departments and fostered their innovation capability.

Regarding R&D intensity, the large gap between Chinese and European firms has narrowed. China now performs better than some European countries in terms of R&D intensity. World Bank statistics show that China's R&D investment in 2018 accounted for 2.14% of its GDP (Figure 1), surpassing that of the United Kingdom (1.733%) and narrowing the gap between China and the United States (2.774%). In 2019, China's R&D investment accounted for 2.18% of its GDP.

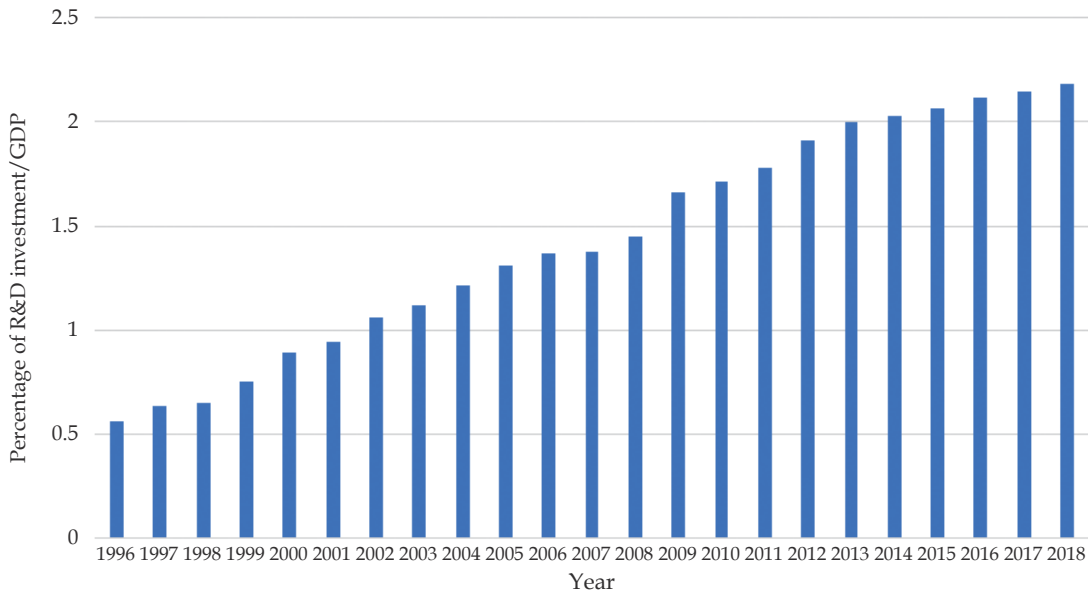

Fig. 1 Percentage of R&D investment/GDP in China (1996-2018)

The number of R&D experts in China has also increased rapidly in the last 40 years. In 2017, the number of R&D employees per million people was 1,224 (Figure 2).

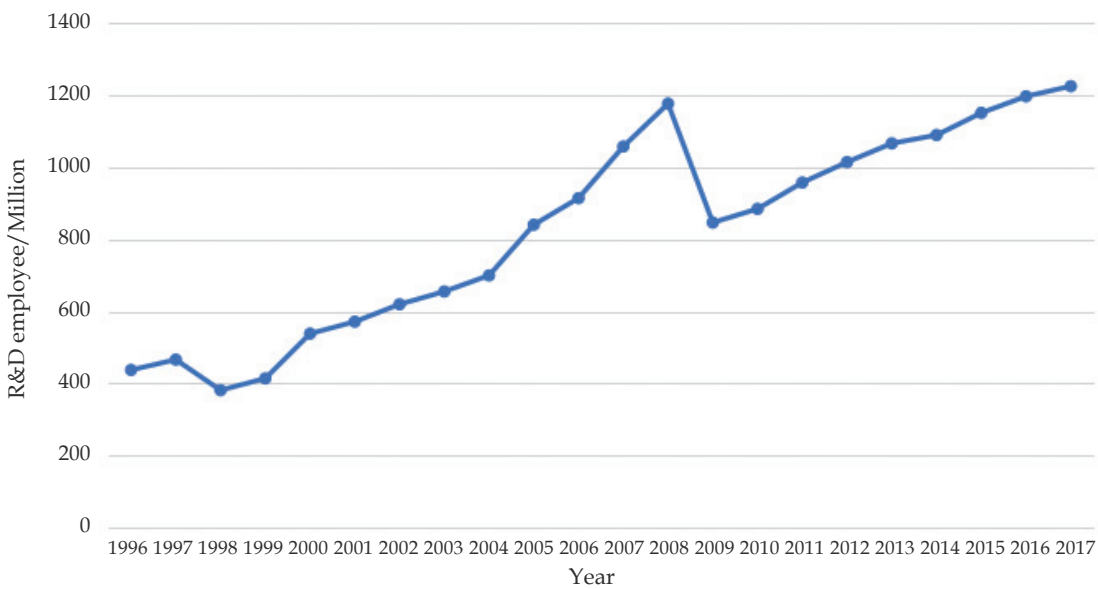

Fig. 2 Number of R&D employees per million people in China (1996-2017)

The number of patent applications has also increased rapidly since 1978 (Figure 3). In 2017, the total number of patents applied for by Chinese residents was 1,393,815. Although room for quality improvement exists, the large number of patent applications indicates that Chinese firms are devoting more attention to innovation.

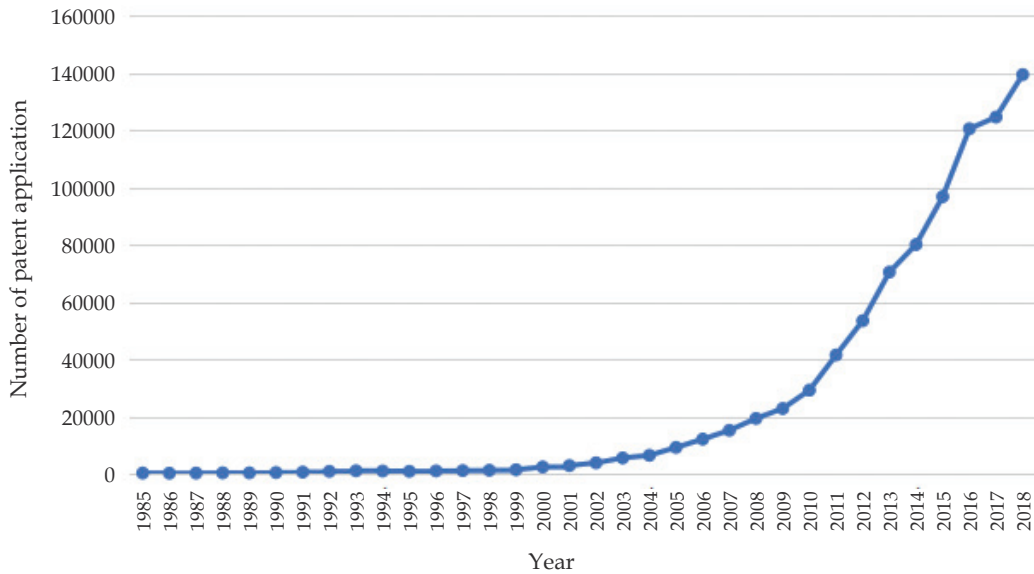

Fig. 3 Number of patent applications in China (1985-2018)

Furthermore, the efficiency of capital exploitation and the quality of technical labor have increased significantly over the last four decades. The output/input ratio has also increased greatly, indicating that the overall technological capability of the economic system has improved. One example is the significant increase in the GDP/employee ratio (Figure 4).

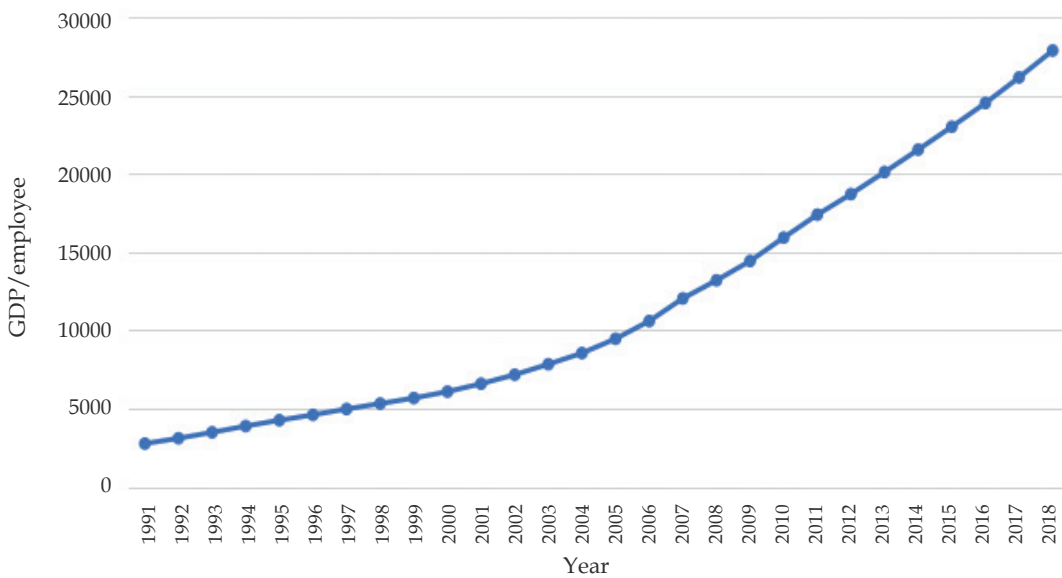

Fig. 4 GDP/employee ratio in China (1991-2018)

Even more importantly, Chinese firms have fostered more intrinsic motivation for innovation. During the first stage, Chinese firms mainly focused on internal production efficiency rather than process innovation or production innovation. Although the central authorities had called for innovation, Chinese firms had little motivation to innovate. However, competition pressure stimulated firms to develop new capabilities to compete dynamically. Innovation attracted more strategic attention and more Chinese firms fostered intrinsic motivation for innovation. China has shifted from a factor-driven economy to an innovation-driven economy. Furthermore, Chinese firms have acquired a global position as a result of their innovation capability and growth.

Second, the innovation paradigm has shifted from absorption-based innovation to endogenous innovation. The four stages of innovation over the last 40 years have covered absorption-based innovation and endogenous innovation. The first two stages mainly focused on the learning and absorption of technology from developed countries to alleviate shortages. Large technological gaps separated Chinese firms from firms from developed countries. During the first stage, Chinese firms mainly focused on learning managerial practices and basic manufacturing technology to improve their production efficiency. Until basic needs were met, Chinese firms did not compete for customers with more attention to innovation. During the last two stages, the innovation paradigm shifted from imitation to endogenous innovation with Chinese characteristics. Chinese firms endeavored to learn more new technologies using the "market for technology" strategy. The spillover from joint ventures and outsourced manufacturing collaboration opened the door to knowledge acquisition. Although it was difficult to learn the latest technological achievements through joint ventures and outsourcing collaborations, Chinese firms made great efforts to catch up with leaders in technology.

Third, institutional innovation, management innovation, business model innovation, and technological innovation have co-evolved in a cross-level fashion. Over the last four decades, innovation practices in China have become embedded in the cross-level economic transition from a planned economy to a market-oriented one. In particular, innovation in Chinese firms started with management innovation in state-owned firms. Such management innovation included changes in managers' duties, top managers' compensation, corporate governance, and ownership structure. It promoted technological innovation in state-owned firms by offering greater power, more opportunities, and stronger incentives.

Along with the process of reform and opening up, institutional innovation at the national level has been pursued in countries worldwide. In China, the increased legitimacy of private firms has greatly promoted the market power for innovation. Private firms put intense competitive pressure on state-owned firms, urging the latter to improve their innovation performance. Meanwhile, many private firms compete to improve product quality based on increased investment in technological and management innovation.

Beyond management innovation, the decoupling of central-plan power from economic factors has released the energy needed for bottom-up market-oriented technological innovation. First, globalization opened the door for Chinese firms to catch up by learning both technology and managerial practices. Second, increased competition intensity promoted technological innovation. Third, the national-level focus on innovation guided firms to prioritize innovation. A number of high-tech zones have even been established to promote the growth of high-tech firms that pay more attention to technological innovation.

Business model innovation has bloomed with the diffusion of the new generation of information technologies. It has been particularly successful in China, given the country's large population.

Facilitated by a new generation of information technology, ecosystem-based innovation has become the main innovation paradigm. Enabled by organizational and institutional innovation, firms are building innovation ecosystems that embrace all stakeholders to promote various innovations.

Fourth, technological innovation is still not the main source of competitive advantage among Chinese firms. These firms have yet to obtain a competitive advantage from core innovation. Although an increasing number of Chinese firms are investing more in innovation, market-oriented innovation rather than technology-based innovation continues to dominate their innovation activities. Most firms focus on architectural innovation rather than the emerging practice of modular innovation. For example, Xiaomi uses the design thinking approach to develop new products with new designs using common product modules. The most important source of competitive advantage is customer complaints, not scientific discoveries. Most importantly, Chinese firms own little technologically advanced manufacturing equipment. This lack of core manufacturing equipment results in a lack of core modular products. Most Chinese firms have developed their product innovation capability without developing their core technological capability. Thus, the technological foundation of Chinese firms remains very weak. For most firms, exploitative innovation rather than exploratory innovation is the main source of competitive advantage. However, firms should consider innovation as a core strategy and continuously invest in core technology.

4. Suggestions for Innovation Practice and Research

4.1. New innovation trends

This review of Chinese firms' 40-year innovation history indicates that future innovation will bear new trends. First, the value proposition of innovation (traditionally derived from customer demands) is expected to embrace multiple dimensions of diverse values. In an ecosystem innovation paradigm, stakeholders collaborate to undertake innovation. For example, in digital manufacturing, such as 3D printing, users become manufacturers. Stakeholders set diverse value propositions for technological innovation. Thus, we expect the sources of new value propositions, the characteristics of new value propositions, and the balance between old and new value propositions to be important research topics in the future.

Second, the business model will shift from standardized production to mass customized production. Enabled by the new generation of information technology, suppliers can directly connect with customers. The business-to-consumer (B2C) business model is giving way to the consumer-to-business (C2B) model. In the future, large-scale standardized manufacturing is expected to yield mass customized solutions. The new business model sets new demands for technological innovation. Furthermore, we expect the logical conflict between the B2C and C2B models, approaches to achieving mass customized production, and the product-service system to become important new research directions.

Third, innovation content will shift from physical products to the interaction between physical products and digital products. Digital innovation is emerging as a new type of innovation that includes new digital elements and sets new demands for innovation research. For example, a digital engine is made of both physical and digital components. Managers should pay more attention to the interaction between digital and physical components, as digital innovation can change product design. Digital technology is also expected to become an important element of process innovation. The manufacturing process is shifting from auto-manufacturing to digital manufacturing, enabled by big data and artificial intelligence. Future research should emphasize innovation strategy, innovation processes, and innovation organization in the digital innovation field.

Fourth, innovation strategy will shift from competition to collaboration. Traditionally, competition has been the central target of innovation strategy. Firms aim to develop a competitive advantage based on their innovation strategy. However, given the increasing importance of the connected economy and the complexity of products, firms now prefer to collaborate with competitors on the development of core technology. Thus, we expect the interaction and evolution of the collaborative relationship to become an important research topic.

Fifth, the innovation paradigm will shift from a firm-centered model to an ecosystem-centered model. Enabled by new-generation digital technology, the innovation ecosystem is expected to become the new locus for value creation and value capture. The innovation paradigm is shifting from central firms to platform-based innovation ecosystems. An innovation ecosystem has two types of firms: business modular and platform firms. The former firms develop the new products in an innovation ecosystem, with platform firms developing new products or core technologies in cooperation with member firms. In this way, the innovation ecosystem and business ecosystem become the locus and new analysis unit of innovation strategy. More research is required to explore the governance mechanisms and structure of such an ecosystem, platform-based competition, and institutional complexity in multiple ecosystems.

4.2. Suggestions for innovation practices and policy making

How can Chinese firms innovate in the new era? First, industry-level innovation should be their crucial target. Core innovation that can foster a new industry is the best choice for firms to build a solid technological base for global competition. To promote core technological innovation, firms should rely more on the commercialization of technology from universities and foster the capability to commercialize scientific technology. Even more importantly, we urge firms to realize that in the new era, core technological innovation relies more on organizational innovation capability than on tangible investment. Thus, firms should invest more in the innovation management system to foster organizational capability and thereby improve innovation performance, rather than just increase their tangible investments.

Second, an innovation ecosystem should be the best paradigm. It relies on extensive interactions between the Internet of Things, service networks, and relationships to foster business model innovation, management innovation, and technological innovation. Firms should find fit ecosystem governance to manage the innovation ecosystem.

Third, sustainability-driven innovation should be a new direction. More attention should be paid to green innovation and inclusive innovation. The coevolution of demand and technology is fundamental to technological innovation. Given the great number of customers at the bottom of the pyramid, firms should find ways to balance technological innovation and financial benefits. Most importantly, the green dimension is expected to become the central concern of customers and the government. Thus, more attention should be devoted to the green performance of new products.

Fourth, firms should collaborate with the government to create an innovation ecosystem embedded in China's unique economy, culture, and government-enterprise relationships (Li and Tian, 2013). Core technological innovation is often created through the collaboration of stakeholders in the ecosystem, such as customers, universities, governments, venture capitalists, and suppliers. Triple helix theory suggests that the government plays a crucial role in building an innovation ecosystem (Etzkowitz, 2008). In China, the government plays a powerful organizing role in the innovation ecosystem. Although platform firms can develop an innovation ecosystem, the diffusion of new technology often relies on government policies

to acquire permission, legitimacy, and complementary assets. Therefore, firms should collaborate with the government to promote core technological innovation based on the innovation ecosystem.

Finally, to promote core technological innovation, the government should build an innovation ecosystem and an institutional system to promote innovation. The central authorities should foster a new chain of innovation incubators to facilitate the commercialization of new technology. However, more efforts are needed to revise the institutional system to protect intellectual rights and increase the accessibility of complementary assets. The government should pay more attention to protecting data and personal information to reduce transactional costs in the digital environment.

4.3. Suggestions for innovation research

In the future, we recommend that researchers place more emphasis on the following issues. First, new contributions based on observations rooted in the Chinese context. Contextualizing is an important means of developing new theories. We can obtain general theoretical insights from the unique innovation practices of Chinese firms. For example, how do innovation practices contribute to China's culture, unique government-firm relationships, and institutional system? Due to the characteristics of Chinese culture, the thinking styles of top managers, customers, and R&D experts often differ. The literature has also indicated that a middle-way orientation, holistic thinking, and the paradoxical cognition frame may affect innovation strategy, innovation processes, and innovation performance. Furthermore, government-firm relationships in China differ from those in developed countries. The ambidextrous structure of the government and market bears unique advantages in many fields, offering more opportunities to develop new insights into innovation theory. As the most important developing country, China also offers chances to develop new insights into how to innovate in an environment with high institutional complexity and an institutional void.

Second, future research should focus on innovation ecosystem theory. Although market power has advantages in individual resource allocation, its adaptive cost is higher than its hierarchical origination. Determining how a flexible innovation ecosystem can be developed in a dynamic environment is the central goal of future research. The architecture, evolution, governance capability, and innovation performance of an innovation ecosystem require more research attention.

Third, future research should pay more attention to the effect of digital technology on organizational innovation. Digital technology creates new ways to connect stakeholders and business activities. Therefore, enabled by digital technology, firms can create new organizational structures and activity systems. Data-driven organizational innovation requires more research attention. Furthermore, business model innovation and organizational innovation should receive greater priority in future studies.

Fourth, more research efforts are needed to explore the role of innovation in the globalization of Chinese firms. Over the last 40 years, Chinese firms have relied on exportation rather than foreign direct investment to increase their globalization. Chinese firms have also recently invested more in countries in Africa, Asia, the E.U., and North America. Innovation plays an increasing role in this globalization process. For example, conducting reverse innovation from their emerging country has allowed Chinese firms to develop a competitive advantage in developed countries. However, international business research has paid little attention to the role of innovation in the globalization of Chinese firms. Future research should attach greater importance to the globalization of high-tech Chinese firms.

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