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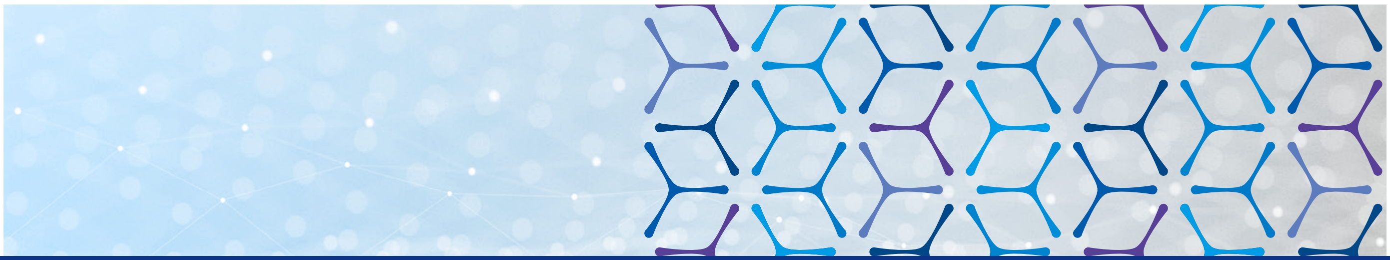
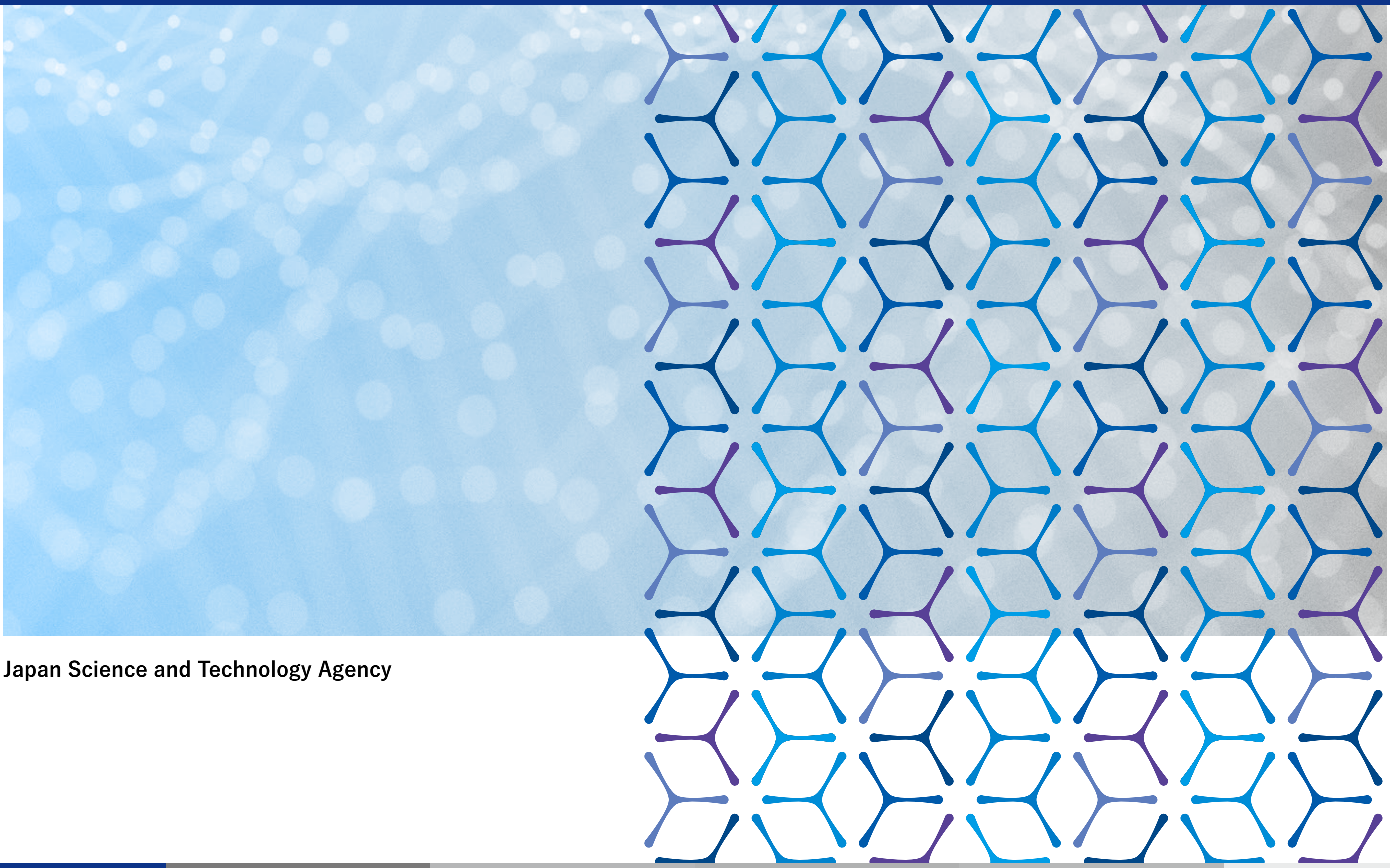


Policies, Key Industries and Science, Technology and Innovation underlying China's Science and Technology Power Strategy

March 2025



Japan Science and Technology Agency

Established in April 2021, the Asia and Pacific Research Center (APRC) of the Japan Science and Technology Agency (JST) aims to contribute to building a foundation for innovation in Japan by expanding and deepening science and technology cooperation in the Asia-Pacific region based on the three pillars of research, information dissemination, and networking.

This report is compiled as part of a research that surveyed and analyzed science and technology innovation policies, research and development trends, and associated economic and social circumstances in the Asia-Pacific region. It is being made public on the APRC website and portal site to enable wide use by policymakers, associated researchers, and people with a strong interest in collaborating with the Asia-Pacific region; please see the websites below for more details.

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Executive Summary

This report is the final report of the Research Study Group "Industrial, scientific, and technological innovation in China's quest to become a 'Science and technology superpower'" (Fiscal year 2023). The specific findings from the case studies are summarized in the introduction (Yasuo ONISHI).

Chapter 1 (Hideo OHASHI) states that China is shifting its economic development strategy to realize a domestic demand and consumption-driven economy and placing greater emphasis on scientific and technological innovation as a driving force for growth. This chapter confirms that a "Holistic view of national security" is becoming more important in China, and that the establishment of a "self-reliance and self-improvement" system of science and technology is being pursued. Specific policy measures include (1) promoting technology transfer and the introduction of foreign capital, (2) acquisitions (especially M&A of Western companies), and (3) strengthening foreign investment regulations in government procurement sector. However, skepticism is expressed as to whether these measures will achieve "self- initiated innovation."

Chapter 2 (Takayuki SHIRAO) analyses the characteristics of the research and development system. Focusing on the method of inputting R&D funds, the author uses objective data and compares it with the international situation. That is a valuable attempt with no precedent. First, it is confirmed that China has a high proportion of competitive funding, even by international standards. However, it is believed that China is moving toward a policy of greater emphasis on institutional grants (non-competitive funding) that responds to national needs and emphasizes purpose-directed research. Furthermore, looking at the National Natural Science Foundation of China (NSFC), the main funding agency in China, "research that starts from national needs and solves bottlenecks" accounts for more than half in the technical science sector and more than two-thirds in the interdisciplinary sector of management science, indicating a large presence of objective-oriented basic research. This appears the fact that the Communist Party of China/ Government has made it a major policy to secure its leadership in basic research.

Chapter 3 (Jianmin JIN) discusses the construction of an innovation system aiming for "self-reliance and self-improvement" from a perspective close to the R&D field, whereas Chapter 1 discusses science and technology "self-reliance and self-improvement" from the perspective of national strategy. First, China aims to become "New system for mobilizing resources nationwide" in which targets are clarified and domestic and foreign resources are concentrated in order to make a breakthrough in key core technologies, which are now difficult to introduce from abroad. Secondly, for realizing a "Science and technology superpower," it is necessary to strengthen the entire research and development system based on basic research. China adopted a "Two-orbit strategy," in which, on the one hand, China introduced advanced technologies from abroad, and, on the other hand, tried to develop technologies it does not have yet. Based on this recognition, this chapter conducted a case study on the state of development and utilization of generative AI.

Chapter 4 (Tomoo MARUKAWA) attempts an objective assessment on current state of the semiconductor industry and presents arguments that have not been made previously. First, in response to the discourse that China's semiconductor policy has been a continuous failure, he states that the current policy also has aspects lessons from the failures. Secondly, it is shown that the investment activities of the National IC Investment Fund, which is the pillar of the current policy, have been successful as investments. Thirdly, this chapter reviews the results of IC domestication as a measure of policy evaluation and estimates the domestic production rate at 25.6%. However, against the argument that this means that the target (58% by 2020) has not been achieved, it points out that in the first place, there is no defined method for calculating the domestic production rate relative to the target, and that the semiconductor industry itself is developing if the filter of product domestication is removed, and that the 5G telecommunications infrastructure is also at the highest level in the world. An author argues that the final evaluation of industrial policy should wait a little longer.

Chapter 5 (Hongyong ZHANG) firstly analyses the innovation policies in the industrial robotics sector, focusing on supply chain. In the industrial robotics market, general-purpose robots are self-sufficient, but the key components and materials are dependent on imports and domestic foreign-funded companies. Regarding future policy directions, it is noted that government subsidies for each stage of the supply chain are generous for the "midstream" stage, but insufficient for the "upstream" and "downstream" stages, which have high added value in the smile curve analysis. Secondly, an author analyses the robotics industry from a perspective of economic security. It concludes that the current situation forms a bottleneck due to high external dependence on the "upstream" stage, and this is the problem of the industrial subsidies policy.

Chapter 6 (Kouta TAKAGUCHI) differs from the other chapters in that it focuses on science and technology innovation in private SMEs. Innovation in this area is not necessarily through the development of new technologies, but through the implementation of existing technologies. This chapter analyses the actual situation using cross-border EC as a case study. What is noteworthy is that, first, the C2M (Customer to Manufacture) has been achieved through low-cost and short-term development. Secondly, it aims to expand to both ends of the smile curve. Thirdly, the supply chain is evolving. This chapter also highlights the successes of these private-sector-led approaches.

Chapter 7 (Yoichi GOTANI) focus on the intellectual property strategies of Japanese and Chinese companies since the 2000s and analyses the impact of these differences on both sides. At that time, Japanese companies, like many other companies around the world, adopted an "open-close strategy" on technological development. The problem in that process were; Japanese companies reduced their market share and profits in the areas of technology they had opened up, while the cost of acquiring new technology was too high and retreated their presence. On the other hand, Chinese companies were able to develop rapidly by utilizing available technologies for free. Recently, Chinese companies have become more competitive in innovations in the IoT and AI sectors. This chapter concludes that Japanese companies need to take note of this situation and integrate their own business strategies with intellectual property strategies.

These chapters have provided a new perspective on the reality of scientific and technological innovation in China, which aims to become a "science and technology superpower." In the future, it will be necessary to continue to monitor the transition while further deepening our awareness of the issues.

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Prologue: China's "Science and Technology Superpower" Current Situation and Challenges

Introduction

It has been pointed out for some time that the Chinese economic growth model, which is based on simple increases in capital and labor inputs, is coming to an end. However, the alternative—growth driven by productivity increases—is also facing difficulties, with the growth in productivity rate showing a declining trend since the second half of the 2000s. With respect to the factors contributing to productivity growth, first, the contribution of increases in labor inputs has been negative since 2014. Second, the contribution of increased capital inputs also shows diminishing marginal productivity (productivity growth per unit input) due to years of capital accumulation. In the future, the most important factor will be to improve the remaining total factor productivity (TFP), which includes the promotion of scientific and technological innovation and the strengthening of human resource development.

Based on this understanding, the Japan Science and Technology Agency (JST) has been conducting research studies since FY2021, focusing on China's science, technology, and industrial policies, which are key for improving TFP. In FY2021, a research study was conducted to provide a background for the newly adopted "Dual Circulation Strategy," along with an overview of macro policy arrangements and industry-specific measures[1]. In FY2022, research focused on the implementation of the "manufacturing superpower" strategy and industry-specific case studies in this regard[2]. In FY2023, based on the results of the above studies, we conducted a more in-depth research study focusing on science and technology innovation in individual industries with the keyword "science and technology superpower." This report is the result of that work.

The report is structured as follows. I would like to focus on understanding the issues raised in each chapter and then conclude by summarizing each chapter's findings, serving as an introduction to the whole.

1 Background of the "Science and Technology Superpower" Strategy and the R&D System

As a basic premise for the study, it is necessary to confirm the macroeconomic conditions as a background to the proposed "science and technology superpower" strategy, as well as the basic framework of the science and technology R&D system. Chapters 1 and 2 address this issue.

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[1] "Chinese Industrial Technology and Science Policy under the Dual Circulation Strategy: With Special Reference to the Influence for Asian Countries" (Japan Science and Technology Agency, 2022).

[2] China's "Manufacturing Superpower" Strategy and Industry, Science and Technology (Japan Science and Technology Agency, 2023)

1.1 "Self-Reliance and Self-Improvement" in Industrial Development and Science and Technology Promotion

As mentioned above, China's economic development has reached a turning point. Chapter 1 (Hideo Ohashi) confirms that China's approach to economic development is shifting toward a model driven by domestic demand and consumption, and that scientific and technological innovation is increasingly emphasized as a driving force for growth.

Furthermore, the author notes the emergence of an important change in industrial and science and technology policy, with an unprecedented emphasis on national security. China has a unique perception of "total national security" (the holistic national security perspective). This perspective holds that national security encompasses 11 areas: politics, national territory, military, economy, culture, society, science and technology, information, ecosystems, resources, and nuclear power.

Even before this concept was proposed, China had set an industrial policy goal of possessing an independent technological system. This objective is demonstrated in documents and plans such as the "Outline of the National Medium- and Long-Term Program for Science and Technology Development" (2006-20), "Guiding Opinions on Expanding Investment in Strategic Emerging Industries and Cultivating Strengthened New Growth Points and Growth Poles" (2020), and "Made in China 2025" (2015). In recent years, China has been pursuing independent development by narrowing its targets further and creating a list of "bottleneck" core technologies (since 2020).

The establishment of a "self-reliance and self-improvement" science and technology system has been pursued in this manner. Specific policy measures to achieve this include ① promoting technology transfer and the introduction of foreign capital, ② launching corporate acquisitions (especially mergers with, and acquisitions of, Western companies), and ③ strengthening regulations in government procurement.

However, Chapter 1 expresses skepticism about whether "independent creation" and innovation, which rely on free and flexible ideas, expression, originality, and creativity, can be achieved in the name of "national security."

1.2 Characteristics of the R&D System

Chapter 2 (Takayuki Shirao) attempts to provide an overall picture of the R&D system in China by focusing on the method of inputs for R&D investment. This chapter uses available objective data to compare China's R&D system with that of other countries, making it a valuable and novel attempt.

This chapter's analysis focuses on R&D funding methods. China's "competitive funds" ratio is observed to be high by global standards (a ratio of 6:4 for non-competitive against competitive funds). However, China appears to be trying to change the current situation and transition to a policy that emphasizes institutional subsidies (non-competitive funding) that respond to national needs and goal-oriented research. Regarding the current situation of competitive funding at the NSFC, China's main funding agency, "research that starts from national needs and resolves bottlenecks" accounts for more than half the funding in the Technological Science Section and more than two-thirds of the funding in the Department of Management Sciences (Interdisciplinary and Integration Section). It can be confirmed that the concept of goal-oriented basic research predicated on national needs has a large presence in the NSFC, which is primarily focused on assistance for basic research.

In addition, the approaches taken by the CCP and government are analyzed. The subject in this case is a speech given by Xi Jinping. In the speech, Xi points out that an urgent need to "strengthen basic research" and "resolve key technology issues." The measures to achieve this include "optimizing the basic research investment mechanisms and the basic research support systems of the National Science and Technology Plan" and "conducting domestic and international peer reviews and promoting non-consensus innovative research (extraordinary research for which no consensus has been reached so far)." While this can be mentioned as "optimization," it can be said that the main policy is to ensure the government's leadership in basic research and institutional guarantees for this purpose.

The actual state of R&D funding is in line with this approach. Given the emphasis in Europe and the U.S. on goal-oriented research investments, the CCP and the government are aiming to strengthen the aforementioned institutional subsidies. The chapter concludes that, for the time being, researcher-led systems will become less prevalent in R&D structures while organization-led systems will become more prevalent.

2 The "Science and Technology Superpower" Strategy at the Industry Level

The second aim of this research study is to understand the current situation of China's science and technology innovation policies at the industry level, as well as innovation by industry. Chapters 3-6 analyze this issue through case studies.

2.1 The "High-Level Self-Reliance and Self-Improvement" Policy: AI Development

While Chapter 1 discusses the necessity of the "self-reliance and self-improvement" policy in science and technology from the perspective of national strategy, Chapter 3 (Jin Jianmin) discusses this issue from a perspective closer to the R&D field, examining the innovation systems that are being established to achieve "self-reliance and self-improvement" in science and technology, The use of "high-level" reflects a shift in China's response to the growing trend toward emphasis on economic security amid friction between the U.S. and China and the COVID-19 pandemic.

The weaknesses in Chinese innovation have become more pronounced amid U.S.-China friction. First, it has become difficult for China to introduce key core technologies, which must be overcome. Second, it is necessary for China to strengthen its overall R&D, starting with basic research to realize its long-term goal of becoming a "science and technology superpower."

Regarding the first point, it is considered that breakthroughs will be made by clarifying strategic objectives and establishing a "new national system." The system aims to leverage the large domestic market to acquire technologies by mobilizing the power of government, business, and society. To address the second point, it is conceivable that technologies that do not yet exist today can be developed while cutting-edge technologies from around the world continue to be introduced. Therefore, a "two-orbit strategy" will be deployed to accomplish these two methods simultaneously.

Chapter 3 also includes a case study on AI development and utilization with these issues in mind. First, the major policies related to AI in China to date are summarized and overviewed. This includes traditional and generative AI and the current state of generative AI development, including its value chain, ecosystem, model development, and current utilization.

The challenges facing the industry include ① restrictions on semiconductors by the U.S. and other countries that limit computing capacity; ② a lack of human resources in the field of generative AI; and ③ geopolitical risks and domestic policy instability, complicating long-term business planning.

2.2 Policy Involvement in the Semiconductor Industry and Its Evaluation

Chapter 4 (Tomoo Marukawa) attempts an objective assessment of the current state of the semiconductor industry, presenting arguments not previously made. First, while many discussions have asserted that policy involvement in the industry has been an ongoing failure, this chapter argues that the policies currently being implemented reflect lessons learned from past failures.

Second, this chapter provides a detailed analysis of the investment activities of the National IC Industry Investment Fund, the axis of the current policy, using objective data. Unlike Japanese subsidies, the Fund is disbursed as investments. Financial statements indicate that the Fund is earning substantial returns and is successful in that sense. This is somewhat different from the prevailing image of huge amounts of money being unsuccessfully poured into the domestic production of semiconductors in China.

Third, the results of China's domestic IC production are reviewed. While various estimates for the domestic production rate exist, Chapter 3 puts the figure at 25.6% (as of 2021). Based on these figures, it cannot be expected that the Chinese government's target for domestic production (58% domestic production rate in 2020) will be achieved. The 80% target for 2030 is not likely to be achieved either. However, this is the result of the commercial operations of the National IC Investment Fund, as mentioned above, and the target number itself was not set as a measure of achievement in the first place. If the filter of domestic production is excluded, the semiconductor industry is developing, and China's telecommunications infrastructure has achieved the world's highest level, as evidenced by its 5G telecommunications network. The conclusion of Chapter 4 is that a final evaluation of the semiconductor industry policy should be conducted a little later.

2.3 The Industrial Robot Supply Chain and Economic Security

Chapter 5 (Zhang Hongyong) covers industrial robots. China is the world's largest industrial robot market, but its supply-demand structure is imbalanced. Although local firms can supply general-purpose robots, they are dependent on imports and domestic foreign firms for important parts and materials. The first objective of this chapter is to clarify how government policy support is operationalized in this context and identify where the challenges lie.

To this end, it analyzes the structure of the industry's supply chain. First, the "upstream" stage involves the production of computer numerical control (CNC) units, servo motor mechanisms, reduction gears, and programmable logic controllers (PLCs). There are 16 local listed companies in this field, focusing on domestic production of parts and materials. However, China's dependency on foreign countries is high, with Japan and Europe accounting for 65% and 30% of CNC supply, respectively, and 37% and 57% for PLCs (as of 2017). The "midstream" stage involves the assembly and production of products (industrial robots). Although there are 16 local companies in this field, the presence of foreign companies (ABB, Fanuc, Yaskawa Electric, and KUKA) is still significant. Finally, the "downstream" stage is the system integration field, which involves the introduction and design of entire systems using industrial robots. There are 10 locally listed companies here.

Government subsidies are generous for the midstream stage but inadequate for the upstream and downstream stages, which are considered as high value-added in the smile curve analysis. Under the influence of such factors, as R&D intensity (R&D investment/sales) indicates, the midstream stage stands out.

The chapter's second objective is to discuss developments in Japan and China with regards to economic security and their implications for scientific and technological innovation in the field of industrial robotics. Looking at Japan, industries where the use of machine tools and industrial robots is essential account for 50% of the manufacturing GDP (2020). These technologies are therefore unquestionably important. However, as noted above, China's high degree of external dependence in this area from the "upstream" stage onward has become a security bottleneck. Resolving this bottleneck is a policy challenge in regard to the subsidies given to this industry, and future trends merit close attention.

2.4 Grassroots Innovation

The above chapters analyze science and technology innovation policies and innovation trends in core technology areas, in which the Chinese government plays a prominent role. In contrast, Chapter 6 (Kouta Takaguchi) focuses on digitalization strategies in the private sector (small and medium-size enterprises), and discusses the implications that can be drawn from them. Innovation in this area does not necessarily depend on the development of new technologies but rather on the implementation of existing ones, and this chapter uses cross-border e-commerce as a case study.

The first notable feature is the realization of the C2M mechanism through low-cost production and reduced development time. This business model does not follow the process of "market research followed by product launch." Rather, it involves providing products (including other companies" products) with good sales results in a short period of time to increase production and generate profits. Shein, a rapidly growing clothing retailer in the cross-border e-commerce market, is a prime example.

The first notable feature is that C2M aims to expand to both ends of the smile curve. By directly connecting China's high manufacturing capabilities with the market (consumers), C2M is a model that will allow China to outperform other countries, especially in the emerging product category. Other examples include various manufacturers of electric vehicles, solar panels, batteries, etc. The scale of their business is significantly large, and they are also making serious advances overseas.

Third, supply chains are evolving. Similar to the direct connection between manufacturer and consumer mentioned above, flexible supply chains that cover product design and development, manufacturing, and raw-material management in an integrated manner have been realized through C2M between companies.

The chapter reaches a highly thought-provoking conclusion that to become a science and technology superpower, China must pay attention not only to "heavy" government-led approaches but also to "light" private-sector-led approaches and not overlook the grassroots innovation realized therein.

3 The Role of Intellectual Property Strategy

The third task of this research study is to analyze the role of intellectual property strategies in science and technology innovation. This may have useful implications for future innovation policies at the national and corporate level.

3.1 The Intellectual Property Strategies of Japanese and Chinese Companies

Chapter 7 (Yoichi Gotani) analyzes the impact that Japan's and China's intellectual property strategies on the rise and fall of companies in both countries during this period of technological innovation.

The "open and closed strategy" involves maximizing profits by balancing the public disclosure (including partial disclosure) and monopolization of proprietary technology. It has been adopted by companies in many countries. The problem here is that while Japanese firms were fully implementing this strategy (around 2000), Chinese firms were adopting a strategy of development through open innovation (commercialization through the introduction of technology from foreign firms). In other words, Chapter 7 finds that Chinese firms have developed through the free use of necessary technology without the need for planning, whereas Japanese firms have seen their market share and profits decline in open technology areas, and the cost of acquiring alternative technology has become too high, resulting in a decline in their presence.

From time to time, the Chinese government has also accelerated this process by adopting policies promoting open innovation development strategies.

It is only natural that Japan and Japanese companies should learn lessons from the above process; however, it is also important to note that technological innovations in IoT and AI in recent years have strengthened the competitiveness of Chinese companies in industrial sectors where they had traditionally been weak. Changes in the business environment brought about by technological innovation are becoming more and more intense. Therefore, Chapter 7 recommends that Japanese companies need to identify trends in technological innovation and integrate their own business strategies with intellectual property strategies.

Conclusion: Where the "Science and Technology Superpower" Strategy Stands Today

Finally, let us summarize the analyses undertaken in the chapters above.

First, China's economic and industrial growth has reached a stage where it must be led by scientific and technological innovation, making becoming a "science and technology superpower" more than a mere slogan.

Second, the intensifying friction between the U.S. and China has made it more difficult to introduce advanced science and technology, and breakthroughs stemming from the domestic development of technology are required to realize the objective of a "science and technology superpower." The emphasis on "self-reliance and self-improvement" in science and technology is a reflection of these circumstances.

Third, China seeks to pursue these innovations while ensuring national security. However, the free exercise of ideas and originality, which is the essence of innovation, is incompatible with the prioritization of national security. In addition, an increasing emphasis on economic security is not confined to China but common among countries around the world. China's policy development will thus continue to be fraught with contradictions.

Fourth, an analysis of China's methods of allocating research funds reveals that the basic framework of the research system whereby it produces scientific and technological innovation is similar to that of developed countries. However, in recent years, the CCP has been stepping up interventions to prioritize national needs and priorities, looking to increase institutional subsidies and emphasize application-oriented research.

Fifth, the current status of the industry-level science and technology innovation policy shows that it is achieving results despite the challenges it faces. Various subsidies have been disbursed to industries designated under the "Made in China 2025" policy (from 2015). For example, in the semiconductor sector, support has been provided by a large-scale investment fund. "Made in China 2025" cannot be evaluated as a success in terms of indicators such as an increased rate of domestic semiconductor production or the development of advanced semiconductors. Nevertheless, thanks to this policy, the semiconductor industry has solidified its foundation and achieved the world's best-developed telecommunications infrastructure, including 5G. The policy can thus be evaluated as a blend of merits and demerits.

Sixth, as clarified by the case study of industrial robots, government support such as subsidies will continue to play an important role in industries that are closely related to economic security. As in Japan, continued attention should be paid to areas that may become bottlenecks for the economy as a whole.

Seventh, the open innovation strategy adopted by the Chinese government and companies in the area of intellectual property has been effective. Especially since the 2000s, Chinese companies have succeeded in rapid industrialization by introducing technologies opened by Japanese and other companies. This process of leveraging the "latecomer advantage" is not limited to China; however, it has achieved substantial results along with the government's adoption of measures to support it.

China has been successful in strengthening its scientific and technological innovation capabilities. With world-leading technological capabilities and human resource groups in many fields, the country appears to have solidified the groundwork to becoming a "science and technology superpower." However, the situation is about to change further. The emergence of unpredictable risks was demonstrated by the COVID-19 pandemic. In response, the decoupling (or de-risking) of economic sectors will proceed with the aim of achieving further technological hegemony. This will be a major shift away from the trend of globalization that made advances in the 2000s. Just as China is pursuing "comprehensive national security," countries around the world are also prioritizing economic security. It will not be easy to realize a "science and technology superpower" against these trends. It is surely necessary to further monitor how China responds to this challenge in the future.

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1 Industrial Development and Science and Technology Promotion in the "New Era" of Xi Jinping: The Logic and Development of "Self-Reliance and Self-Improvement"

1.1 Introduction

The Chinese economy has established itself as the "world's factory" by pursuing export- and investment-driven growth based on a policy of "putting two heads overseas" (i.e., seeking suppliers for raw materials and destinations for product sales in overseas markets) and "large-scale imports and exports." However, as a consequence of more than three decades of rapid growth, the Chinese economy has faced structural changes, including a gradual decline in investment efficiency, the emergence of excess liquidity, and the end of the demographic dividend. In response, since the mid-2000s, China has promoted a "shift in development methods" toward growth driven by domestic demand, consumption, and innovation through "independent innovation."

In the "new era" of Xi Jinping's China, industrial development and the promotion of science and technology are emphasized more than ever, reflecting the structural transformation that has accompanied the end of high growth. At the same time, the Xi Jinping administration has emphasized "self-reliance and self-improvement" in industrial development and the promotion of science and technology from the perspective of national security, transcending economic logic. This chapter will examine the characteristics and challenges of industrial development and the promotion of science and technology in contemporary China through a discussion of the process of development of the "national security" and "self-reliance and self-improvement" logic in industrial development.

1.2 National Security and "Self-Reliance and Self-Improvement"

1.2.1 Proposal of the "Holistic National Security Concept"

"National security" is a concept that encompasses not only external threats to China but also the elimination of domestic threats to the CCP one-party system. In 2000, the Jiang Zemin administration established the Central National Security Leadership Small Group. In 2013 it was reorganized into the Central National Security Commission, elevating it to become the core of the centralized decision-making mechanism of the Xi Jinping administration[1]. However, the concept of national security is multifaceted and can be applied flexibly. In the "new era" of Xi Jinping, industrial development and science and technology are now positioned as sources of national security.

At the first meeting of the Central National Security Commission in April 2014, a comprehensive interpretation of national security was presented. It included 11 areas related to national security: politics, national territory, military,

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[1] Takagi, Seiichirou (2017) "The Central National Security Commission," in *The Dynamics of U.S.-China Relations in a Period of Turmoil for the International Order*, Japan Institute of International Affairs, pp. 7. https://www2.jiia.or.jp/pdf/research/H28_China/01-takagi.pdf

economy, culture, society, science and technology, information, ecosystems, resources, and nuclear power, which were conceptualized as "holistic national security"[2]. However, the November 2021 "history resolution" expanded "national security" to include overseas interests, space, the deep sea, the polar regions, and living organisms. The Report to the 20th National Congress of the Communist Party of China further added economic, major infrastructure, financial, cyber, data, biological, resource, nuclear, space, and maritime security, stating that protecting national security and social stability is the fundamental activity of the Party and the country[3].

In an effort to institutionalize the "holistic national security concept," legal developments have been underway since the mid-2010s, including the National Security Law (effective July 2015)[4] .

1.2.2 The "Self-Reliance and Self-Improvement" Logic

In the past, the CCP has responded with what could be called excessive caution to events that could affect the survival of the regime, such as the collapse of the Soviet Union and the "color revolutions" in Central and Eastern Europe and Central Asia. In the 2010s, the economy, the source of the CCP's legitimacy during the reform and opening-up period, began to experience low growth. In Xi Jinping's Report to the Report to the 20th National Congress of the CCP in October 2022, national security was emphasized more than the reform and opening up or economic development, and the Report contained a dedicated rubric to "comprehensively strengthen the national security system and national security capabilities." According to the report, it is required to promote science and technology on the basis of "national security" and "self-reliance and self-improvement" and aim for "high-quality development." Indeed, pursuing "high-quality development" is considered the "overarching task" in the overall construction of a modernized socialist nation. Thus, the logic was developed that without a material and technological foundation, the full completion of a strong socialist modernized country would not be possible, and the need to significantly improve "self-reliance and self-improvement" in terms of industrial development and the promotion of science and technology was stressed.

For China, which had experienced "a hundred years of national humiliation" and became a great power through sustained rapid growth during the period of reform and opening-up, "national security" is a prerequisite for realizing the "Chinese dream" and the "great revival" of the Chinese nation. The National Security Law (Article 19)[5] states that "the State maintains the basic economic system and order of the socialist marketplace, completing institutional mechanisms for prevention and resolution of risks to economic security" to guarantee the security of critical economic

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[2] "First Meeting of the Central National Security Commission Convened; Xi Jinping Delivers Important Speech," April 15, 2014 https://www.gov.cn/xinwen/2014-04/15/content_2659641.htm

[3] "Resolution of the CPC Central Committee on the Major Achievements and Historical Experience of the Party over the Past Century" November 16, 2021.https://www.gov.cn/zhengce/2021-11/16/content_5651269.htm
Xi Jinping: "Hold High the Great Banner of Socialism with Chinese Characteristics and Strive in Unity to Build a Modern Socialist Country in All Respects": Report to the 20th National Congress of the Communist Party of China, October 16, 2022; https://www.gov.cn/xinwen/2022-10/25/content_5721685.htm
The remainder of this chapter uses this text as the Report to the 20th National Congress of the Communist Party of China.

[4] In addition to the National Security Law, the following laws can be mentioned: the Counter-Espionage Law of November 2014 (amended in July 2023); the Counter-Terrorism Law of January 2016; the Law on the Administration of Activities of Overseas Foreign NGOs of January 2017; the Cybersecurity Law of June 2017; the National Intelligence Law of June 2017; the Nuclear Safety Law of January 2018; the Export Control Law of December 2020; the Anti-Foreign Sanctions Law of June 2021; the Data Security Law of September 2021; and the Personal Information Protection Law of November 2021.

[5] National Security Law of the People's Republic of China, July 1, 2015. https://www.gov.cn/zhengce/2015-07/01/content_2893902.htm

interests, including key industries and infrastructure related to the lifeblood of the national economy; it is oriented toward the integration of industrial development and the promotion of science and technology.

1.2.3 Development of the Dual Circulation Strategy

"National security" and "self-reliance and self-improvement" in industrial development and the promotion of science and technology are reflected in the Dual Circulation Strategy proposed by Xi Jinping as CCP General Secretary in 2020. This is a development strategy that focuses on "domestic circulation" (domestic consumption) and mutually promotes domestic and "international circulation" (international trade and investment). According to Xi, under the external environment of rapid economic globalization, the strategies of "putting two heads overseas" and "large-scale import and export" have made a tremendous contribution to China's rapid economic growth. However, in an external environment of rising protectionism, a sluggish world economy, and atrophying global markets, China's huge domestic market advantage and self-contained "domestic circulation" must be fully exploited. In implementing this policy, it is necessary to focus on upgrading supply chains, promoting innovation, and developing core technologies while adhering to the policy of structural reforms on the supply side and expanding domestic demand[6].

Based on the concept of national security, the dual circulation strategy aims to reduce China's vulnerability to external shocks and increase its independence such that it can better cope with international fluctuations. Therefore, China is increasingly oriented toward becoming a state-led, "self-rehabilitating" and "self-sufficient" science and technology superpower, aiming to improve its ability to build innovation through "independent innovation" based on the premise of a huge domestic market and internalize a supply chain that guarantees such innovation. However, while China is already a world leader in telecommunications, high-speed rail, and digital technology, there remain many industrial sectors that lack core technologies or cannot overcome technological bottlenecks. Therefore, it is necessary for China to continue to stay open to the outside world without becoming a closed economy. However, the focus of "opening up" is shifting from exports and the introduction of foreign capital to the acquisition of technology and know-how, and there is also evidence of attempts to control the interdependent relationship between the Chinese and international economies. When economic reform was the primary emphasis, "external pressure" was used as a driving force for economic reform; however, from the perspective of national security, it is increasingly viewed as a nexus of potentially hostile actions and relationships.

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[6] Regarding Xi Jinping's proposal for a Dual Circulation Strategy, see "Xi Jinping Chairs a Meeting of the Standing Committee of the CCP Central Committee Politburo to Analyze the Situation of Domestic and Foreign COVID-19 Pandemic Prevention and Control, Study and Act to Ensure the Effective Implementation of Standardized Pandemic Prevention and Control Measures, and Study to Improve the Stability and Competitiveness of the Industrial and Supply Chains," May 14, 2020; http://www.gov.cn/xinwen/2020-05/14/content_5511638.htm, "Xi Jinping: Discussion at the Roundtable Meeting with Entrepreneurs," July 21, 2020; http://www.xinhuanet.com/2020-07/21/c_1126267575.htm, and "Xi Jinping: Discussion at the Roundtable Meeting of Economic and Social Field Experts," August 24, 2020; http://www.xinhuanet.com/politics/leaders/2020-08/24/c_1126407772.htm

1.3 Development of "Self-Reliance and Self-Improvement"

1.3.1 Development of industrial policy

China is actively developing its industrial policy for "independent innovation," which is key for the transformation of its development methods. Specifically, the policies involved include "Outline of the National Medium- and Long-Term Program for Science and Technology Development (2006-2020),"[7] which aims to make China an innovation-oriented nation with world-class science and technology capabilities by 2020; the selection of "strategic emerging industries"[8]; the promotion of "mass entrepreneurship and innovation"[9]; and "Outline of the National Innovation-Driven Development Strategy."[10] Among these, "Made in China 2025,[11]" known as the Chinese version of "Industry 4.0," has attracted the world's attention. The "Made in China 2025" policy has already disappeared from the stage due to the international community's rejection of its basic premise of excessive domestic production, its subsidy-oriented industrial policy, and its long-term goal of making China a "manufacturing superpower." However, the preface to the policy states, "Manufacturing is the mainstay of the national economy, the basis on which the nation is established an instrument of rejuvenation, and the foundation of a world power... The history of the struggle of the Chinese nation has repeatedly proved that without a strong manufacturing industry, there will be no country and no nation... Building an internationally competitive manufacturing industry is the only way China can enhance its comprehensive national strength, ensure national security, and build itself into a world power." Therefore, as we can see, the spirit of "Made in China 2025" is still alive and well.

Furthermore, "Made in China 2025" calls on the nation to "accelerate the conversion and industrialization of national defense science and technology achievements and promote the two-way transfer and conversion of military and civilian technologies." In China, barriers between military and civilian life have always been low, as evidenced by the promotion of "military-to-civil conversion" (the conversion of military technology for civilian use). In March 2015, at the Third National Meeting of the People's Liberation Army at the 12th National People's Congress, Xi, who also serves as Chairman of the Central Military Commission, announced that he would elevate this to a national strategy, thereby accelerating the "military-civil fusion" movement.[12] In this way, defense construction, which is directly linked to "national security," has been linked to economic development, leading to the vigorous promotion of "self-reliance and self-improvement" in industrial development and science and technology promotion, the domestic development of core technologies, and the overcoming of bottlenecks.

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[7] Outline of National Medium- and Long-term Scientific and Technological Development Program (2006-2020), February 9, 2006
https://www.gov.cn/gongbao/content/2006/content_240244.htm

[8] "Decision of the State Council on Accelerating the Cultivation and Development of Strategic Emerging Industries" October 10, 2010
https://www.gov.cn/zwgk/2010-10/18/content_1724848.htm

[9] "Opinions of the State Council on Several Policies and Measures for Vigorously Promoting Mass Entrepreneurship and Innovation," June 16, 2015
https://www.gov.cn/zhengce/content/2015-06/16/content_9855.htm

[10] "Outline of the National Innovation-Driven Development Strategy," May 20, 2016
http://politics.people.com.cn/n1/2016/0520/c1001-28364670.html

[11] "Made in China 2025," May 8, 2015. https://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm

[12] Xi Jinping: "Deeply Implement the Development Strategy of Military-Civil Fusion and Strive to Create a New Situation of Strengthening and Rejuvenating the Military," March 13, 2015;
http://cpc.people.com.cn/n/2015/0313/c64094-26685982.html

1.3.2 Domestic Production of Core Technologies

Xi reminded China's scientific and technological circles that to "achieve the great goal of building a modern and powerful socialist country and realize the Chinese dream of the great rejuvenation of the Chinese nation, we must have strong scientific and technological strength and innovation capabilities." He added, "There are many in-adaptations in the field of vision, innovation ability, resource allocation, system and policy. The shortcomings of basic scientific research in China are still prominent: enterprises do not pay enough attention to basic research; there is a lack of major original achievements, underlying basic technology, and basic process capacity; bottlenecks such as industrial mother machines, high-end chips, basic software and hardware, development platforms, basic algorithms, basic components and basic materials are still prominent; and the situation that key core technologies are controlled by people has not fundamentally changed… Only by mastering key core technologies in our own hands can we fundamentally guarantee national economic security, national defense security and other security[13]."

Among these points, at the Second Meeting of the Central Financial and Economic Affairs Commission in July 2018, Xi Jinping declared that "Key core technologies are an important weapon for the country and are of great significance to promoting the high-quality development of our economy and ensuring national security. We must seriously improve our innovative capabilities in key core technologies, firmly seize the initiative in scientific and technological development, and provide a strong scientific and technological guarantee for our country's development[14]." On his visit to China First Heavy Industries in Qiqihar, Heilongjiang province, he reiterated that "advanced and core technologies are becoming increasingly hard to obtain internationally, and with the rise of unilateralism and trade protectionism, we are forced to take the path of self-reliance, which is not a bad thing. China ultimately has to rely on itself[15]." During his visits to production sites around the country, Xi has repeatedly stressed the need to "break through" bottlenecks[16].

What exactly are the core technologies that hold the key to forming bottlenecks? In April 2018, immediately after the U.S. imposed sanctions on ZTE, a major Chinese telecommunications equipment manufacturer, *Science and Technology Daily*, listed "35 Bottlenecks that Constrain China's Industrial Development"; these were the core technologies that were predicted to form the bottleneck at the time (Table 1-1)[17]. It should be noted that five years after this report, China has already "broken through" 21 of the 35 major "bottlenecks"[18].

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[13] Xi Jinping: Speech at the 19th Academician Conference of the Chinese Academy of Sciences and the 14th Academician Conference of the Chinese Academy of Engineering, May 28, 2018; https://www.gov.cn/xinwen/2018-05/28/content_5294322.htm

[14] "Xi Jinping Presides over the Second Meeting of the Central Financial and Economic Affairs Commission," July 13, 2018; https://www.gov.cn/xinwen/2018-07/13/content_5306291.htm

[15] Xi Jinping: "Only by Practicing 'Internal Strength' Well can the Equipment Manufacturing Industry Remain Invincible," September 26, 2018; http://www.xinhuanet.com/politics/2018-09/26/c_1123486536.htm

[16] Xi outlines the specifics involved at talks during inspection visits to HGTech in Wuhan (June 28, 2022), Siasun in Shenyang (August 19, 2022), and Suzhou Industrial Park (July 08, 2023).

[17] For a more detailed description of the 35 "bottleneck" technologies and 63 "bottleneck" core technologies not yet in China's possession, see "35 'Bottleneck' Technologies Reported by *Science and Technology Daily* and Over 60 Core Technologies that China has not yet Mastered are Clarified"; https://www.fdx- fund.com/cn/case-detail-1553.html

[18] "Five Years On, Do You Know How Many of the 35 'Bottleneck' Technologies We Have Cracked?" June 9, 2023; https://jres2023.xhby.net/sy/kj/202306/t20230609_7969289.shtml

Table 1-1. 35 Key Core Technologies Forming Bottlenecks

1	Lithography equipment	19	High-pressure plunger pumps
2	Chips	20	Aircraft design software
3	Operating systems	21	Photoresist technology
4	Tactile sensors	22	High-voltage common-rail systems
5	Vacuum evaporation equipment	23	Transmission electron microscopes
6	Cellular radio frequency devices	24	Main bearings for load headers
7	Aircraft-engine nacelles	25	Microspheres
8	iCLIP technology	26	Underwater connectors
9	Large gas turbines	27	Main materials for fuel cells
10	Laser radar	28	High-end welding power supply
11	Airworthiness standards	29	Fuel-cell diagrams
12	High-end capacitors and resistors	30	Parts for medical imaging equipment
13	Core industrial software	31	Database management systems
14	Indium tin oxide target materials	32	Epoxy resins
15	Core algorithms	33	Ultra-precision polishing processes
16	Aircraft steels	34	High-strength stainless steel
17	Milling cutters	35	Scanning electron microscopes
18	High-grade bearing steels		

Source: *Science and Technology Daily*, September 24, 2020

1.3.3 Internalization of Industry and Supply Chains

While setting out to overcome bottlenecks, China has reiterated its policy to promote import substitution and internal production of core technologies. In his April 2020 address to the Central Financial and Economic Affairs Commission, General Secretary Xi Jinping made clear his intention to link this move to national security[19].

In his address, Xi first insisted on the solid implementation of the strategy to expand domestic demand, and then submitted that the advantage of a large economy lies in its ability to create domestic circulation. A virtuous cycle should be achieved by increasing dependence on China's domestic market, the largest and highest-potential consumer market in the world. He argued that the expansion of domestic demand and of external openness are not contradictory; the smoother the domestic circulation, the better China will be able to form a global gravitational field of resources and factors.

Therefore, he emphasized the optimization and stabilization of industrial and supply chains. Past models should not be repeated, but new industrial chains should be built, and scientific and technological innovation and import

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[19] "Major Issues Concerning China's Strategies for Mid-to-Long-Term Economic and Social Development": General Secretary Xi Jinping's Speech at the Seventh Meeting of the Central Financial and Economic Affairs Commission on April 10, 2020," October 31, 2020. http://www.qstheory.cn/dukan/qs/2020-10/31/c_1126680390.htm

substitution should be strengthened across the board. China must strengthen and elevate the international leading position of its dominant industries; develop several "assassin's mace" technologies; and continue to strengthen overall industrial-chain advantages in areas such as high-speed rail, power equipment, new energy, and telecommunications equipment. "We must," he added, "tighten international production chains' dependence on China, forming powerful countermeasures and deterrent capabilities based on artificially cutting off supply to foreigners." Xi insisted on building independent, controllable, safe, and reliable domestic production and supply systems in areas and nodes related to national security, achieving self-circulation at critical moments and ensuring normal operations of the economy even under extreme circumstances.

Thus, he proposed that the internalization of supply chains would achieve technological breakthroughs while helping form "powerful countermeasures and deterrent capabilities" for national security.

1.4 Policy Measures for "Self-Reliance and Self-Improvement"

1.4.1 Technology Transfer and Introduction of Foreign Capital

Technology transfer from foreign countries is an essential route for "self-reliance and self-improvement." However, China has faced repeated external frictions and disputes over the introduction of technology. The additional tariffs imposed by the Trump administration in 2018 based on the investigation under Section 301 of the Trade Act were based on an allegation that China was unfairly acquiring U.S.-developed technology and infringing on its intellectual property rights. The main issues in question included copyright infringement, reverse engineering, illegal import of controlled items, industrial espionage and cyber-theft of technology, as well as forced technology transfer (restrictions on foreign investment, localization of R&D and data, discriminatory catalogues, voluntary technology standards, and administrative licensing systems), corporate leaks, the activities of non-traditional information collectors (international students and researchers), and the recruitment of experts[20].

The specific technologies that China is seeking can be found in its "Foreign Investment Catalogue." Since the then State Planning Commission, the State Trade and Economy Commission and the Ministry of Foreign Trade and Economic Cooperation issued the "Catalogue for the Guidance of Foreign Investment Industries" in 1995, the "Foreign Investment Catalog" has already been revised 10 times in response to the economic situation and the opening up of the country to the rest of the world[21].

The latest version, the "Catalogue of Encouraged Industries for Foreign Investment" (2022 Edition)[22], consists of a National Catalogue of Encouraged Industries for Foreign Investment and a Catalogue of Priority Industries for Foreign Investment in Central and Western China. Compared with the 2020 edition, a total of 239 new items have been added and 167 items have been revised (Table 1-2). With manufacturing as the focus of foreign investment and the upgrading

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[20] See: Ohashi, Hideo (2020) *The Economics of the China Shock: An Examination of the U.S.-China Trade War*, Keiso Shobo, Chapter 5, "U.S.-China Relations Regarding Technology and Intellectual Property"

[21] The "Catalogue for the Guidance of Foreign Investment Industries" became the "Catalogue of Encouraged Industries for Foreign Investment" in the 2020 edition, and the "Encouraged Categories" of the previous "Guidance Catalogue" are now posted in this document.

[22] National Development and Reform Commission and Ministry of Commerce (2022), "Catalogue of Encouraged Industries for Foreign Investment" (2022 Edition);
http://www.mofcom.gov.cn/article/xwfb/xwrcxw/202210/20221003363087.shtml

of industrial chains and supply chains, the following items were added or revised: ① End products: aeronautical ground equipment, glow discharge mass spectrometers, transmission electron microscopes, and equipment related to industrial water conservation, etc.; ② Components: bearings for shield machines, core components related to automated driving, and high-performance light metals, etc.; ③ Raw materials: high-purity electronic chemicals, high-performance paints, and organic polymer materials, etc. Other items added or revised include the development, production, and application of new biomass energy technologies and products, as well as the development and production of consumable goods related to pharmaceutical manufacturing and high-performance photoresists. Meanwhile, hydrogen fluoride and hydrofluoric acid, which have made headlines due to Japan's tightening of semiconductor material export controls to South Korea, are classified as deleted items. The "Foreign Investment Catalogue" will serve as a reference when examining China's technology level.

In addition, the following items were added: ① Production of finished products and core components for smartphones and tablets, processing and production of clothing and accessories, and production of LCD and OLED display materials (in Shanxi, Liaoning, Anhui, and Ningxia); ② Development and utilization of clean coal technology products (in Jiangxi, Guizhou, Heilongjiang, and Inner Mongolia); ③ Commercial chain-store operations and cross-border logistics (in Yunnan, Qinghai, Xinjiang, and Tibet). Moreover, in some cases, such as high-precision reduction gears for robots in Gansu province, the deleted items in the National Catalogue are retained in the Catalogue of Priority Industries for Central and Western China. The document thus reflects industries with comparative advantages in various regions of China.

Table 1-2. Additions and Deletions in the Catalogue of Encouraged Industries for Foreign Investment (National; Manufacturing)

Chemical raw materials and energy	
Added items	**Deleted items**
· Production and R&D of therapeutic medical hygiene fiber products, artificial skin, absorbable sutures, materials for inguinal hernia repair surgery, new dialysis membrane materials, catheters for interventional treatment, and high-end functional biomedical dressing materials, etc. · High-performance photoresists · Green production technology for hydrogen fuel · Production of organic polymer materials: Ultra-high refractive index optical resin materials, separators for lead-acid batteries for vehicle operation, separators for lead-acid batteries for energy storage, etc.; and advanced processing of high-performance light metal and copper alloy materials for energy-saving and eco-friendly fields · Aluminum laminate film for lithium-ion batteries	· Production of lithium-ion battery separators, etc. · Compound semiconductor materials and some aluminum and copper foil materials · Hydrogen fluoride, hydrofluoric acid
High-end equipment	
Added items	**Deleted items**
· Aerospace engineering equipment, advanced rail transportation facilities · Biopharmaceutical and high-performance medical equipment · Energy-saving and new-energy vehicles · High-end numerical-control machine tools and robots · Bearings for tunnel boring machines and heat treatment equipment · Charging stations; manufacture of energy-storage charging stations: Integrated charging/energy-storage energy-saving complex facilities or solutions	· Robotics (development and manufacture of robots and industrial robots, high-precision reduction gears for robots, smart gateways for industrial use, etc.)

· Offshore wind power generation equipment, new energy storage equipment, glow discharge mass spectrometers, molecular diagnostic equipment, snowmaking machines, etc.	
Automotive, computer, communications, and electronic equipment	
Added items	**Deleted items**
· Thermal management and control system for new energy vehicles · Manufacture of hardware and critical components related to Level 3-5 automated driving: Smart cameras · Wafer manufacturing and recycling · Development and manufacture of smart health and care products for older adults (e.g., manufacture of goods and assistive products, medical equipment and rehabilitation assistive devices, and smart wearable devices)	· Nutritional foods and food additives for older adults · Development and production of prepared foods and production of puffed foods · In-vehicle electronic technology (e.g., automotive information and navigation systems) and Internet of Vehicles (loV) technology

Source: An Yiqing and Yasuo Onishi (2022)

1.4.2 M&As

At the turn of the 21st century, Chinese outbound investment surged under the "Go Global" strategy for overseas expansion[23]. Initially, investments were focused on securing markets and resources, but around the time when "transformation of the development method" and "independent innovation" came to be emphasized, China's overseas investments began to shift to a full-scale offensive to acquire Western companies possessing key technologies.

The most significant feature of China's outbound investments is the overwhelming weight of M&A investment (Figure 1-3). After the Chinese government eased restrictions on outbound investments in 2014, large-scale M&A investments led to a record USD 46 billion in Chinese investments in the U.S. in 2016. However, the Chinese government's renewed tightening of capital controls and crackdown on highly leveraged private investors has led to a significant decline in outbound investments, particularly in real estate and entertainment. Since then, Chinese investments in the U.S. have continued to decline, most notably due to the decoupling/de-linking from China by the U.S. in recent years. The U.S. government has restricted the activities of some Chinese companies in the U.S. market for national security reasons. Such restrictions include a ban on the use of Chinese-made telecommunications equipment. In addition, the vetting process for foreign investment in the U.S. has been further tightened, reducing Chinese investments in the U.S. to less than USD 10 billion per year by 2019[24].

Chinese investments in Europe shows a similar trend to those in the U.S. Since the August 2016 acquisition of the German industrial robot manufacturer KUKA by Chinese general electronics manufacturer Midea, Europe's caution about Chinese companies acquiring European companies has rapidly increased. Subsequently, due to a decline in M&A investments, Chinese investments in Europe fell to a 10-year low in 2022. However, in the same year, new Chinese investments exceeded the M&A investment for the first time since 2008. While real-estate investment fell

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[23] In December 1997, the then General Secretary Jiang Zemin discussed the concept of "Go Global" as being inseparable from the introduction of foreign capital during a meeting with representatives of the National Foreign Investment Promotion Conference. For a background on the "Go Global" strategy, see Ohashi, Hideo (2008), "The Structural Shift of the Chinese Economy to the 'Go Global' Strategy," in Goro Takahashi (ed.), *The Chinese Economy Expanding Overseas*, Nippon Hyoron Sha

[24] Ohashi, Hideo (2023) "Issues Regarding U.S. Trade Policy toward China," in Koichi Ishikawa, Keiichi Umada, and Kazushi Shimizu (eds.), *Growing Geopolitical Risks and the Asian Trade Order*, Bunshindo

sharply, electric vehicle-related investments by major Chinese battery manufacturer CATL and others were the driving force. European governments continue to strengthen their investment screening of semiconductor companies and critical infrastructure, which has had a significant impact on the acquisition of strategic assets in Europe by Chinese companies.

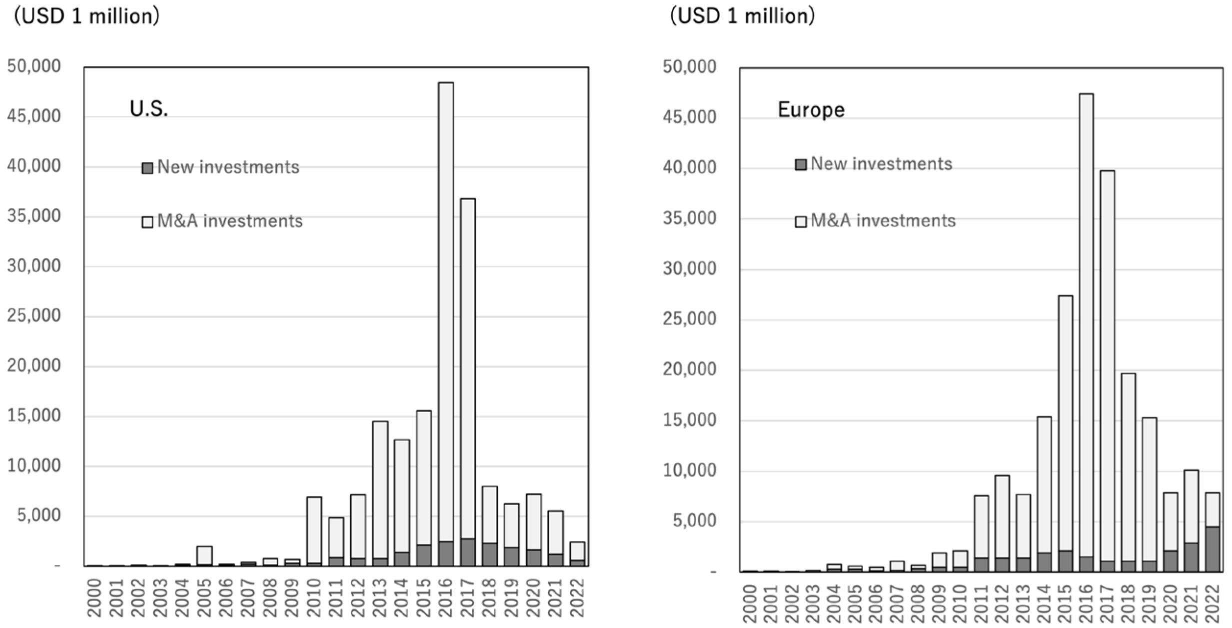

Figure 1-3. Chinese Investment in the U.S. and Europe

Sources: (left) Rhodium Group (2023), Rhodium Group and National Committee on U.S.-China Relations (2020); (right) Rhodium Group (2023), Rhodium Group (2021)

1.4.3 Government Procurement

1.4.3.1 Government Procurement and Domestic Production Strategy

In China, government procurement is being promoted as a means of promoting the domestic production of core technologies, with preference given to domestically produced goods. According to an internal notice sent by the Ministry of Finance and the Ministry of Industry and Information Technology in May 2021 to domestic hospitals, companies, and state agencies, local procurement ratios of 20%-100% have been set for 315 items, including medical equipment such as X-ray and MRI machines, ground-based radar equipment, optical equipment, livestock-related products, and marine and geological equipment[25].

A similar trend of prioritizing domestic production can be seen in the IT sector[26]. In 2016, the China Electronics Standardization Association, a non-profit organization under the Ministry of Industry and Information Technology,

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[25] For a report on Order 2021/551, "Auditing Guidelines for Government Procurement of Imported Products" (May 14, 2021), see "China Quietly Sets New Localization-Rate Target for State-Owned Enterprise Procurement" (August 3, 2021), available at https://www.reuters.com/article/idUSKBN2F404.

[26] "China's 'Secret Organization' to Promote IT Domestication," *The Nihon Keizai Shimbun*, May 21, 2020

established a Work Committee on Securing Safe and Reliable Technologies for the R&D of safe and reliable core hardware and software technologies. The Committee prepared a draft "Secure and Controllable (or 'Innovative Information Application') Catalogue" of member companies' products, and after a review by the Ministry of Industry and Information Technology, local governments procure products from the Catalogue. The Catalogue lists the names of "Secure and Controllable" member companies, model numbers, and prices for each product, such as printing machines, copiers, and antivirus software. The conditions for being listed in the Catalogue are as follows: ① company depends on non-foreign capital (foreign capital ratio of 20% or less, CEO and spouse of CEO are Chinese nationals, and company has a sales record of at least three years in China); ② company undertakes production, design, and planning in China; and ③ company has the ability to test product functions in-house and provide after-sales service. Apparently, however, the conditions for being listed are not given in writing but communicated orally by supervisors at the Ministry of Industry and Information Technology.

1.4.3.2 Government Procurement Issues

In response to the trend toward government procurement that prioritizes domestic production, foreign business organizations such as the Japanese Chamber of Commerce and Industry in China have pointed out problems with the "Secure and Controllable" and "Innovative Information Application" systems[27]. China's Government Procurement Law (2002) limits the scope of government procurement to "domestic goods, construction, and services" (Article 10). China also does not participate in the World Trade Organization (WTO) Agreement on Government Procurement. An important point of contention in trade negotiations among Japan, the U.S., Europe, and China has been the inclusion of local governments as entities implementing government procurement. Moreover, in recent years, there has been a growing trend toward excluding foreign-owned companies from government procurement for "data security."

According to the Japanese Chamber of Commerce and Industry in China, the "Secure and Controllable" and "Innovative Information Application" systems went into effect in 2019, after which listings have been in progress. However, official information is "internally notified" to foreign firms, and the conditions and criteria for selection for government procurement are not disclosed. As a result of the "internal notice" in May 2021, which indicated a policy to increase the ratio of purchasing domestically produced products in government procurement for some medical equipment and measuring equipment, there was a series of lost orders and bidding restrictions for foreign firms involved in government procurement. In response, China's Ministry of Finance issued the "Notice on the Implementation of Relevant Policies regarding Equal Treatment for Domestic and Foreign-invested Enterprises in Government Procurement Activities" (October 2021). However, products eligible for equal treatment are limited to those manufactured in China by foreign-invested companies, and restrictions on foreign companies' participation in government procurement continue.

However, some information about the "Innovative Information Application" system can be confirmed through publicly available information. According to the Chinese Institute of Electronics, which is under the umbrella of the Ministry of Industry and Information Technology: ① Product areas include the four fields of basic hardware, basic software, application software, and information security; ② the most important fields are chips, complete machines,

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[27] The Japanese Chamber of Commerce and Industry in China points out problems with government procurement in China in the 2020 edition of the "White Paper on the Chinese Economy and Japanese Companies." The following statements are based on the "White Paper on the Chinese Economy and Japanese Companies," 2020-2022 editions.

operating systems, databases, and middleware; and ③ application areas include major infrastructure areas such as party/government, finance, and telecommunications, for a total of 10 fields. The Institute forecasted that the "Innovative Information Application" system would be fully deployed in key industry sectors over the next three years (2021-23)[28].

From this, the Japanese Chamber of Commerce and Industry in China summarizes the issues as follows. First, there is concern that Chinese companies will be obliged to use independently developed and manufactured products for key components and software in a wide range of product and service areas. Second, while many countries publish relevant systems and clarify procurement standards upon joining the WTO Agreement on Government Procurement, in China, the existence of this list is not made public in a manner that can be confirmed. Therefore, the requirements for inclusion are opaque, meaning that foreign companies are unfairly excluded and suffer disadvantages.

1.4.3.3 Office Machines

In the case of office machines, due to the revision of security standards, all design and manufacturing processes for multifunction printers/copiers must be carried out in China, and key components must be designed and manufactured in China. These components comprise main control chips, laser scanning components, capacitors, electrical resistors, and motors[29]. The Japanese government and Japanese companies have expressed objections to the exclusion of products with high-security features from government procurement. Simultaneously, however, concerns have been expressed about technology leakage through cooperation in domestic production. Meanwhile, there are growing expectations among the Chinese government and companies for domestic production with the acquisition of technology through technology transfers. Especially at the high-security level, any involvement of foreign companies in domestic production is prohibited, and foreign investment is excluded in terms of national security. In particular, control boards and software related to communications are to be made entirely in China.

The multifunction printer/copier market in China is facing a shrinking market due to the increasing use of paperless products, and revenue is dependent on consumables such as toners. As a result, local companies such as Ninestar have emerged as third parties; these Chinese companies are the driving force behind domestic production. Under these circumstances, the Chinese government has been promoting a policy of domestic production of office equipment; in January 2008, it introduced a certification system for security-related products based on the China Compulsory Certificate (CCC) System[30]. However, in April 2022, it was reported that the Chinese government had begun to consider revising the national standards[31]. The initial draft called for design, development, and production within China, including for core components related to semiconductors and lasers needed to operate office equipment. However, the working group of the National Information Security Standardization Technical Committee (TC260), which considers the renewal of national standards, deleted this required item in a public comment presented to companies in May 2023. This was probably due to technical issues with regard to domestic production and out of consideration for foreign investment.

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[28] Chinese Institute of Electronics, "China Innovative Information Application Industry Development White Paper (2021)"; https://potato.gold/data/uploads/pdf

[29] "Multifunction Printers/Copiers: Design and Manufacturing Requirements in China," The *Yomiuri Shimbun*, July 3, 2022

[30] China Compulsory Certificate System (CCC) Certification

[31] "China Withdraws Request for Technology Transfer of Multifunction Printers/Copiers, Perhaps Out Of Consideration for Foreign Firms," *The Nihon Keizai Shimbun*, July 26, 2023

1.4.3.4 Medical Equipment

The Chinese government's stance on the domestic production of medical equipment is quite clear, given that the medical and healthcare sectors, which are vital to the lives of its citizens, are inseparable from national security. Soaring medical costs associated with the use of expensive imported medical equipment have become a social problem.

According to the above-mentioned Ministry of Finance and Ministry of Industry and Information Technology import screening criteria for government procurement, as of May 2021, of the 315 items subject to screening, 178 were medical devices (domestic procurement ratio 100%: 137 items; 75%: 12 items; 50%: 24 items; 25%: 5 items; 50% or less: 29 items [24 + 5 items]). Items to be 100% domestically produced include MRI machines, digital X-ray imaging systems, positron emission tomography (PET) machines, fundus cameras, microscopes, dynamic blood pressure systems, specimen testing equipment, dialysis machines, endoscopes, and exercise rehabilitation equipment[32]. However, some leeway has been given with regard to those items being completely produced domestically. Local governments have designated items for which prior screening of imports can be omitted, and the Ministry of Industry and Information Technology has announced a "Catalogue of Key Technological Equipment" to be introduced into the Chinese market for the first time. However, the very establishment of screening standards for imported products came as a major shock to foreign medical device manufacturers.

Meanwhile, support for domestically produced medical equipment is extremely generous. First, there is government procurement to support projects, including those using state funds. In addition, if a company is certified as a high-tech enterprise, it is allowed a 15% corporate income tax rate, tax credits, and a shortened depreciation period for fixed assets. In addition, the state provides financing support, issues bonds, attracts venture capital funding, provides financial support for mass production, and provides priority review for patent applications.

In response, major foreign medical device manufacturers, such as General Electric, Siemens, and Philips, are seeking to expand their opportunities to avail government procurement by registering products produced in China. The state is promoting the establishment of R&D centers, localization of production lines, and domestic procurement of parts. It is also paying close attention to the risk of technology leakage.

1.4.3.5 Information and Data

Movements related to "self-reliance and self-improvement" are inextricably linked to movements in China's information and data management. In September 2022, the State-owned Assets Supervision and Administration Commission instructed government agencies and state-owned enterprises in an "internal document" ("Document No. 79") to complete the "domesticization" of their information systems by 2027. Meanwhile, from January 2023, they are to report quarterly on their progress in domesticization. "Document No. 79" was shared through verbal explanations only and was not physically distributed[33]. The target for domestic production is office equipment such as computers and multifunction printers/copiers, servers, email, and file systems. The plan is to proceed in three stages: ① the CCP and the government will promote domestic production to improve the quality of domestic products and foster medium-

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[32] Yan Hua, "Rising Domestic Production in China's Medical Equipment Market Forces Foreign Companies to Change," The Japan Research Institute, *Opinion*, November 19, 2021; https://www.jri.co.jp/page.jsp?id=101530

[33] "China's Internal Instructions for Total 'Domesticization' of Information Systems: Elimination of Foreign Firms," The *Yomiuri Shimbun*, July 7, 2023

sized manufacturers; ② domestic production will be expanded to the "eight key industries": finance, communications, electricity, oil, transportation, aerospace, education, and medicine; and ③ it will then be expanded to all other industries.

The demand for the domestic production of IT equipment is closely related to data localization and free cross-border transfer of data. China's Network Security Law[34] requires that personal and important data that the individual does not consent to share, that pose a political, economic, technological, or national security risk, or that the relevant government department does not allow to be transferred out of the country, should be stored domestically.

Today, China is characterized by an IT-enabled authoritarianism ("digital Leninism"), with the concept of "national security" at its core. Giant overseas IT companies, such as Google, Apple, Facebook and Amazon (GAFA), are blocked from the Chinese market due to their refusal to localize data, and IT companies, most notably Baidu, Alibaba, and Tencent (BAT), have established a dominant position in China by filling the gap. Thus, the interests of the CCP and BAT, which has now gained a monopoly, are aligned; in the "new era" of Xi Jinping's China, it is possible to see the formation of a mutually complementary and reinforcing relationship between "national security" and "self-reliance and self-improvement" in industrial development and the promotion of science and technology.

1.5 Conclusion

Moves to promote domestic production have also been seen in the electric vehicle (EV) industry. The Chinese government has directed the use of domestically produced electronic components and is working to prevent the outflow of technology for automotive batteries and high-performance magnets, with the goal of creating a complete domestic supply chain in the EV industry[35]. Considering the future potential and scale of the EV industry and the fact that China is currently the world leader, this will have an enormous impact on the international economy.

If industrial policies, including various promotion measures and preferential treatments, are implemented in the name of "national security," it may lead to a certain level of development and promotion of industries and science and technology that would be difficult to generate from an economically rational standpoint. However, it is difficult to believe that this will bring about autonomous and sustainable development. To begin with, "national security" is incompatible with "independent innovation" and innovation activities that rely on free and flexible ideas and expression, as well as originality and creativity.

Meanwhile, in today's international economy, where the U.S.-China conflict and the "New Cold War" are afoot, there are many cases where regulations and restrictions are imposed on economic activity for security reasons, and these are often discussed in relation to the security exceptions in GATT Article XXI[36]. At issue here are measures that a contracting party "considers necessary for the protection of its essential security interests." Specifically, this refers to trade in fissionable materials, arms, ammunition, and implements of war, as well as measures to be enforced in time of war and other emergencies in international relations. However, as this chapter should have made clear, China's

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[34] The People's Republic of China Network Security Law, November 7, 2016; https://www.gov.cn/xinwen/2016-11/07/content_5129723.htm

[35] "China's Domestic Production of EVs in Crisis Due to Conflict with U.S.; Aims to Establish Technological Hegemony," The *Yomiuri Shimbun*, September 17, 2023

[36] Kenta Hirami (May 16, 2019) "Economic Regulation on National Security Grounds and the WTO Security Exception," Japanese Society of International Law *Expert Comments*, No 2019-6; https://jsil.jp/archives/expert/2019-6

concept of "national security" is quite foreign to the WTO security exception. China's quest for "self-reliance and self-improvement" in industrial development and the promotion of science and technology involves contentious issues that could be the seeds of new international conflicts.

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https://www2.jiia.or.jp/pdf/research/H28_China/01-takagi.pdf

National Security Law of the People's Republic of China; https://www.gov.cn/zhengce/2015-07/01/content_2893902.htm

"Made in China 2025"; https://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm

Chinese Institute of Electronics, "China Innovative Information Application Industry Development White Paper (2021)"; https://potato.gold/data/uploads/pdf

Hirami, Kenta (2019) "Economic Regulation on National Security Grounds and the WTO Security Exception," Japanese Society of International Law *Expert Comments*, No 2019-6; https://jsil.jp/archives/expert/2019-6

2 Features of Recent Chinese Research Funding Policies: Current and Future R&D System from the Viewpoint of R&D Funding Methods

2.1 Introduction

The recent remarkable growth in the numbers of, and citations to, China's scientific papers has attracted attention in many countries, including Japan. Given Japan's declining research capabilities, there is growing interest in what distinguishes China's science and technology policy and R&D systems. Behind this interest may be two questions: what is the secret to China's development of its research capabilities, and why has this development apparently not led to the creation of original results? While finding immediate, specific answers to these questions is difficult, let us set aside for the moment the constant emphasis on China's development and discover some new aspects on the situation and a better understanding of the background. Doing so may offer some pointers for Japan, which has been suffering from a decline in research capacity in recent years.

Few research studies have conducted an in-depth analysis and evaluation of China's science and technology policy and R&D systems. In particular, if one tries to find answers to the above two questions, one is confronted with various limitations, and it is difficult to get a clear picture of the actual situation. The number of researchers in China alone amounts to more than 2.2 million, and there is a plethora of views on their achievements. Local governments are also trying to create a variety of new innovations in an effort to stand out. Individual views and activities are only one part of the story, and it is difficult to find a starting point for further questioning. The APRC of the JST has conducted several research studies that have risen to the challenge of taking a fresh approach[1]. In particular, "China's Presence in International Scientific and Technological Activities" provides a summary of China's growing presence and leadership in various international contexts. China's ambition to improve the quality of its domestic scientific journals and become a leading force in science internationally is in stark contrast to the reality that it has not progressed halfway toward this goal. However, it would be interesting to watch how China will distinguish itself in a variety of noteworthy aspects by 2035. This is the halfway point between 2021, the 100th anniversary of the founding of the Communist Party of China, and 2049, the 100th anniversary of the founding of the People's Republic of China. Plans include increasing the proportion of basic research expenditure to more than 8%, strengthening basic research efforts in private enterprise, attracting excellent overseas research talent, and developing world-leading scientific journals.

This chapter takes a new perspective of China's science and technology policy and R&D systems. Various countries have established R&D funding systems. However, the success or failure of research depends not only on the amount of R&D funds but also on the method of allocation and the degree of freedom in how the funds are used. In particular,

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[1] Research Report, "Policies, Key Industries and Science and Technology underlying China's Manufacturing Power Strategy": https://spap.jst.go.jp/investigation/downloads/2022_rr_03.pdf; "China's Presence in International Science and Technology Activities": https:// spap.jst.go.jp/investigation/downloads/2023_rr_01.pdf; "R&D Policy Trends on Carbon Neutrality in China and Korea": https://spap.jst.go.jp/investigation/ downloads/2022_rr_04.pdf: and "Study on Analysis of the Structure and Functions of China's Science and Technology Intermediary Agent": https://spap.jst.go.jp/investigation/downloads/2022_rr_06.pdf; etc.

the method of investing R&D funds is an issue directly related to research outcomes.

China's distinctive approach to investing in R&D appears to reveal how the Chinese government and the CCP perceive and position science and technology. It is of deep interest to see what developments unfold as China's international presence grows. Furthermore, approaches to investing in R&D are also a topic of debate in Japan, the U.S., and Europe. Indeed, this is an issue that will determine the future of science and technology not only in China but also in every country. Therefore, it can be believed that R&D investment approaches are an important perspective for making cross-sectional evaluations.

2.2 Analysis from the perspective of the issue of approaches to investing in R&D

2.2.1 Global R&D Expenditures

Before discussing approaches to investing in R&D, let us touch on the situation of R&D investment in major countries. As shown in Figure 2-1, China's investment growth has been remarkable, and is already approaching that of the U.S. This section examines how the public sector, which accounts for just under 20% of total national R&D expenditure in Japan, the U.S., and China, invests in R&D.

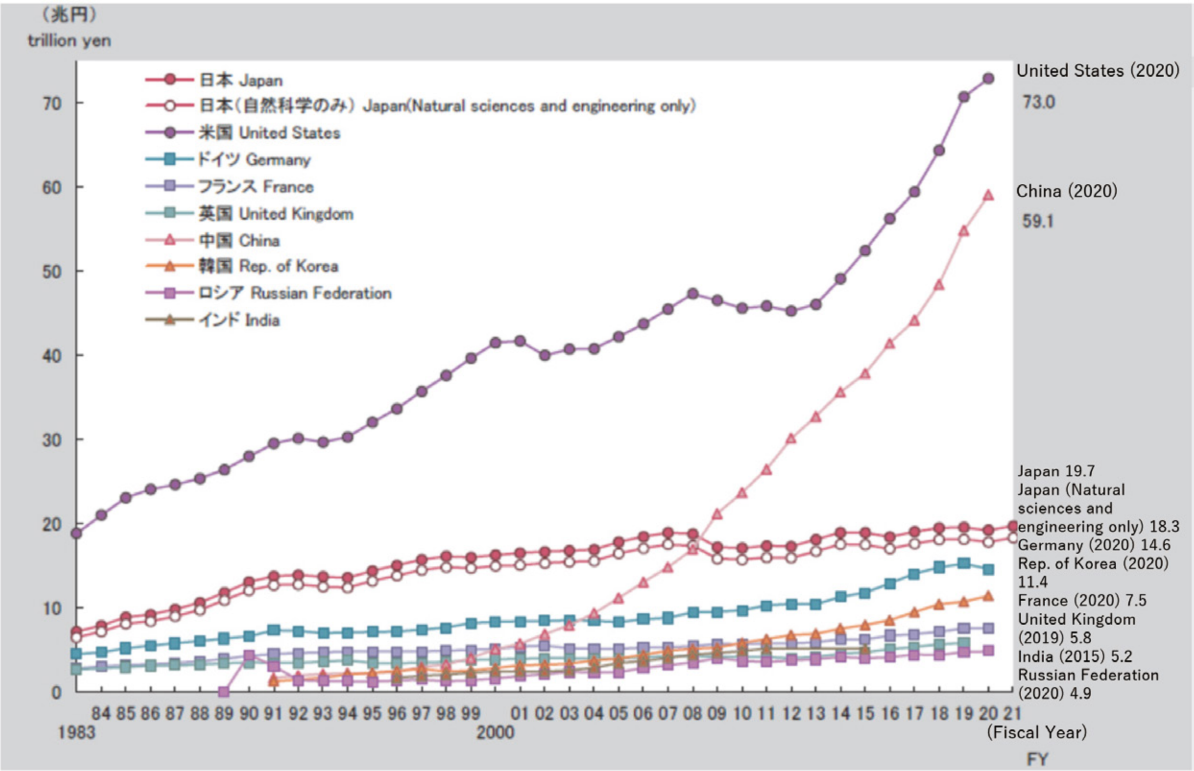

Figure 2-1. R&D Expenditures in Major Countries (OECD Purchasing Power Parity Equivalent)

Source: Fiscal Year (FY) 2022 Science and Technology Handbook
(Ministry of Education, Culture, Sports, Science and Technology)

2.2.2 Discussions on Approached to Investing in R&D (European Research Area and Japan)

The OECD Frascati Manual is well-known for its classification of R&D expenditures, which is used in policy analyses in many countries. Its statistical contents include the total amount of R&D expenditures, their proportion in the GDP, the public-private burden and usage ratios, basic research/applied research investment amounts and ratios, and usage ratios by institution. However, most of these statistics are limited to quantitative comparisons, and there is little analysis of their impact on R&D outcomes.

What should we look at to derive policy implications from statistics? What can offer suggestions on their implications in terms of policy, leading us to a deeper understanding? As one way to do so, it may be important to focus on how R&D expenditures are invested and used, with indirect costs, mainly personnel costs, being particularly crucial. For example, in the U.S., government research grants to universities and research institutions often include researchers' salaries. The European Union (EU) has no uniform standards for the use of personnel expenses in research grants, leaving this to be decided at the national level.

Meanwhile, in Japan, there has been much discussion regarding the use of operating-expense grants and external funds (competitive funds, subsidies, etc.) for financial measures for higher education institutions. In the European Research Area, there has also been discussion about the need to harmonize institutional subsidies and competitive funding[2]. The concept of a "dual support system"[3] has been raised, under which multiple types of support are provided with an appropriate balance. There is a need to combine two approaches to build a diverse and detailed funding system. These approaches are subsidies for basic expenses such as operating-expense grants and the allocation of competitive funds.

Therefore, the focus is on the ways in which the public sector bears R&D costs in terms of total amounts and their distribution ratios. Figure 2-2 shows the situation of allocations to national university corporations in Japan. Such statistics for the U.S. and other countries are hard to find. It would be difficult to classify funding into competitive and non-competitive funding, organize the scale, and make international comparisons.

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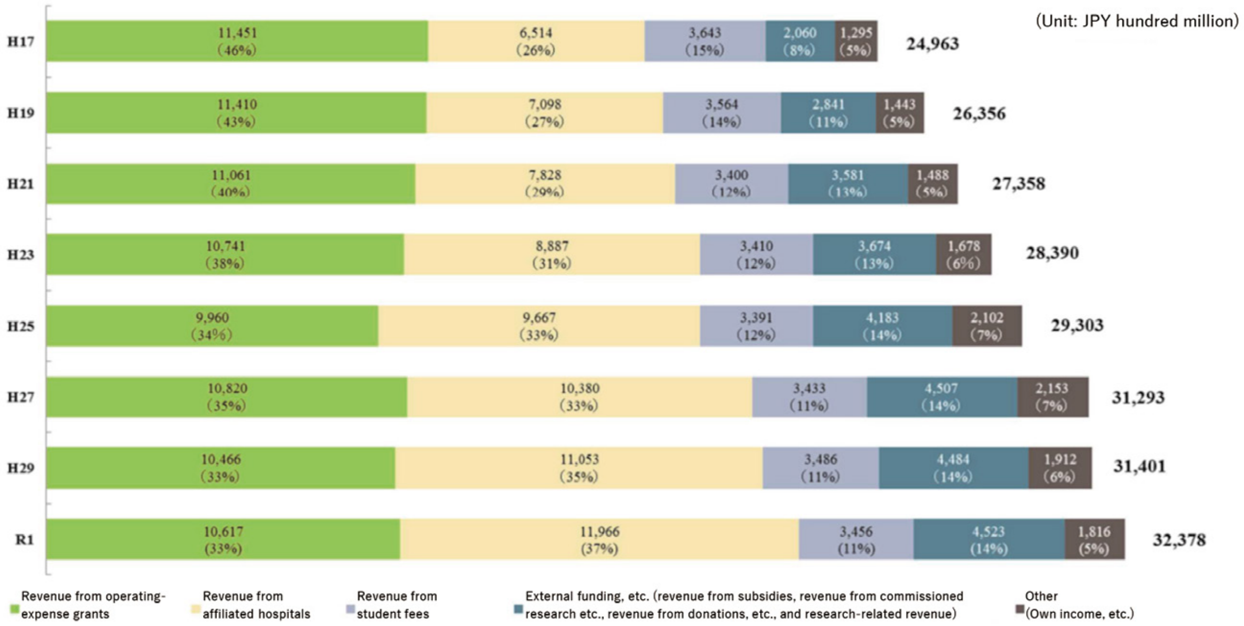
[2] European Research Area and Innovation Committee (ERAC; 2015), "ERAC Opinion on the European Research Area Roadmap 2015-2020"
https://data.consilium.europa.eu/doc/document/ST-1208-2015-INIT/en/pdf

[3] Central Council for Education, Ministry of Education, Culture, Sports, Science and Technology, "Future Vision of Japanese Higher Education," January 28, 2005
https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/attach/1335597.htm



Prepared on the basis of each national university corporation's financial statements for Fiscal Year 2019, etc.

Figure 2-2. Ordinary Income of National University Corporations (90 corporations)

Source: "Current Situation Surrounding National University Corporation Operating-Expense Grants" (Ministry of Education, Culture, Sports, Science and Technology)

2.2.3 Why is the approach to be chosen for investing in R&D an issue?

What results could be achieved by a discussion on how to invest in R&D? An example of interesting previous research is given in Figure 2-3[4]. It can be seen that competitive funding is relatively high in science and engineering universities and low in education universities. It would be important to consider, for example, what impact this has on the number of papers published and their citations. For example, Heyard and Hottenrott[5] analyzed the impact of competitive funding allocations on knowledge creation and found an effect of one additional publication two to three years after the receipt of funds.

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[4] Urata, H. (2010), "Trends in Financial Resources of National University Corporations: Operating-Expense Grants, Own Income, and Competitive Funds";
https://www.niad.ac.jp/media/001/201802/ni006008.pdf

[5] Heyard, R. & Hottenrott, H. (2021) "The value of research funding for knowledge creation and dissemination: A Study of SNSF Research Grants"; https://www.nature.com/articles/s41599-021-00891-x#Sec16

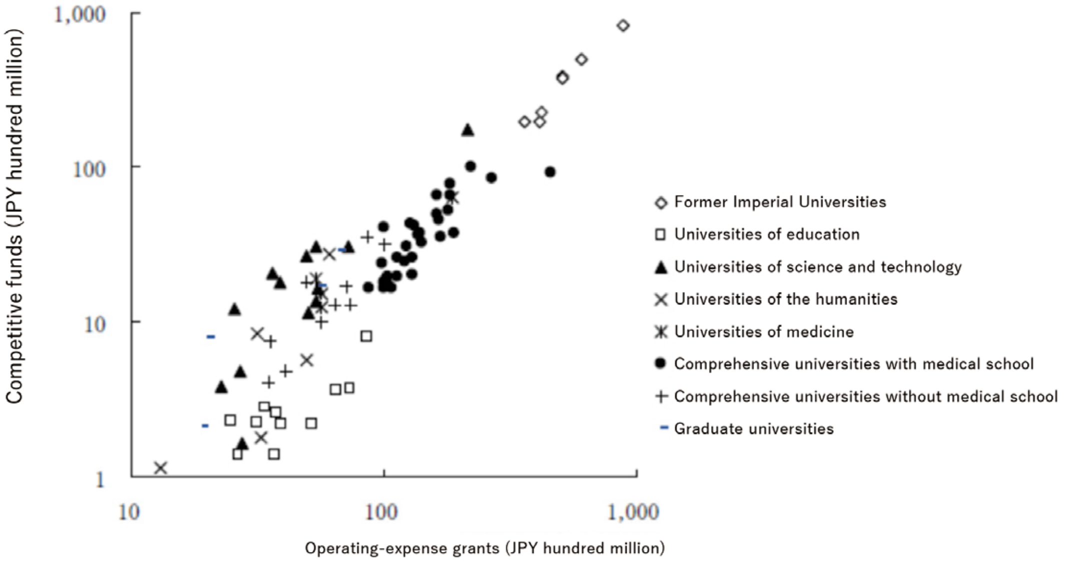

Figure 2-3. Grants-in-Aid for Operating-Expense Grants and Competitive Funding

Source: "Trends in Financial Resources of National University Corporations: Operating-Expense Grants, Own Income, and Competitive Funds" (Hiroaki Urata)

There is no space here to discuss specific methods for managing the use of R&D funds. It is noted, however, that the details of how R&D funds are to be used have a direct impact on the creation of research outcomes. These details include how funds can be used, what they can be used for, whether they are subject to organizational management, and whether researchers have a large degree of discretion, especially regarding personnel costs. Japan's competitive funding places many restrictions on the freedom of using personnel expenses, both for permanent and fixed-term employees. This poses an important challenge that negatively impacts Japan's ability to win in the global competition for young, talented researchers.

2.2.4 Issues of Competitive and Non-Competitive Funding in China

What do we know about R&D spending in China? To date, no previous studies that have analyzed it from this perspective have been found. In addition, in the statistics published by China, such as the China Statistical Yearbook on Science and Technology, no information for analyzing the situation of institutional subsidies and competitive funding allocations in the country is available.

In 2014, China's funding system was reorganized into five programs with the aims of eliminating drawbacks such as duplication and excessive concentration of competitive research funds and managing funds more efficiently. The five systems are the National Natural Science Foundation, Major National Science and Technology Projects, the National Key R&D Plan, the Technology Innovation Guidance Plan, and Research Centers and Talent Program. The programs are implemented at three levels: central government (Ministry of Science and Technology, Ministry of Education, National Development and Reform Commission), local governments at various levels (science and technology agencies, finance bureaus, etc.), and some private organizations. Of these funding programs, only the National Natural Science Foundation has disclosed the total size of its funding. In 2022, it was RMB 32.5 billion (approximately 650.5 billion yen, more than twice the size of Japan's Grants-in-Aid for Scientific Research [KAKENHI]).

The ratio of competitive to noncompetitive funding at the Chinese Academy of Science (CAS) is shown at Figure 2-4. Research expenditures, which totaled approximately RMB 44.3 billion in 2015, increased to approximately RMB 81.5 billion in 2020. The total amount allocated to the affiliated institutes is approximately RMB 74 billion, of which approximately RMB 29.7 billion (40%) is from central government grants, RMB 21.9 billion (30%) from competitive central government funds, RMB 8.5 billion (11%) from local government funds, RMB 12.7 billion (17%) from private funds including CAS-funded companies, and RMB 1.3 billion (2%) from other sources, including foreign funds.

While the nature of local government and private funding is unknown, a comparison between 2015 and 2020 shows that the ratio of competitive funding has not changed much. Grants determined to be noncompetitive have decreased, with the ratio of central government grants to competitive funding being approximately 6:4 in 2020. Thus, it is not possible to reach a definitive conclusion based on the CAS situation alone. However, let us note that in 2007 and 2008, 21 of the 27 EU countries had less than 40% of their research funding coming from competitive sources[6] (as of 2008, the member states included the UK but not Croatia). There should thus be no major problem in assuming that the percentage of competitive funding is relatively high in China's leading domestic and world-class research institutions.

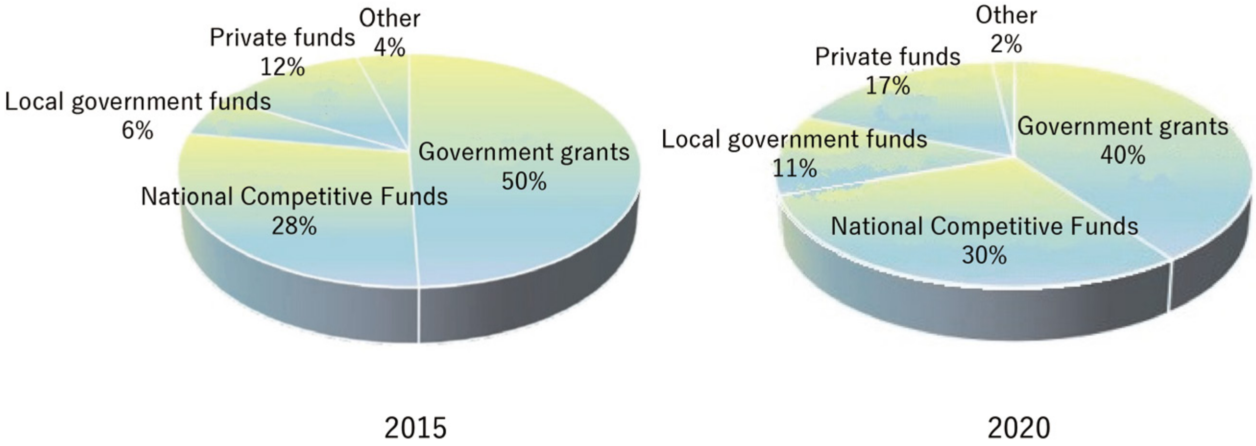

Figure 2-4. Sources of Research Expenditures at the Chinese Academy of Sciences

Source: Overview of the Chinese Academy of Sciences and the Current Situation of Science and Technology in China" and "Research Functions of the Chinese Academy of Sciences" (Yukihide Hayashi)

In Japan, at the University of Tokyo, a national university corporation, revenues from commissioned projects (revenues from obtaining competitive funds, etc.) were approximately JPY 75 billion compared with approximately JPY 80 billion in operating-expense grants in FY2022. The sources were thus about the same size[7]. However, it is difficult to estimate the percentage of the operating-expense grant spent for research, which is the basic cost for conducting education and research. Assuming that the same amount was spent on education and research, respectively, the ratio of operating-expense grants and commissioned-project revenues spent on research would be

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[6] ERA-WATCH (2007, 2008)

[7] The University of Tokyo, "Financial Results for FY2022"; https://www.u-tokyo.ac.jp/content/400221442.pdf
Revenue from commissioned research, etc. includes indirect expenses from Grants-in-Aid for Scientific Research.

about 3:7. In contrast, at RIKEN, a designated national research and development corporation, in FY2022, revenues from commissioned projects were approximately JPY 21.5 billion compared with operating-expense grants of approximately JPY 54.5 billion, a ratio of approximately 7:3[8].

As a discussion of global trends in research funding and the situation in China, the report by Bai et al.[9] is of deep interest. They explain that there are two main ways of investing research funds for basic research: institutional subsidies and competitive funding. They raise the issue that Chinese universities and research institutions have become extremely homogenized under a state of excessive competition and explain that the funding system needs to be optimized. The report goes on to say that China is working on achieving a balance between institutional subsidies and project funding, but that there is an increase in competition-oriented project funding and a lack of institutional subsidies to provide long-term support to meet the country's needs and provide incentives to continue working on specific issues.

Although there is no space to discuss this in detail here, the U.S. and Europe have made institutional and organizational enhancements in recent years to promote goal-oriented R&D. The creation of the National Science Foundation's Directorate for Technology, Innovation and Partnerships in 2022 is a prime example. This situation is also highlighted by Bai et al. as being in the purview of China's policy formulation.

Some observers believe that China has an advantage in promoting goal-oriented research. Chen et al.[10] look back on 150 years of the history of the development of science and technology and argue that in the present era, when the driving force has shifted from Europe to the U.S., China, which has established a dominant science and technology policy and promotes goal-oriented research, will become a major force in global science and technology development in the next few decades. China, which has accumulated practical experience in balancing the roles of government and the market, is the best at promoting goal-oriented research.

Considering these two reports, it is likely that China will choose policies that will further strengthen its innovation by moving away from the current situation, in which competitive funding is dominant, as shown by the example of the CAS. It will likely adopt policies that emphasize institutional subsidies concentrating on goal-oriented research. China will do so while leveraging its extensive experience in harmonizing the roles of the government and the market. In Japan, exploratory basic research is mainly conducted with the help of institutional subsidies such as operating-expense grants and a portion of the competitive KAKENHI funds, whereas goal-oriented basic research and applied/development research is mainly conducted with competitive funding, excluding a portion of the KAKENHI funds. It is therefore important to bear in mind the differences in the sources and uses of R&D funding in China and Japan.

2.2.5 General Secretary Xi Jinping's Recent Policies (July 2023)

Since assuming office, Xi Jinping has occasionally laid out his guiding principles on the state of science and technology innovation, academics, and research. In particular, the strengthening of basic research is addressed below.

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[8] RIKEN "Financial Report for FY2022"; https://www.riken.jp/medialibrary/riken/about/info/zaigen/zaimu-2022-2.pdf

[9] Bai, A. et al. (2021), "Evolution and Features of China's Central Government Funding System for Basic Research"; https://doi.org/10.3389/frma.2021.751497

[10] Chen, J. et al. (2021) "Beyond catch-up: Could China become the global innovation powerhouse? China's innovation progress and challenges from a holistic innovation perspective," https://doi.org/10.1093/icc/dtab 032

In February 2023, the CCP Central Committee Politburo conducted a third collective study session on strengthening basic research[11]. On that occasion, Xi stated the need to strengthen the forward-looking, strategic, and systematic development of basic research. He declared that it is necessary to adhere to the “Four Orientations” and the “Walking on Two Paths” of goal-oriented research and free exploration, link the world’s scientific and technological forefront with the country’s major strategic needs and economic and social development goals, integrate the cutting-edge issues raised as per the laws of scientific development and the theoretical problems arising from major applied research, and formulate key scientific issues in basic research. Furthermore, he stated that it is necessary to strengthen the nation’s strategic scientific and technological capabilities; optimize the establishment of basic disciplines; support the development of priority, emerging, unnoticed, and weak disciplines; promote integration among disciplines and interdisciplinary research; and build a high-quality discipline system with overall and balanced development. The “two paths” of goal-oriented and free exploration have been mentioned frequently in the past. China’s high expectations for basic research are reflected in its emphasis on the need for strategically and systematically promoting exploratory basic research into cutting-edge scientific problems and basic research into theoretical problems required for applications.

Xi’s “Strengthening Basic Research to Achieve Self-Reliance and Self-Improvement in High-Level Science and Technology” was published in *Qiushi*, the official journal of the CCP Central Committee (*Qiushi* No. 15, 2023)[12]. In the article, he stated that strengthening basic research and solving key technology issues are urgent tasks for achieving high-quality development, and that they should be implemented appropriately in line with the report to the 20th National Congress of the CCP. He also stated that the world’s most advanced science and technology should be integrated with the nation’s major strategic needs and economic and social development goals to strengthen the strategic and systematic allocation of basic research with an eye to the future. He pointed out a need to identify trends in scientific and technological developments and national strategic needs, and continued to make the following exhortations: Organize basic research as a deepening of the reform of basic research institutions and mechanisms and expand the impact of institutional guarantees and policy guidance on basic research. Give full play to the value-driven and strategic traction roles of systems and policies. Improve the mechanism for basic research investments and optimize its support system for the national science and technology plan. Implement international and domestic peer review and promote non-consensus-based innovation research (extraordinary research for which no consensus has been reached so far). In other words, the main policy is to ensure government initiatives in the field of basic research and to ensure institutional guarantees for this purpose.

2.2.6 Specific Mechanisms of Funding Agencies for Research in Response to National Needs

One situation in which the above policies are to be specifically implemented is in the responses undertaken by funding agencies. As an example, let us consider the handling of institutional subsidies at the National Natural Science

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[11] Xi Jinping, “Strengthening Basic Research, Laying the Foundations for Science and Technology Self-Reliance and Self-Improvement,” *People’s Net Japanese Edition*, February 23, 2023;
http://j.people.com.cn/n3/2023/0223/c94474-10211904.html

[12] Xi Jinping: “Strengthening Basic Research to Achieve Self-Reliance and Self-Improvement in High-Level Science and Technology”
http://www.qstheory.cn/dukan/qs/2023-07/31/c_1129776375.htm

Foundation of China (NSFC).

The NSFC is a funding agency with a budget more than twice the size of the KAKENHI, as mentioned above, and works to "uphold free exploration" and elicit originality. Focus on Issues in Cutting-Edge Areas and Resolve Bottlenecks. In accordance with the principle of promoting research in line with common needs, cross-fertilization, and fusion research, the NSFC subsidizes efforts to address scientific problems.

The research to be supported is classified by attribute into four categories: Attribute 1: Research with strong exploratory nature or originality; Attribute 2: Research focusing on cutting-edge problems; Attribute 3: Research starting from national needs and resolving bottlenecks; Attribute 4: Research that can resolve issues common to many studies, or those based on intersecting or fusing fields. The "two paths" referred to by Xi Jinping are here classified into four categories.

Of these, it is interesting to see what weight is given to Attribute 3, which is oriented toward national needs. Table 2-5 shows the results of support for general projects by attribute for each Department and Section in FY2022. The NSFC has nine scientific departments in four sections. Attribute 2 is more common in the Department of Mathematical and Physical Sciences (Basic Science Section) and the Department of Health Sciences (Life and Medical Sciences Section), whereas Attribute 3 accounts for more than half of the Technological Science Section. Attribute 3 also accounts for more than two-thirds of the Department of Management Sciences in the Interdisciplinary and Integration Section[13]. Even at the NSFC, where the main focus is on supporting basic research, some Departments and Sections have a relatively high weight of national needs-oriented research projects, indicating a significant presence of goal-oriented basic research.

The results of other surveys conducted by the APRC likewise indicate that China's basic research policy is mainly oriented toward goal-oriented basic research. This chapter's analysis suggests a situation in which R&D investments have moved from competitive to non-competitive funding or institutional subsidies (grants), with the addition of application-oriented priority policies initiated by the government (Party). Although it is extremely difficult to determine the direction of China's policies given the limited publicly available statistical data, it is surely important to continue to follow the ratio of competitive to non-competitive funds and trends in the adoption of national needs-oriented research proposals at the NSFC.

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[13] Wen, Jun et al. (2022) "Overview of Proposal Application, Peer Review and Funding of the Department of Information Sciences of National Natural Science Foundation of China in 2022"; https://www.nsfc.gov.cn/csc/20345/20348/pdf/2023/202301-44-47.pdf

Table 2-5. National Natural Science Foundation of China General Projects Supported; by 4 Attributes (FY2022)

		General Projects			
		Attribute 1	Attribute 2	Attribute 3	Attribute 4
Basic Science Section	Department of Mathematical and Physical Sciences	4.00%	69.00%	22.00%	5.00%
	Department of Chemical Sciences	18.57%	23.36%	20.43%	14.69%
	Department Earth Sciences	-	-	-	-
Technological Science Section	Department of Engineering and Materials Sciences	2.41%	23.03%	71.46%	3.10%
	Department of Information Sciences	3.29%	37.54%	50.55%	8.62%
Life and Medical Sciences Section	Department of Life Sciences	-	-	-	-
	Department of Health Sciences	2.20%	70.54%	24.65%	2.60%
Interdisciplinary and Integration Section	Department of Management Sciences	2.70%	20.93%	69.50%	6.88%
	Department of Interdisciplinary Sciences	-	-	-	-

(Prepared by the author)

2.3 What will the Chinese government and CCP do? How will they conceptualize and position science and technology?

This chapter outlines the characteristics of R&D investment in China. China recognizes that its investment rate in basic research is low, and is planning to increase it. However, the target is about 8% of total R&D expenditures, which is lower than the ratios in Japan, the U.S., and Europe. Under such circumstances, basic research, which has been given the mandate to aim for "0 to 1," has also heavily focused on goal-oriented basic research, that is, research that contributes to resolving socioeconomic issues[14]. Therefore, even though the emphasis is on basic research or increased investments, the approach can be said to be application oriented. In fact, of the research projects subsidized

[14] Over the three-year period from 2020 to 2022, the NSFC called for original academic ideas from young and unproven researchers as "Original Exploratory Plan Projects," selected them based on new screening methods such as double-blind review and adoption of non-consensus proposals, and allowed flexible management with regard to the use of research funds. An investment of RMB 770 million was disbursed on 329 projects. It will be interesting to see how this type of funding will develop in the future. Reference: The Pilot Project of the National Natural Science Foundation of China's Original Exploration Program has Achieved Remarkable Results; https://finance.sina.com.cn/jjxw/2023-04-08/doc-imyprrzp8531591.shtml

by the NSFC, a relatively large number are classified under Attribute 3 of the four attributes: “Research starting from national needs and resolving bottlenecks.” There are concerns about the current situation, in which universities and research institutions are exhausted from coping with competitive funding. Given that Europe and the U.S. stress upon goal-oriented research investment, there is a tendency in China to seek proportional increases in institutional subsidies. There are no formal indications that a policy to reduce competitive funding is in place. Nevertheless, the policy appears to be aimed toward promoting application-oriented research by expanding institutional subsidies. This approach is more likely to more thoroughly implement the intentions of the state, Party, or organization. The Chinese government and CCP are not thinking of expanding the independent efforts of researchers driven by free exploration and then implementing the resulting innovations. Instead, they appear to be positioning science and technology as a subject that the government and Party should guide in a planned manner, and are placing emphasis on ways to allocate research and development funds in an appropriate manner.

Meanwhile, how does the funding system in China appear from the perspective of the degree of researchers' independence? Funding systems that focus on institutional subsidies rather than competitive funding tend toward a narrowing of researcher-driven structures and a broadening of organization-driven structures. In China, institutional subsidies are likely to be expanded in terms of funding, narrowing the scope of researchers' initiative. In addition to this, there are signs of a narrowing of researchers' initiative in the allocation of competitive funds. Specifically, with regard to the fairness and expertise of research, rather than relying on the independent and autonomous efforts of individual researchers and the establishment of research ethics, the trend has moved toward actively trying to introduce mechanisms that do not involve the subjectivity of researchers, such as the market and AI. The movement to impose certain restrictions on researcher-led structures appears to be an attempt to pursue more objective indicators for judgment, rather than relying on the abilities of individual researchers; another aim also appears to be systematically tackling misconduct and bad practice and making them less likely to occur. Nonconsensual research evaluation would be one such movement. Going beyond the premise that researchers participate in evaluation by bringing their respective scientific expertise, the evaluation and review methods are based on numerical indicators and outcomes, which seems to be a distinctively Chinese approach.

There is no surefire solution for any of the above issues in either Japan or China. In fact, operating-expense grants has been reduced in Japan since the creation of national university corporations, but it is difficult to assess the impact of this reduction. However, it is believed that some evaluations must be made from the perspective of science and technology administration. With China, in addition to the fact that its policies are built around the idea of managing science and technology in accordance with government and Party policies, it appears that the portion of R&D funding that is left for the free exploration of researchers is being reduced.

It is important to adopt fresh perspectives in both countries to carefully observe various aspects of their policies to evaluate the impact they will have on the future. Using the discussion in this chapter as a starting point, it is necessary to develop perspectives that respond to changes in the situation, as mentioned in the Introduction, to consider how the quality of China's R&D will change over the next decade and beyond.

2.4 Conclusion

In this chapter, approaches to investing in R&D are examined through critical thinking. Long after its period of high economic growth (1955-1973), Japan aspired to become a research superpower in the public and private sectors.

However, amid the backdrop of sluggish economic growth, long-term growth in R&D spending has been slower than in other major countries. As a result, Japan has lost its position at the forefront of R&D, along with much of its research base. Japan has been overtaken by China, India, and South Korea in the number of academic papers published and cited, and the number of students and young researchers going abroad has stagnated, leading to a decline in the number of people obtaining PhDs and making the research environment less attractive to foreign researchers. In the 30-plus years leading up to this point, the face of the country, and of science and technology, have changed dramatically. Various measures have been taken in recent years, and these endeavors will hopefully bear fruit as soon as possible.

Meanwhile, the future of science and technology in China is difficult to predict, and it will take time to determine how things will change. The perspective presented in this chapter on approaches to investing in R&D may lead to interesting discussions. However, it is unclear at this time whether China will release the necessary information for a closer examination. For the sake of international comparisons, it is hoped that China will continue to disseminate information in the future. It is also expected that future researchers and analysts of China's science, technology, and R&D systems will track the country's approach to investing in R&D. It is necessary to continue observing China from fresh perspectives and apply our findings as pointers for Japan's science, technology, and R&D systems.

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https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/attach/1335597.htm

3 China's Policy of "High-Level Technological Self-Reliance and Self-Improvement" and Research into the Development and Use of Generative AI

3.1 Introduction: The Issues Involved

Around 2015, the world's view of China's innovation capabilities changed dramatically. Before that time, the prevailing, pessimistic view was that even if China was capable of catch-up innovation, it could not become an innovation leader. Institutional and educational obstacles to innovation were cited. It was argued that China's society and education system are too homogenized and controlled, making them poor candidates for innovation and entrepreneurship. Subsequently, alarmist views of China's innovation activities and capabilities emerged, and U.S. officials began to worry about China's potential to lead and dominate the most economically important emerging technology industries. This was because, regardless of the unfair practices for which the U.S. had criticized China, it was becoming apparent that even on a level playing field, China had the potential to surpass the U.S. in areas such as 5G communications equipment, commercial drones, solar panels, and mobile payments. As a policy response, the U.S. imposed a series of technology restrictions on China and began to develop a "decoupling" policy[1].

Meanwhile, China tried to close the gap in industrial technology by riding the wave of globalism and introducing technology underwritten by foreign capital. The country has been rapidly increasing its technological capabilities under the slogan of "innovation-driven economic growth." The Chinese government has also taken the lead in enacting industrial policies, such as "Made in China 2025" (2015), to further advance the country's industries and make it technologically independent. This situation may have amplified the US wariness mentioned above and may have also triggered talk of US technology restrictions on China and a policy of decoupling. However, in an environment where technology restrictions on China and moves towards technological decoupling are occurring, China is on the defensive. It is devising ways to reduce its technological dependence on other countries and become more self-reliant. This is to be achieved through the policy of "high-level technological self-reliance and self-improvement." This constitutes a priority policy for industrial technology.

However, the battle for technological leadership between the U.S. and China is heavily charged politically, and some are questioning whether the struggle is being waged on the basis of objective analysis and evidence. This chapter will review the facts about the current state of Chinese innovation (China being the lead protagonist in the U.S.-China technological conflict), and the country's policy of "high-level technological self-reliance and self-improvement." The focus will be on generative AI as the latest emerging technology, taking it as a case study.

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[1] Bateman, J. (2022) "U.S.-China Technological 'Decoupling'";
https://carnegieendowment.org/2022/04/25/u.s.-china-technological-decoupling-strategy-and-policy-framework-pub-86897

3.2 Strategies for Building an "Innovative and Creative Nation" and the Limits of Chinese-Style Innovation

Since the start of the reform and opening up, more than three decades of rapid growth have transformed China radically, making it the second-largest economy in the world. However, the resource-intensive economic growth model has reached its limits and the economic growth rate has gradually declined, forcing a structural shift to an innovation-driven model.

3.2.1 Limitations of the Growth Model: Decline in Total Factor Productivity (TFP)

China's population has been aging and the rate of population growth began declining since around 2005. The decline in the working-age population resulted in labor shortages and rapid wage increases. In addition, while debt was increased to raise funds for fixed capital formation, the return on investment on assets was declining, making it difficult to maintain high levels of economic growth. Furthermore, the transfer of technologies underwritten by foreign capital began to stagnate. Investments shifted from export-oriented manufacturing toward domestic demand for services, and the outward-looking catch-up model of economic growth was reaching its limits.

China, like the mature economies in Japan, the U.S., and Europe, has had to compensate for lost labor and investment, the engine of growth, by increasing productivity through innovation. In reality, however, the contribution of China's multifactor productivity (approximately equivalent to TFP) to growth has declined since 2000. Figure 3-1 presents trends and estimates of the contribution of the three factors of production and multifactor productivity as a residual to China's economic growth[2]. According to this estimate, China's multifactor productivity contribution to growth is expected to be 35%-50% of the GDP (2.0%-3.0% of GDP growth) from 2015 to 2025.

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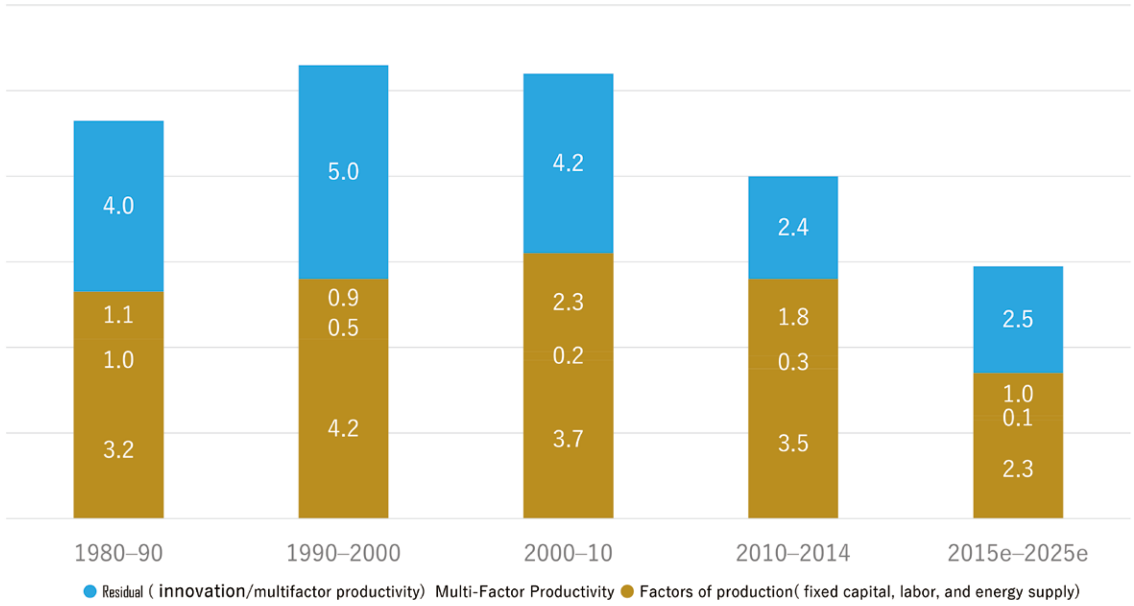
[2] McKinsey (2015) "The China Effect on Global Innovation";
https://www.mckinsey.com/~/media/mckinsey/featured insights/Innovation/Gauging the strength of Chinese innovation/MGI China Effect_ Executive summary_October_2015.ashx



Source: McKinsey (2015)

Figure 3-1. Trends and Estimates of the Contribution of the Three Factors of Production and Multifactor Productivity (TFP) as a Residual to China's Economic Growth

(Prepared by author based on McKinsey, 2015)

3.2.2 Strategy for an "Innovative and Creative Nation" and a "National System"

In light of these changes, China enacted the "National Medium- and Long-Term Program for Science and Technology Development (2006-2020)"[3] in 2006, and launched a policy aimed at becoming an "innovative and creative nation." This is an innovation-driven growth strategy that aims to make China become "innovation-creating country" by 2020 and an "innovation-leading country" by 2035, with a "national system" based mainly on corporate innovation as one of the key policy instruments. However, at present, there are no large companies with innovation capabilities (in terms of basic or large-scale technologies). Thus, the government is aiming for a style of innovation that brings together all of China's strengths, based on a "national system" that fully utilizes domestic resources, and sometimes overseas resources, to create individual innovations. Under this policy, the efforts of the government and the private sector have produced various outcomes. The three main ones are as follows.

(1) Innovation through private capital (especially progress in the digital sector)

There are several examples of successful companies implementing social innovation, including BAT (Baidu, Alibaba, and Tencent: Internet technology), DJI (mini drones), and Sany Heavy Industry (engineering machinery).

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[3] Outline of the National Medium- and Long-Term Program for Science and Technology Development (2006-2020); https://spc.jst.go.jp/policy/downloads/aprc-fy2022-pd-chn01.pdf

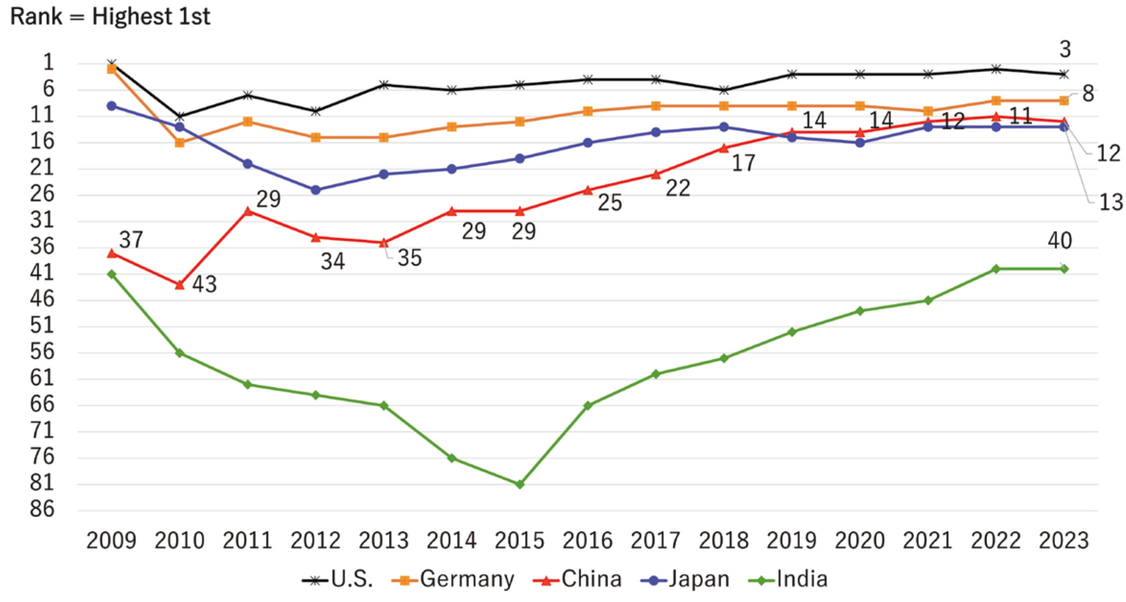
(2) An innovation model where bottom-up (private capital) and top-down (government policy) gears work together

Telecommunications equipment represented by Huawei and ZTE, wind and solar panels, and electric vehicles are thought to have benefited from efforts to form a domestic market (procurement by the state-owned sector) and promote technology transfer, based on market principles.

(3) Creation of innovations through a "national system"

In particular, successes have been achieved in the field of heavy, large-scale infrastructure, such as high-speed railways, ultra-high voltage power transmission technology, nuclear power generation, space technology, supercomputers, and the BeiDou Navigation Satellite System. The projects promoted under the "national system" are conducted as industry-government-academia collaborations. They can be evaluated as an approach to integrated innovation that involves the accumulation of applied technology development within the context of market formation, even in cases where the underlying technologies are not readily available.

Thus, China's innovation activities have achieved some success, but it is difficult to assess whether the country has realized its 2020 goal of becoming an "innovative and creative nation." The World Intellectual Property Organization (WIPO) defines the top 25 innovation leaders in its annual Global Innovation Index (GII). Figure 3-2 shows the GII of the five major countries for the last 15 years. According to WIPO's definition, China joined the ranks of innovation leaders in 2016, and although not the "most innovative country," it could be understood as an "innovation-creating country."



Data Source: WIPO; prepared by the author.

Figure 3-2. Global Innovation Index (GII) for Five Major Countries (2009-2023)

(Prepared by author based on WPO data)

3.2.3 The Previous Chinese Innovation Model: The Innovation "Sponge" Model

The most common indicators to assess innovation capacity are R&D expenditures, number of PhDs awarded, number of patent applications, and number of papers published. However, these indicators do not address innovation in the broad sense, which includes not only scientific invention but also successful commercialization of ideas and technologies, the creation of new business models, and innovation in production processes. It also does not provide information on how successful a country is in innovation[4]. For example, although China has high R&D expenditures, numbers of PhDs awarded, and numbers of patent applications, Chinese companies are not yet highly competitive internationally in fields that require long-term research efforts and innovation with scientific breakthroughs.

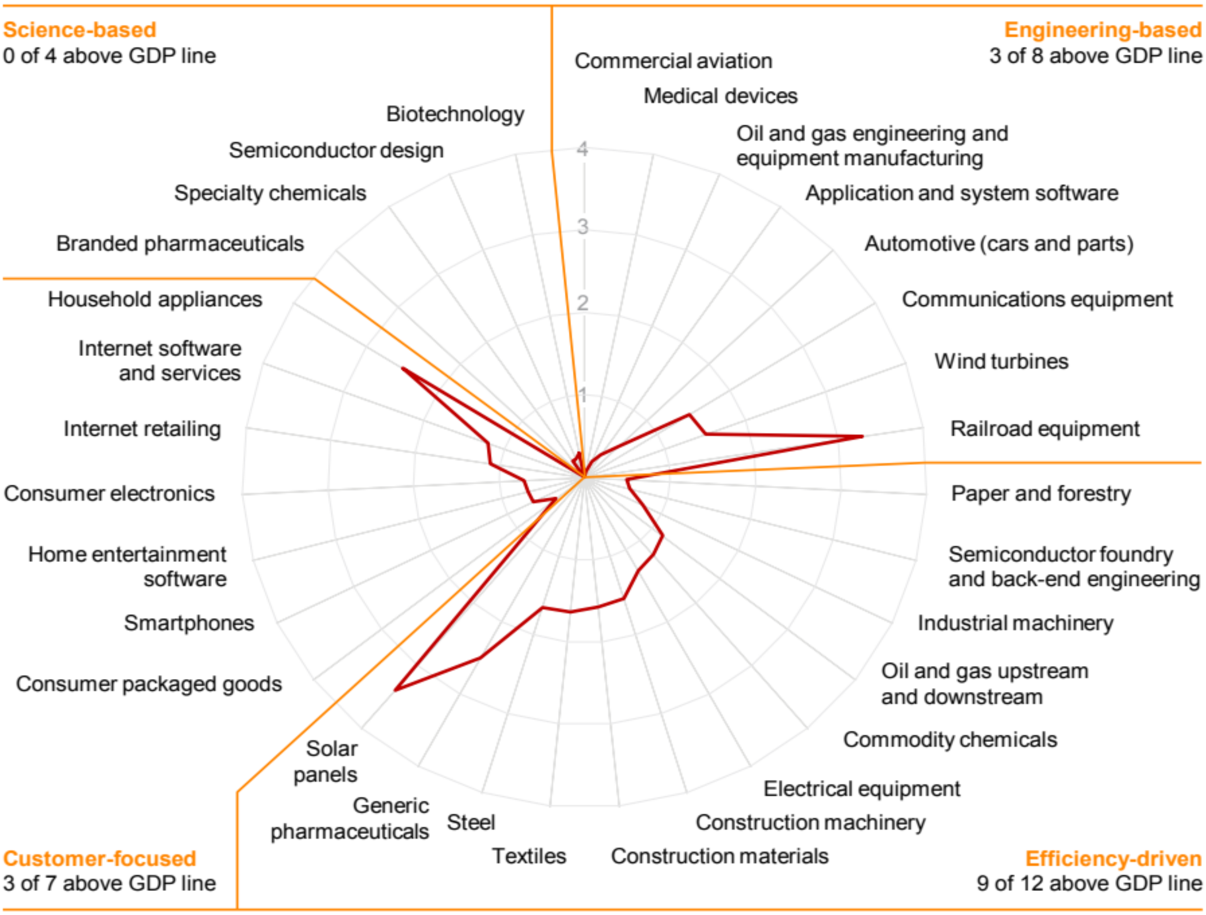


Figure 3-3. Appropriate Market Share of Revenues of Chinese Companies (2013)

Source: "The China Effect on Global Innovation" (McKinsey)

Note: Ratio of China's share of total global revenues in the sector (market share) to China's share of global GDP (GDP share) An index of 1 is when GDP share and market share are equal.

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[4] McKinsey (2015) "The China Effect on Global Innovation"; https://www.mckinsey.com/~/media/mckinsey/featured insights/Innovation/Gauging the strength of Chinese innovation/MGI China Effect_Executive summary_October_2015.ashx

McKinsey dubbed China's innovation model the innovation "sponge" model (i.e., imitating, assimilating, and replicating existing scientific research in developed countries). Rather than using macroeconomic indicators such as technology commercialization and market performance to assess China's ability to achieve innovation outcomes, McKinsey used indicators such as R&D expenditures, PhDs, patent applications, and publications. In their assessment, they categorized China's innovation activities into four "archetypes": ① science-based innovation; ② engineering-based innovation; ③ efficiency-driven innovation; and ④ customer-focused innovation. They assumed that China's ability to innovate is comparatively strong when its market share in the world in individual sectors exceeds its GDP share. Figure 3-3 shows the market share (as a percentage of GDP share) by sector. Their conclusions can be summarized in the following three points.

(1) China has established strengths in customer-focused and efficiency-driven innovation, but its engineering-based innovation has strengths and weaknesses, and its science-based innovation is lagging.
(2) Success factors for Chinese innovation in some sectors include large scale, speed, low costs, and policy promotion.
(3) At this stage, while China's innovation capacity is likened to a "sponge," it has the potential to become an innovation leader.

Another study called China's innovation model as a "ranking-driven catch-up model." It states that China encourages researchers to create short-term results by following the "paths" of technological pioneers in the West or innovating along those paths. This approach has been chosen in preference to the long-term pursuit of knowledge based on academic curiosity, which is highly uncertain and risky. It concluded that policy-driven innovation plans and resource allocations may increase the number of published papers but do not guarantee the effectiveness of research and innovation[5].

3.2.4 The "Bottleneck" Problem and Weaknesses in China's Innovation System Revealed by the U.S.-China Confrontation

As numerous studies and practices in developed countries have shown, innovation is a gradual and cumulative process. The history of industrial innovation in China is relatively shallow and, as noted in the study above, dependent on "paths" (path dependence). As a result, China has little advantage in existing industries such as semiconductors and pharmaceuticals, where existing Western firms have established "patent thickets" that prevent China from catching up.

The U.S. has selected the weak points in China's innovation system, that is, "choke points" (bottlenecks) for industrial technology, and imposed various restrictions on them. Some researchers have concluded that restrictive measures against China alone cannot guarantee U.S. technological dominance in the long term, but that they can and should curb Chinese innovation and momentum toward dominance in the short term[6],

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[5] Zhang, M.Y. et al. (2022) "Demystifying China's Innovation Machine";
https://global.oup.com/academic/product/demystifying-chinas-innovation-machine-9780198861171?facet_narrowbybinding_facet=Paperback &lang=en&cc=dk
Zhang M.Y. (2023) "Chinese tech dominance more myth than reality";
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[6] Bateman, J. (2022) "U.S.-China Technological 'Decoupling'";
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3.3 The Policy of "High-Level Technological Self-Reliance and Self-Improvement" and the "Science and Technology Superpower" Strategy

3.3.1 China's Perception of the U.S.-China Technology Dispute and its Policy of "High-Level Technological Self-Reliance and Self-Improvement"

Recognizing the weaknesses and quality issues in its innovation system, China has been encouraging bottom-up innovation since around 2015. It has shifted its policy focus from investing in innovation and creating intermediate products (such as papers and patents) to improving productivity and creating new industries.

Meanwhile, as the U.S. and other countries escalate their technology restrictions on China, its companies are struggling to cope with the damage caused by disruptions to their supply chains. The Chinese perception of this situation can be summarized in the following three points.

(1) Even if there is a change of administration in the U.S., the environment of international relations and trade will continue to be challenging, with the U.S.-China confrontation a central concern.

U.S. technological restraints and restrictions on China will continue, even if there is partisan conflict within the U.S. China should abandon its illusions, and "independence and liberation" from the situation of being "bound by others" is urgently needed[7]. Safety in science and technology is an important component of national security[8].

(2) The Need to Ensure Resilience and Security of the Domestic Industry Supply Chain

The infrastructure that has facilitated global business is being weaponized by the state, shifting from "win-win" in globalism to "lose-lose" in decoupling[9]. The Wassenaar Arrangement, established to replace the Coordinating Committee for Multilateral Export Controls (CoCom), has resulted in a number of regulatory and unilateral sanctions that have disrupted the global supply chains of home-grown industries, and improving the resilience and security of the supply chain is a crucial and urgent task[10].

(3) "We must prepare for global competition for the leadership of future industries.

The major trends of digital transformation (DX), deep technology revolutions such as biotechnology, and green revolutions (GX) such as carbon neutrality represent the next-generation industrial revolution, which is both a challenge and an opportunity for China. China needs to strengthen its innovation capacity and take the lead in the global competition for new science and technology"[11].

Specific strategic responses are condensed in the book[12] by Xi Jinping, General Secretary of the CCP. The book

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[7] "Harbor No Illusions About Introducing High-Tech; Abandon Illusions and Speed Up Innovation"; https://xhpfmapi.zhongguowangshi.com/vh512/share/6281039?isview=1&homeshow=1

[8] "Support and Safeguard Overall National Security with High-Level Scientific and Technological Security"; http://www.qstheory.cn/qshyjx/2021-04/15/c_1127333313.htm

[9] Farrell, H. and Newman A.L. (2020) "Choke Points: countries are turning economic infrastructure into political weapons, and that poses a major risk to businesses." https://hbr.org/2020/01/choke-points

[10] "Ensure the Security and Stability of Industrial Chains and Supply Chains"; http://theory.people.com.cn/n1/2023/0803/c40531-40049482.html

[11] "Xi Jinping on Scientific and Technological Innovation"; http://www.xinhuanet.com/politics/2016-06/03/c_129039031.htm

[12] Xi Jinping (2023) Discussing Science and Technology Self-Reliance and Self-Improvement, Central Literature Publishing House

covers a wide range of topics, including the science and technology strategies that China should adopt, the direction of innovation, and human resource strategies. The following two points may be considered particularly important. One is to establish and deploy a "new national system"[13] to win global competition in future industries and to realize the high-level self-reliance and self-improvement of advanced technologies as soon as possible. The other is to develop the "two-orbit strategy" in the medium term to realize "technological self-reliance and self-improvement," and in the long term, to become a "science and technology superpower."

3.3.2 Development of a policy of "high-level technological self-reliance and self-improvement" to eliminate technological bottlenecks

The policy of "high-level technological self-reliance and self-improvement" aims to eliminate bottleneck technologies that are mature in certain countries but not yet established in China and that have been (or are likely to be) sanctioned or restricted by the U.S. This can be described as a fast-breakthrough policy driven by strategic objectives for "1 to N" (not the "0 to 1" exploratory innovation of Silicon Valley but follow-up innovation based on technologies that have been established in developed countries but not in China[14]).

When the news broke on April 16, 2018, that the U.S. had imposed sanctions on ZTE, there was an uproar in Chinese society. Subsequently, in a three-month series of articles, *Science and Technology Daily* reported on 35 bottleneck technologies (see Table 3-4) that constrain China's industrial development, including chips, operating systems, tactile sensors, vacuum deposition machines, and components for medical imaging equipment. Since then, efforts have been made to address bottleneck technologies. These efforts have involved the government, industries, and the science and technology sectors. In the course of 5 years, 21 technologies have either been successfully developed independently or are on a path to success. These include LiDAR, cellphone radio frequency devices, tunnel boring machine main bearings, and underwater connectors[15].

Table 3-4. List of 35 Bottleneck Technologies China Needs to Address (as of 2018)

	Technology		Technology		Technology
1	Lithography equipment	13	Core industrial software	25	Microspheres
2	High-end chips	14	Indium tin oxide target materials	26	Underwater connectors
3	Operating systems (OS)	15	Core algorithms (robots)	27	Key materials for fuel cells
4	Aircraft-engine nacelles	16	Aircraft steels	28	High-end welding power supply
5	Tactile sensors	17	Milling cutters	29	Lithium battery separators

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[13] Unlike the previous system, in which the government led the implementation of specific technological policy goals under a planned economy, the "new national system" leverages China's huge domestic market (utilizing market mechanisms) and mobilizes the power of government, business, and society to break through the country's targeting technologies.

[14] Thiel, P. and Masters, B. (2014) "Zero to One: Notes on Startups, or How to Build the Future" Crown Currency

[15] "How Chinese Companies Can Overcome These 35 Bottlenecks in Key Technologies"
http://www.cfgw.net.cn/2023-06/08/content_25048001.html?eqid=fe3f3e3200001ebb000000066498081e

6	Vacuum evaporation equipment	18	High-end bearing steels	30	Components for medical imaging equipment
7	Cellular radio frequency devices	19	High-pressure plunger pumps	31	Ultra-precision polishing processes (technologies)
8	iCLIP technology	20	Aircraft design software	32	Epoxy resins
9	Heavy-duty gas turbines	21	Photoresist technology	33	High-strength stainless steel
10	LiDAR	22	High-voltage common-rail systems	34	Database management systems
11	Airworthiness standards (aircraft engines)	23	Transmission electron microscopes	35	Scanning electron microscopes
12	High-end capacitors and resistors	24	Main bearings for tunnel excavators		

(Prepared by the author based on a report in *Science and Technology Daily*)

Of course, bottleneck technologies are neither limited to the 35 mentioned above, nor is the role of eliminating these technological bottlenecks limited to any one industry or sector. For example, the Chinese Academy of Sciences, whose main objective is basic research, is bundling resources from more than 100 of its institutes and is trying to resolve bottleneck issues through joint projects with companies. In 2018, China launched three special projects in supercomputing systems, network security, and underwater vehicles. In 2019, five special projects were launched in the following areas: processor chips and basic software, electromagnetic measurement, bionic synthetic rubber, high-end bearings, and voice translation technology[16]. Some projects have already been successful and recognized as possible import substitutes. In Phase II (2021-2030) of these special projects, the list of U.S. technology restrictions on China will be included on the task list in an effort to focus on breaking through bottleneck issues.

3.3.3 The Long-term Goal of Becoming a Science and Technology Superpower: Accelerating R&D, Starting with Scientific Research

The policy development of "high-level technological self-improvement and self-independence" does not mean that there is complete freedom to explore, whether such exploration is strategic and aimed at eliminating technological bottlenecks or if it is market oriented. Nevertheless, to realize the long-term goal of becoming a science and technology superpower by 2050, resources are also being prioritized for exploratory basic research to develop technologies and foster industries that do not exist worldwide. Specifically, the following policies and approaches are recognized.

(1) Strengthening exploratory basic research.

Prioritizing resource allocation to basic research and encouraging free, exploratory, and non-consensus research

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[16] https://www.gov.cn/xinwen/2020-09/16/content_5543820.htm

toward the goal of becoming a science and technology superpower[17]. While it may seem surprising that free, exploratory, and non-consensual research is being discussed by a top leader of a one-party state, it does suggest that it is a high policy priority.

(2) Development of a National Laboratory System

A system comparable to that of the U.S. National Laboratories system is to be developed. To counter brain drain, the system will serve as a receptacle for a large number of PhD STEM personnel[18] and function as infrastructure for innovation in national projects and the private sector. In particular, the system will concentrate on the domestic production of research infrastructure, including test equipment, operating systems, and basic software.

(3) Human Resource Policies (with a Focus on STEM Human Resource Development)

To independently develop basic research talent, the government will cultivate STEM talent through 43 designated "double first-class" universities. It will further promote a program launched in 2013 to cultivate potential science and technology innovation talent among junior and senior high school students. However, initiatives to attract high-level STEM talent from abroad are also expected to remain as is. The abundance of STEM talent is a potential Chinese advantage in the future technology race (see Figure 3-5).

In addition, various policy and governance reforms are being implemented. These include a quantitative increase in basic research funding and the introduction of funding management mechanisms for different research types. Industries are encouraged to participate in the government's decision-making process regarding basic research, and companies are recognized as leading players in national projects. It can be seen that the private sector is expected to play a greater role in basic research.

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[17] Xi Jinping: "Strengthening Basic Research to Achieve Self-Reliance and Self-Improvement in High-Level Science and Technology"; https://www.gov.cn/yaowen/liebiao/202307/content_6895642.htm

[18] Human resources who can contribute to the development of science and technology in the future through integrated studies in the fields of Science, Technology, Engineering, and Mathematics

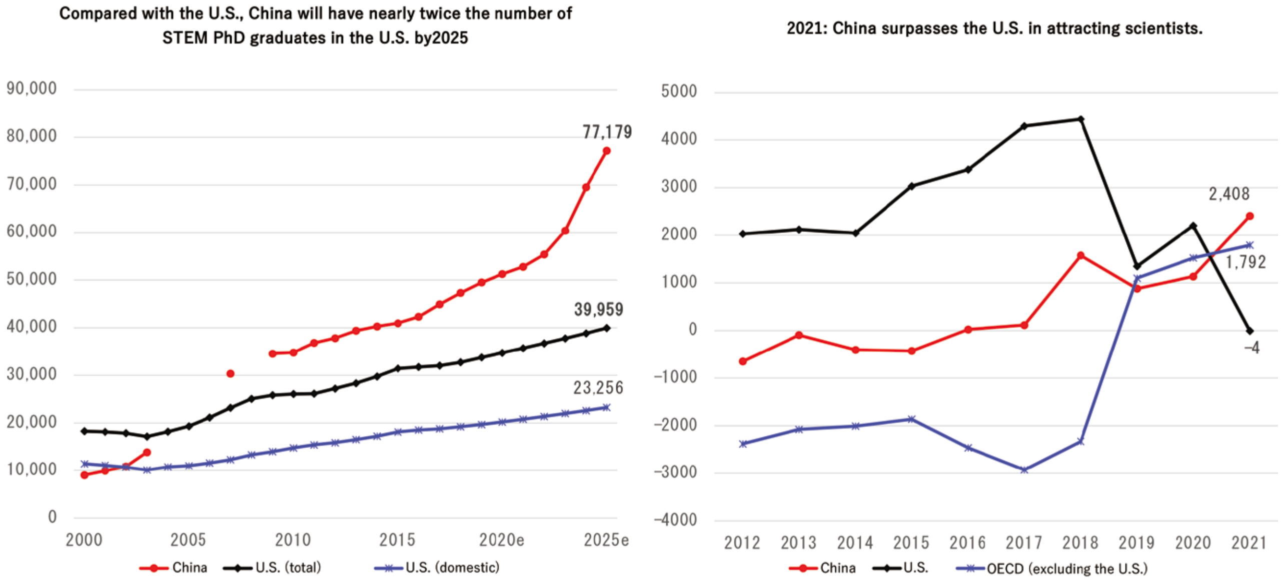

Figure 3-5. Competition between the U.S. and China for High-Level STEM Talent

(Prepared by author based on data from the Center for Security and Emerging Technology (2021) and the Cato Institute (2023))

Left: Number of STEM PhD graduates (2000 to 2025); Right: Net inflow of scientists (2012 to 2021)

3.3.4 Future Prospects for the Policy of "High-Level Technological Self-Reliance and Self-Improvement" and the "Science and Technology Superpower" Strategy

As seen above, China's catch-up approach to innovation began in the wake of the reform and opening up. It was typified by the decades-long innovation "sponge" model. This model has led to commercial and economic success through active social implementation based on the fundamental technologies imported from developed countries. However, bottlenecks remain in areas such as semiconductors, pharmaceuticals, and other advanced materials. These are areas that require accumulated innovations and where no cutting-edge companies have emerged. In addition, it appears that technological innovation, which is based on academic curiosity and involves long-term intellectual pursuits with uncertain outcomes, is only just beginning. In the face of the technology restrictions imposed by the U.S. and other countries, China is focusing on innovation in bottleneck technologies. It has set itself the ambitious goal of becoming a "science and technology superpower." The outcomes, however, will involve failure and uncertainty. Here, three points are listed regarding the future.

(1) High potential for technological innovation and commercial success in the digital sector

China's digital sector has abundant resources in terms of human resources, data, and use cases, as well as ample experience, and a vast consumer base that is comfortable adopting new innovations without resistance. The digital economy will be a major battleground for the national economy and foreign trade and investment, and new industries are likely to emerge in DX, GX and sustainable manufacturing.

(2) It will take time to eliminate bottlenecks in specific existing fields such as semiconductors, which require advanced technology.

Facing difficulties due to the restrictions imposed by the U.S. and other countries, China will have to be content with being a middle-tech power for the time being. Even if a set of rapid policy responses can achieve technological independence for China, it is unclear whether this development would be commercially successful in terms of quality, stability, and cost performance. In terms of global trends, the time for technological independence is already ripe. The question, therefore, is whether the businesses involved will be viable. One can expect that this issue will be resolved over time.

(3) Under the current governance structure, making a success of global "0 to 1" technology and industry (on a basis of research through free exploration) will be a major challenge

The emphasis on scientific exploration and basic research is a response to the accusation of being a "free rider" that Japan also experienced in the past. China is also expected to contribute to the world. However, the country faces numerous challenges. For example, externally, there is the risk of China decoupling from the U.S. and other countries in terms of knowledge. Internally, "excessive" government intervention and internet restrictions stemming from the "new national system" could pose severe challenges to China's structural and governance mechanisms, along with the strengthening of the CCP's leading position in science and technology policy.

3.4 Case Study: Development and Utilization of Generative AI

ChatGPT and similar applications embody generative AI's limitless potential for value creation. They have the ability to interact on par with humans and have a revolutionary ability to create new content and innovate work methods. This allows for increased productivity, foresight, and exploration. User-friendly generative AI applications typify inclusiveness, along with ubiquitous and universal accessibility. These applications are driving the democratization of technology and are changing the traditional technology-adoption curve.

The potential value creation of generative AI has already led to significant investment from venture capitalists, industry, government, and other investors. China, in particular, is the second-largest center (after the U.S.) for the development and utilization of generative AI. However, unlike most countries, China has imposed restrictions on the use of existing generative AI applications such as ChatGPT without modification. As with other emerging technologies, China is currently more inclined to develop and foster its own. Here, the current situation and challenges in the development and adoption of fundamental models for generative AI in China are presented as a case study.

3.4.1 The Generative AI Value Chain and China's Involvement

The generative AI value chain involves developing infrastructure, preparing large datasets for pre-training, introducing foundation models such as large language models (LLMs) that act as the engines of generative AI, and building application use cases that leverage the potential of the foundation models for tangible value creation. Figure 3-6 is an image of the generative AI value chain. This value-chain structure is unique to generative AI, which is distinct from traditional AI. Model vendors provide a foundation model that can be pre-trained on large datasets of text, images, and voice, and then customized and refined for a variety of tasks.

Chinese research institutes, universities, and companies are involved in most stages of the generative AI value chain but lack the capacity to produce AI chips such as advanced graphics processing units (GPUs), custom application-specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs), which are needed to develop foundation models and to train or retrain them for customization. U.S. semiconductor restrictions on China have also cut off the overseas procurement path for advanced AI chips.

Therefore, Chinese development vendors are forced to either utilize the hardware infrastructure they have already purchased (with cutting-edge GPUs installed) or use chips with inferior performance. However, the products made by Chinese companies such as MetaX (Muxi), Biren Technology, and Innosilicon, which design GPUs and GPU functional blocks (GPU Intellectual Property: GPU IP), do not match the performance of cutting-edge chips from American companies such as NVIDIA. The same is true for Chinese companies developing and producing AI chips, such as Cambricon Technologies, Hygon, and Huawei. Nevertheless, these products are noteworthy as alternative training chips for foundation models. In addition, the preparation of cloud infrastructure and datasets (including those from overseas) and the use of open-source infrastructure software are not expected to present a major obstacle at this stage. Furthermore, with regard to the use of AI, China has the highest number of users among the world's major countries who believe that "products and services using artificial intelligence have more advantages than disadvantages" and that they "trust companies using artificial intelligence as much as other companies"[19]. Thus, it can be said that China has a social infrastructure that facilitates the diffusion of generative AI.

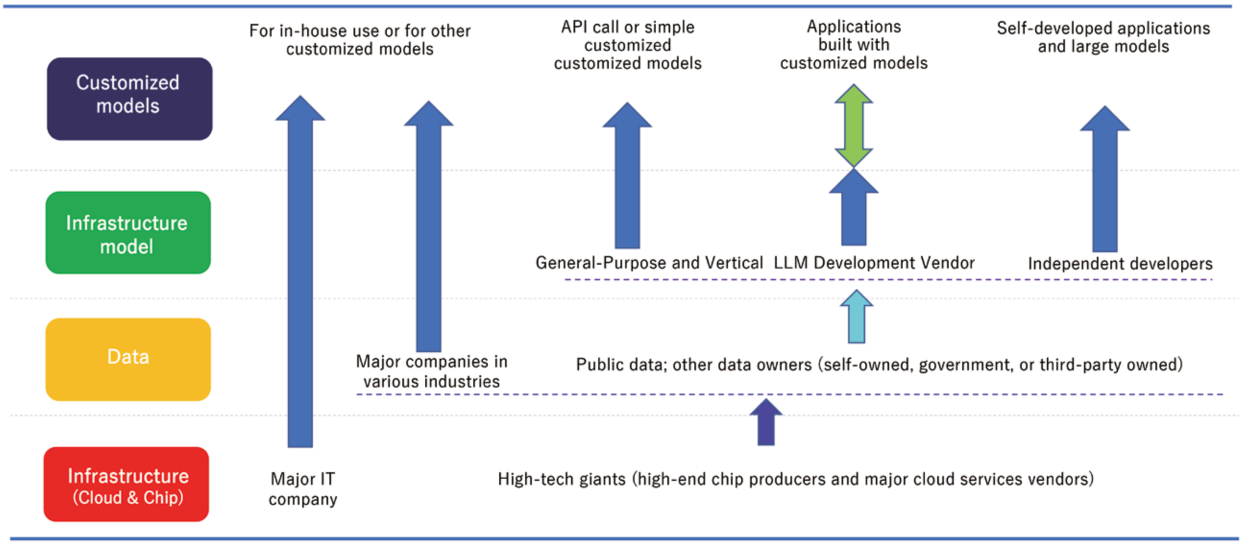

Figure 3-6. Overview of the Generative AI Value Chain

(Prepared by the author)

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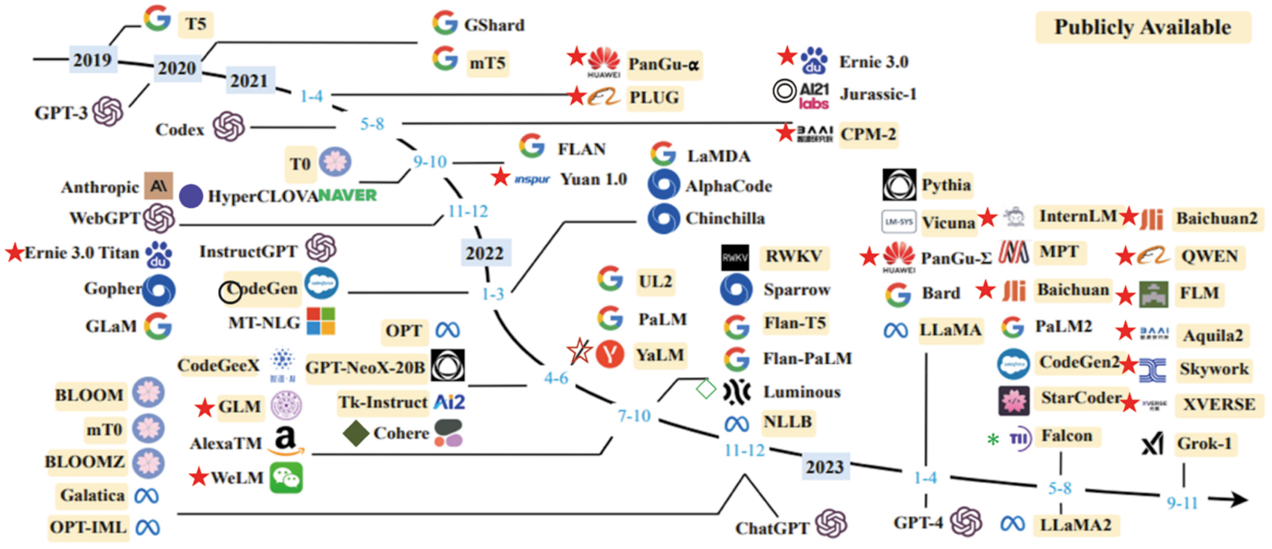
[19] Stanford University (2023) "Artificial Intelligence Index Report 2023"

3.4.2 Trends in the Development of General-Purpose and Vertical Models (Industry-Specific Models) for Generative AI

The foundation model acts as the engine enabling new value creation through generative AI, and the applications or use cases act as "wheels" that deliver value to end users. This process can be called the essential foundation for developing generative AI. In general, LLMs can be classified by training datasets into ① general-purpose models (horizontally trained LLMs or general-purpose LLMs); ② vertical models trained on industry data (vertically trained LLMs or domain-specific LLMs); and ③ custom LLMs, which customize general-purpose models or vertical models using user data.

Figure 3-7 lists LLMs for which the number of model parameters (the number of variables a machine learning model needs to optimize during training) is more than 10 billion and for which evaluation results have been published. The majority of these major LLMs belong to American-based firms, including tech giants such as GAFA or leading startups such as OpenAI. However, Chinese presence is also strong, including tech giants such as Baidu, Alibaba, Tencent, and Huawei (BATH), along with IT companies such as Inspur. Universities and independent research institutes are also represented, including Tsinghua University and Beijing Academy of Artificial Intelligence (BAAI). BAAI is an independent AI research institute founded by leading stakeholders from around the world, and it also has major government backing.



Note: Unmarked: the U.S.; ★:China;●: South Korea; ○: U.K.;◆: Canada; ☆:Russia;◇: Germany;◎: Israel ; ＊: UAE

Figure 3-7. Outline of the World's Major LLMs

(Prepared by author based on "A Survey of Large Language Models" (Zhao, W.Z. et al, 2023))

Note: Includes only LLMs with published evaluations through November 2023 and parameter sizes greater than 10 billion

Meanwhile, the success of OpenAI has stimulated venture activities in the field of generative AI in China, and a number of ventures have emerged to develop the foundation models. Three companies with generative AI as their core business--Zhipu AI, Baichuan AI, and 01.AI--have become unicorn companies (ventures with a market valuation of

USD 1 billion or more).

Developing a general-purpose platform model requires a large number of model parameters, large amounts of training data, and a long training period; therefore, it requires substantial finance and computing infrastructure. In China, vertical models, specialized for specific industries or tasks, are being developed relatively commonly. According to GitHub, as of December 17, 2023, 28 of the 189 LLMs announced in China were general-purpose LLMs, and the other 161 were vertical models. (GitHub is a program management service widely used for developing software)[20]. However, some of these LLMs were developed based on overseas open-source models.

The characteristics of Chinese LLMs, as discussed above, can be summarized as follows.

(1) The size of the foundation model is large.

The number of parameters in general-purpose platform models ranges from thousands to trillions. For example, Baidu's Ernie 3.0, released in 2021 and Huawei's PanGu-Σ, released in 2023, have 260 and 1,852 billion parameters, respectively. Although the event was not announced globally, Alibaba's research institute, DAMO Academy, apparently trained an LLM (M6) with a parameter count reaching 10 trillion on 512 GPUs in 2021[21].

(2) Increasing Open Sourcing of Foundation Models

In line with LLMs around the world, open sourcing is gaining ground among Chinese LLM development vendors. In particular, startups with weak brands tend to engage in open sourcing. Additionally, major vendors such as Alibaba have open-sourced models with billions or even tens of billions of parameters. This is thought to be an attempt to attract developers and expand the development ecosystem.

(3) Most of the models are bilingual English-Chinese, but a few are multimodal LLMs

While most LLMs developed in Japan support only Japanese, the majority of Chinese LLMs support English and Chinese. However, their performance in Chinese tends to be better than that in English. This may be due partly to the fact that Chinese datasets are easier to incorporate than US-based multilingual LLMs. The positions of Japan and China may have been reversed with regard to English-language responses. Meanwhile, in China, the number of multimodal LLMs[22] has been increasing recently, and such models are showing signs of development while remaining in the minority.

3.4.3 Trends in the Utilization of Generative AI

Although the capabilities of the foundation model functioning as the engine of the generative AI described above can be interpreted in various ways, the author will summarizes them, in terms of the level of human intellectual tasks, into four categories of capabilities: ① automating intellectual tasks; ② condensing large amounts of information and extracting important points; ③ generating new ideas and concepts from existing data; and ④ discovering new

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[20] List of LLMs in China: https://github.com/wgwang/awesome-LLMs-In-China

[21] https://m6.aliyun.com/#/

[22] Refers to a single AI model that can process multiple modalities (data types) such as numeric/image/text/sound in combination or in association.

patterns and correlations within existing data. These capabilities are delivered through applications or use cases that create value for end users, such as increased productivity, new innovations, and new experiences. They can either be used directly in a general-purpose platform model through an application or customized through retraining (fine-tuning) with industry-specific or proprietary data. Alternatively, a vertical model can be developed for each industry or task as described above. In Japan, it is quite rare to utilize existing open-source models or develop LLMs in-house, but it is considered a common option in China.

Figure 3-8 provides an overview of China's generative AI industry. Diverse vendors make up the value chain. As of December 2023, the overall adoption rate of generative AI by Chinese companies is around 15%, with a figure of 13% for retail, 10% for telecommunications, 7% for pharmaceutical and healthcare, and 5% for manufacturing. Figures are according to the China Center for Information Industry Development, a thinktank under the Ministry of Industry and Information Technology[23]. This large difference in adoption rates between industries is because LLMs, the engines of generative AI, are large-scale language models; therefore, the more tasks (occupations) that relate to language, the greater the impact and hence the higher the adoption rate. For example, the adoption rate of generative AI in the U.S. is 37% in marketing and advertising, 35% in technology, 30% in consulting, 19% in education (teaching), 16% in accounting, and 15% in healthcare[24].

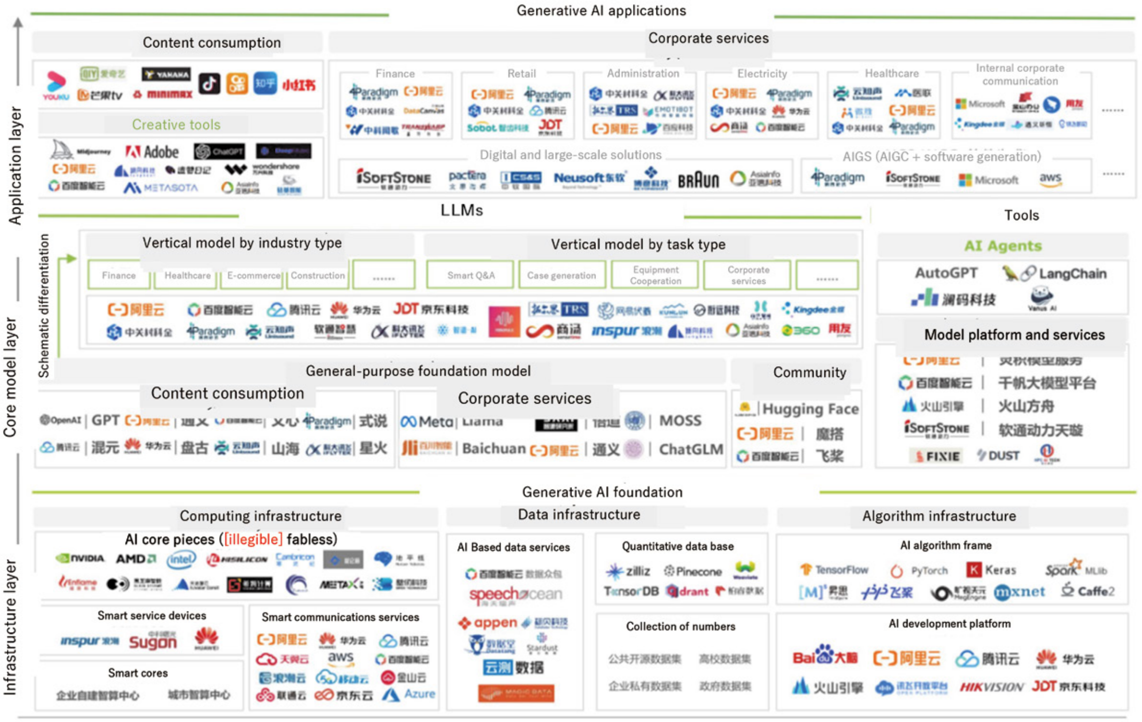

Figure 3-8. Overview of China's Generative AI Industry in 2023

(Prepared by author based on "2023 China AIGC Industry Landscape Report" (iResearch, 2023))

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[23] CCTV: China's AI Computing Power is Developing Rapidly, Becoming a New Driving Force for the Growth of the 'Digital Economy'"; https://news.cctv.com/2023/12/14/ARTIyCnADHxmxpE4pvPSQ9DN231214.shtml

[24] "Adoption of Generative AI in the U.S. Workplace in 2023, by Industry"; https://www.statista.com/statistics/1361251/generative-ai-adoption-rate-at-work-by-industry-us/

Additionally, while foundation model development requires various resources (financial capacity, technical ability, and data accumulation) in the application field, the needs of end users are extremely diverse. Thus, venture firms, rather than large corporations, can play a role here. According to the China Center for Information Industry Development, China is expected to see ongoing development, with just under 400 new generative AI-related venture firms in 2023. However, these new venture firms are in the early stages of development (funding is often up to Pre-A). In comparison, the number of U.S. generative AI-related venture firms is higher. In addition, the amount of funding has been large, and more than 10 unicorn companies have emerged in each application field[25].

Moreover, China's use of generative AI is concentrated in emerging industries with a complete digital infrastructure (including consumer base), such as e-commerce, media, entertainment, and gaming. Most traditional industries, such as finance, energy, and education, are at the small-scale pilot stage[26]. Given this background, the vertical application areas of generative AI in China are mainly focused on text, image, audio and video generation. However, while the current target customers of Chinese generative AI companies are mostly end users (the consumer market), as China's SaaS[27] market matures and enterprises' willingness to pay increases, domestic text-generation and image-generation startups are expected to rapidly expand into the corporate client market.

Meanwhile, in the U.S., where many systems are written in early programming languages such as COBOL and many companies face high programming labor costs, a number of generative AI-based development platforms, data-analysis platforms, and code-writing platforms are emerging. In addition, the American SaaS market is mature, with a large group of corporate customers applying generative AI in a wider range of fields such as high-tech industries, telecommunications, and various traditional industries (e.g., healthcare and education, etc.).

Various forecasts have been made for the size of the generative AI application market. According to Statista Market Insights, the Chinese generative AI market will have a relatively high compound annual growth rate (2023-2030) of 27.32%. However, its size will be USD 29.6 billion (as of 2030); this will not come close to matching the U.S., the world's largest market, which is forecast at USD 65.7 billion (see Figure 3-9). This difference may be attributed to the degree of adoption by corporate clients.

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[25] China's generative AI unicorns (three companies) are mainly focused on model development at this point.

[26] McKinsey, "China's Generative AI Market: Current Situation and Future Development Trends"; https://mp.weixin.qq.com/s?__biz=MzIwOTA1MDAyNA%3D%3D&mid=2649984157&idx=3&sn=1647ef4c37b09905cde3d8dc8aba60a1&ref =openi.cn

[27] SaaS (Software as a Service) refers to users accessing software running on the provider's (server) side as a service via the internet or other networks, rather than by installing software on the user's (client) side.

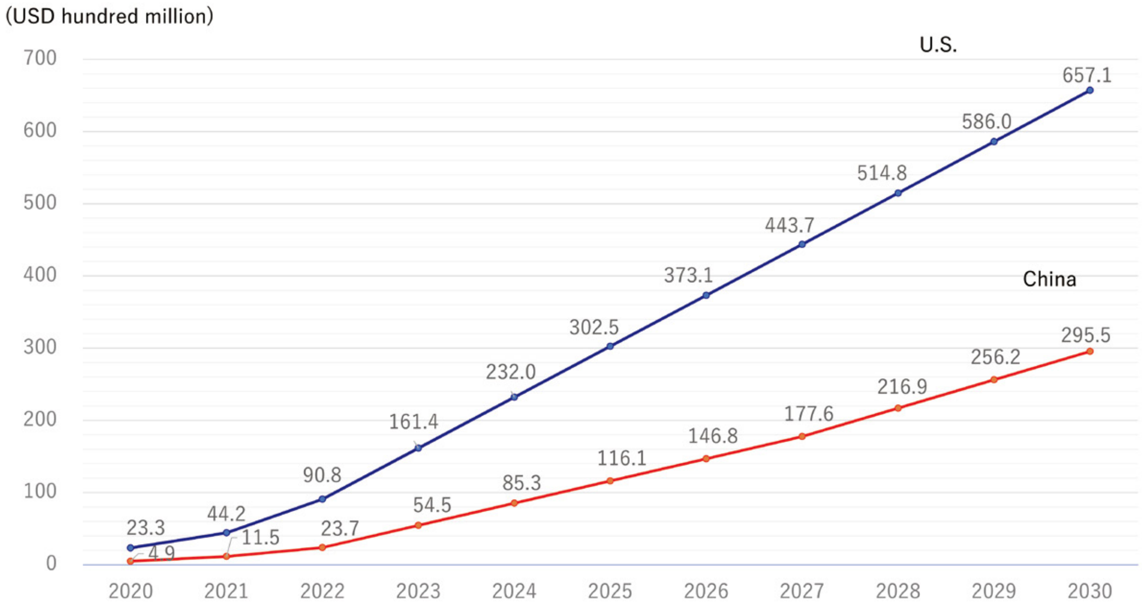

Figure 3-9. Estimated Size of Generative AI Application Markets in the U.S. and China

(Prepared by the author based on data from Statista Market Insights)

3.4.4 Policy Trends and Issues

From the 12th Five-Year Plan to the 14th Five-Year Plan, the Chinese government has developed AI as a macro-level policy, which has had a major impact on technology development and industrial growth. In recent years, the policy trend has shifted to focusing on innovation of more practical applications and use cases. For example, following the announcement of the "Next Generation Artificial Intelligence Plan," which is a master plan, in July 2017, the Next Generation Key AI Project was launched in November in the same year, certifying five open platforms led by major private IT companies. To manage risks, ethical regulations, and safety along with market development in AI, the Governance Principles for the New Generation Artificial Intelligence were established in 2019, along with a New Generation AI Governance Expert Committee.

In response to the development of ChatGPT and other generative AI, China has been quick to take policy action. This may be due to a sense of urgency with respect to keeping up with global trends in generative AI technology and concern about the risk of generative AI expanding beyond conventional AI. For example, following the "Provisions on the Administration of Deep Synthesis Internet Information Services,"[28] enacted in November 2022, the "Interim Measures for the Management of Generative Artificial Intelligence Services" (limited to public services)[29] were enacted in July 2023 for generative AI. This can be seen as an attempt to promote innovation in generative AI and

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[28] "Provisions on the Administration of Deep Synthesis Internet Information Services";
http://www.cac.gov.cn/2022-12/11/c_1672221949354811.htm

[29] "Interim Measures for the Management of Generative Artificial Intelligence Services";
http://www.cac.gov.cn/2023-07/13/c_1690898327029107.htm

the development of new businesses by establishing policy rules and ensuring transparency. As of December 2023, 150 notifications of generative AI algorithms based on the "Provisions on the Administration of Deep Synthesis Internet Information Services"[30] and 11 notifications of general-purpose LLMs based on the "Interim Measures for the Management of Generative Artificial Intelligence Services"[31] have been accepted.

These provisions primarily stipulate the responsibilities of providers, but are notable in that they include a notification system to ensure the transparency of algorithms and their conditional safety evaluations. They also include prohibitions on the generation of discriminatory content, the legality of model training data, transparency, and the protection of privacy; similar to the regulations on generative AI being discussed worldwide. In addition, Article 4.1 of the "Interim Measures for the Management of Generative Artificial Intelligence Services" clearly stipulates the obligation to "uphold the core values of socialism," a provision that is unique to China.

As seen above, based on the current state of China's development of generative AI from the value-chain perspective, the development of general-purpose and vertical LLMs and some services for end users is progressing, with applications for corporate customers still in the exploratory stage. There are several challenges that must be overcome for future development to progress. The main ones are listed below.

(1) Computing Capacity Constraints

Restrictions on advanced semiconductors (e.g., chips, equipment, and materials) have been imposed by the U.S. and other countries on China. These restrictions are impairing the training capabilities of foundation models and inference capabilities at the utilization stage. However, although the performance of chips from some Chinese manufacturers does not match the level of cutting-edge chips from American companies such as NVIDIA, they are noteworthy as alternative training chips for foundation models.

(2) Lack of Generative AI Talent

The U.S.-China technology dispute is restricting the inflow of excellent human resources from abroad. In addition, human resource strategies in China tend to concentrate on the development of technical personnel for development, neglecting the development of human resources for applications such as the design and development of use cases that are directly related to value creation.

(3) Lack of Stability and Unpredictability of the Regulatory Environment for New Businesses

Geopolitical risks and frequent changes in domestic policies can have a significant impact on the development and adoption of emerging technologies with novel risks, such as generative AI, making long-term business planning difficult.

It is necessary to continue to monitor these issues closely.

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[30] "Internet Information Service Algorithm Registration System"; https://beian.cac.gov.cn/#/notice

[31] "Using the 'Arrow' of the Big Model to Accelerate the Reshaping of the Work Paradigm in the Security Industry"; https://m.huanqiu.com/article/4EPjCRKunB8

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4 China's Semiconductor Industry: Policy Involvement, and the Current Situation

4.1 Introduction

On August 29, 2023, Huawei abruptly began sales of its new Mate 60 Pro smartphone online. This new model is capable of communicating through 5G networks and satellites. The introduction of this new model was greeted with great surprise. This is because Huawei is the Chinese company at the focal point of the U.S.-China competition for hegemony, and the U.S. government has done everything in its power to prevent its rise. First, the U.S. lobbied to exclude Huawei equipment from telecommunications networks in the U.S., Japan, and Europe, and banned the export of advanced integrated circuits (ICs) and software produced by American companies such as Qualcomm to Huawei. In response, Huawei designed ICs at its subsidiary HiSilicon and outsourced production to Taiwan Semiconductor Manufacturing Company (TSMC) to procure 5- to 7-nm-class microfabricated ICs for use in 5G smartphones. In the second quarter of 2020, Huawei increased its global market share of smartphones to 20%, making it the world leader along with Samsung, and appeared to have rebounded from American pressure. However, the U.S. government responded by banning companies such as TSMC and Samsung from accepting IC manufacturing orders from Huawei. With its access to advanced ICs blocked, Huawei was forced to spin off a large portion of its smartphone business as a separate company called Honor. This has significantly eroded its share of the global smartphone market.

Given this background, the release of the Mate Pro 60 meant that a Chinese company was upsetting the U.S. government. This was a major achievement from China's perspective, while from the US perspective, it constituted the exploitation of a regulatory loophole. How did Huawei obtain the ICs required to support a 5G device? The Mate Pro 60 uses the Kirin 9000S, designed by HiSilicon. It is believed that its manufacture was contracted to the Shanghai-based Chinese firm Semiconductor Manufacturing International Corporation (SMIC). The U.S. government is pressuring the Netherlands to prevent China from acquiring advanced IC manufacturing capacity and blocking the export of extreme ultraviolet (EUV) exposure equipment, which is produced exclusively by Dutch company ASML. Without an EUV lithography system that prints fine circuit patterns on wafers, it would be difficult to manufacture ICs of 7 nm or smaller. However, the Kirin 9000S is made with 7 nm-class microfabrication. How could this have been possible? According to a former TSMC engineer, deep ultraviolet lithography equipment allows 7nm-class processing using double patterning. It is likely that SMIC, which has scouted many engineers from TSMC, manufactures in that way[1].

The purpose of this chapter is to present an objective overview of China's semiconductor industry, which has become the main battleground in the U.S.-China race for hegemony. Section 4.2 briefly summarizes the development of China's semiconductor industry policy. Section 4.3 provides an analysis of the investment activities of the National IC Industry Investment Fund, which has been at the core of the Chinese government's support for the semiconductor

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[1] "'SMIC Has a Favorable Path to 5-nm Processing,' Observers Say," *EE Times Japan*, September 26, 2023; https://eetimes.itmedia.co.jp/ee/articles/2309/25/news171.html

industry since 2014. Section 4.4 examines the outcomes of China's semiconductor industry policy. Section 4.5 summarizes the characteristics of Chinese government involvement in the semiconductor industry.

4.2 Semiconductor Industry Policy Development

Discrete semiconductors such as transistors have been produced in China since the 1960s, but full-scale production of integrated circuits (ICs) did not begin until the 1980s[2]. At the time, IC production was mainly handled by Jiangnan Radio Equipment Factory (Factory 742), a state-owned company under the direct control of the Ministry of Electronics Industry in Wuxi, Jiangsu province. The Chinese government (Ministry of Electronics Industry) began working on domestic production of color TVs in 1978. A cathode-ray tube manufacturing line was installed in Xianyang, Shaanxi province, while the Jiangnan Radio Equipment Factory engaged in domestic production of linear ICs for color televisions. The company introduced technology and equipment from Toshiba and created an integrated factory to handle silicon ingot manufacturing, 3-inch wafer manufacturing, and front-end and back-end IC manufacturing. The processing level at this plant was 5-μm line width, with an annual production capacity of 30 million ICs. The ICs produced there were used in about 40% of Chinese color televisions, the domestic production of which was rapidly expanding at the time, and they were a great success.

Later, as the circuitry inside color TVs became increasingly digitalized, Jiangnan Radio Equipment Factory introduced technology from Toshiba and Siemens in the late 1980s and began making CMOS digital ICs with a processing level of 2- to 3-μm line width and a wafer size of 4-5 inches. At this juncture, the company changed its name to China Huajing Electronics.

During the 1990 Gulf War, Chinese political leaders were shocked by the high-tech weaponry of the U.S. and realized that the semiconductor industry needed to be strengthened. Therefore, the Ministry of Electronics Industry launched the "908 Project" in August 1990, aiming to upgrade China Huajing Electronics to a state-of-the-art semiconductor manufacturer. This project set the technological goals of a processing level of 1 μm and a wafer size of 6 inches. However, it was not clear from beginning to end what kind of applications the ICs would be made for. The U.S. firm Lucent Technologies was brought in to guide the introduction of production lines, and the plant finally began operating in 1998, eight years after the project had been launched. However, there was a dearth of orders and the company was unprofitable from the start. However, Taiwanese engineers, who happened to hear that the company had excess IC production capacity, offered their cooperation. They established their own company in Hong Kong. They began collecting IC orders from overseas and outsourcing production to China Huajing Electronics. Thus, China Huajing Electronics unexpectedly became the first IC foundry (contract manufacturing company) in China.

While the Ministry of Electronics Industry's 908 Project was faltering, more advanced ICs were being manufactured elsewhere in China. The Japanese firm NEC started dynamic random-access memory (DRAM) chip production in 1994 through a joint venture with Beijing-based steelmaker Shougang Corporation, using a line width of 1.2 μm and a wafer size of 6 inches. In 1997, the line width was upgraded to 0.5 μ. Around 80% of the DRAMs and MCUs made at Shougang NEC were exported overseas and delivered to users around the world as NEC products. In other words, Shougang NEC became one of NEC's global manufacturing bases.

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[2] This section draws primarily on Marukawa (2023). Please see the References for details.

The Ministry of Electronics Industry was by no means content to see China being used as a manufacturing base for global IC makers, and wanted to foster independent IC makers open to Chinese control. Therefore, the Ministry of Electronics Industry launched the “909 Project” in 1995. The 908 Project had failed because a factory had been built without consideration being given to sales channels for ICs. In light of this failure, China decided to set up an IC manufacturing factory with a line width of 0.5 μm and wafer size of 8 inches and simultaneously set up 3-4 IC design companies. The aim was to establish a division of labor between foundries and fabless (design companies) like that found in Taiwan.

The problem, however, was that such advanced manufacturing technology could not be obtained without the cooperation of global IC manufacturers. While many IC manufacturers approached by China were hesitant, it was once again NEC that agreed to cooperate. However, NEC rejected the foundry idea on the grounds that it had no experience in operating a foundry, only accepting the offer on the condition that they would manufacture DRAM chips. NEC also took a minority stake in the project, and Hua Hong NEC, a joint venture between a state-owned company in Shanghai and NEC, was formed to operate the IC plant. In 1999, the Hua Hong NEC factory started production. It had the most advanced processing technology in China at that time, with a line width of 0.35μ and a wafer size of 8 inches. At the time, 80% of the production was 64 MB DRAM chips; NEC took the entire output and sold it on to its customers. Hua Hong NEC, which had been created as a Chinese national project, had once again become a manufacturing base for NEC.

However, the bursting of the dot-com bubble in 2001 forced Hua Hong NEC to discontinue DRAM chip production. Hua Hong NEC decided to convert into a foundry, and brought in American IC foundry Jazz Semiconductor as a new joint venture partner. When Hua Hong NEC was first established, minority shareholder NEC held control of its management. However due to the change in business operations, management control was handed over to the Chinese side in October 2003. This was six months earlier than had been planned.

Having failed in two state-sponsored IC projects, the Chinese government subsequently refrained from direct intervention in the IC industry. Instead, it promulgated “several policies to further encourage the development of software and IC Industries” in 2000. Since these policies included refunds of value-added tax on domestically produced ICs, they were later brought to the WTO by Europe and the U.S. and forced to be withdrawn. However, these policies triggered a momentum to give preferential treatment to the IC industry in each region. Both domestic and foreign funded companies began to offer preferential land prices to IC manufacturers setting up operations in local industrial parks. In response, various overseas firms built IC factories in China, including TSMC, Intel, Samsung, SK Hynix, ST Micro, and Hejian (a subsidiary of Taiwan's United Microelectronics Corporation). In addition, Richard Chang, a Taiwan native who had worked for Texas Instruments for 20 years, founded SMIC, an IC foundry in Shanghai in 2000.

The establishment of foundries in China has also led to the establishment of many fabless companies specializing in IC design. In particular, China has become the world's largest market, and numerous manufacturers have sprung up to design the ICs used in cellphones. Examples include Spreadtrum (UNISOC), which designs baseband ICs for cellphones, and RDA, which designs high-frequency circuit ICs. By receiving orders from fabless companies, SMIC also expanded its scale of operations and increased its level of processing, closing the gap with the world's leading IC makers to about 1-2 years.

In 2014, the Chinese government once again increased its direct involvement in the IC industry. In the same year, the “Guidelines to Promote National Integrated Circuit Industry Development” were promulgated. The aim of this policy was to form several world-class companies that would join the forefront of the global IC industry by 2030. The instrument established to realize this goal was the National IC Industry Investment Fund. The Fund was established in 2014, with the announcement that 16 national agencies and state-owned enterprises would contribute. RMB 36 billion was sourced from the Ministry of Finance, RMB 22 billion from Guokai Financial, a subsidiary of the China Development Bank, RMB 11 billion from China Tobacco, and RMB 10 billion from Beijing Yizhuang International Investment, a subsidiary of the Beijing municipal government, for a total investment of RMB 138.7 billion.

In 2015, "Made in China 2025" was announced. This policy aimed to promote high-tech industries in general. Ten industries, including new energy automobiles, new energy, and new materials, are listed as priority sectors, and one sector, the "new generation IT industry," included the IC industry. Virtually all industries considered high-tech were listed, and the aim appeared to be to reduce dependence on foreign countries in this field through their promotion. However, perhaps due to concern for consistency with WTO principles, the targets were expressed in very vague terms, with the "independent assurance" ratio for critical parts and materials set at 40% by 2020 and 70% by 2025. As it has never been explained what exactly this "independent assurance" ratio means, it is unclear whether it is even a valid goal. However, these figures have taken on a life of their own, and the Japanese media and others often incorrectly report them as "target" IC domestic production rates[3]. In fact, nowhere in "Made in China 2025" is there any target for IC domestic production rate to be found.

The target for the domestic production rate actually appears in the "Made in China 2025 Technology Roadmap" prepared by the National Manufacturing Strategy Advisory Committee as one of the sector-specific policies of "Made in China 2025." The roadmap sets out numerical targets for the domestic production rate and global market share of 56 products and industries, including ICs, with the IC domestic production rate set at 49% by 2020 and 75% by 2030. This roadmap was also revised at the end of 2017, with the IC domestic production rate target raised to "58% by 2020 and 80% by 2030." However, this roadmap only presents numerical values. It does not define the criteria necessary to actually calculate the domestic production rate, for example, in the case of ICs, whether domestic production is determined in the front- or back-end processes. Ultimately, these figures were effective in creating the impression that the Chinese government and industry are aiming for domestic IC production, but they were not goals that could actually be evaluated for achievement.

While "Made in China 2025" was significant in creating momentum for prioritizing high-tech industries, it did not set goals whose achievement or lack thereof can be verified; this sets it apart from previous five-year plans. However, China's ambitions as expressed in "Made in China 2025" aroused strong alarm in developed countries. The U.S. stopped supplying CPUs for China's supercomputers and ICs for the BeiDou navigation satellite system around 2015. Furthermore, from 2017, when the Trump administration was formed, Vice President Pence called for vigilance against "Made in China 2025" and quickly stepped up the offensive by regulating IC and technology exports to Huawei and others. With the advent of the Biden administration in 2021, America's determination to curb the development of China's IC industry and its use of ICs has only strengthened. In response, the Chinese government has been desperately trying to counterattack by further supporting IC domestic production. It launched the Phase II of the National IC Industry Investment Fund in 2019, this time setting the total investment at RMB 200 billion.

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[3] See, for example, Shunsuke Tabeta (2021) "China Far From 70% Self-Sufficiency in Semiconductors, at 10% Last Year," *The Nihon Keizai Shimbun*, October 13; IC Insights (2020), "China to fall far short of its 'Made-in China 2025' goal for IC devices," Research Bulletin, May 21

4.3 Activities of the National IC Industry Investment Fund

The National IC Industry Investment Fund was established by the 2014 "National Integrated Circuit Industry Development Guidelines." The first thing to keep in mind is that the Fund is not an institution that disburses subsidies but a company that invests in IC-related companies, holds equity, and aims to eventually sell its holdings for profit. This is different in nature from the subsidy as a unilateral benefit that the Japanese government is about to provide to TSMC's Kumamoto plant and Rapidus.

Phase I of the Fund (more accurately, a joint-stock company called the China Integrated Circuit Industry Investment Fund) launched in 2014. It announced a total investment of RMB 137 billion; however, its actual capital was RMB 98.72 billion, and as of the time of writing (January 2024), it had already entered the investment recovery stage. When Phase I of the Fund was launched in 2014, it was capitalized at RMB 6.4 billion, and the capital was then gradually increased in line with the expansion of the investment portfolio. In 2019, each investor paid the full amount promised and the capital has not increased from RMB 98.72 billion since then (Table 4-1).

Since January 2022, when the author began checking the investment data of the Phase I of the Fund through corporate information provider Qichacha, the amount invested in enterprises has been declining: from RMB 98.16 billion (January 2022) to RMB 94.83 billion (September 2022), to RMB 93.64 billion (August 2023), and to RMB 93.17 billion (January 2024). The number of companies in which the Fund invests has also decreased, from 80 in January 2022 to 74 in January 2024. However, it can be inferred that the capital surplus and other retained earnings of the Phase I Investment Fund increased from RMB 19.4 billion at the end of 2018 to RMB 113.4 billion at the end of 2021, before decreasing to RMB 89.1 billion at the end of 2022. The Fund accumulated the profits from its investments as retained earnings, but in July 2021, Tsinghua Unigroup, which had been its main investment, went bankrupt. The RMB 24.3 billion decrease in internal reserves in 2022 likely resulted from this event. The Phase I Investment Fund is gradually reducing its investments and accumulating the profits earned from its investment activities, and is believed to be moving toward dissolution.

Table 4-1. Financial Data of the China Integrated Circuit Industry Investment Fund

(RMB hundred million)

	2017	2018	2019	2020	2021	2022
Operating revenue	1.3	1.3	265.5	499.5	504.3	1.1
Net profit	73.3	−86.0	220.8	420.2	375.1	−80.4
Total assets	1031.8	1159.4	1642.9	2011.9	2352.9	2049.3
Total liabilities	41.9	0.5	52.4	134.5	231.8	171.2
Shareholders' equity	989.8	1158.9	1590.4	1877.4	2121.1	1878.1
Capital stock	697.4	964.4	987.2	987.2	987.2	987.2

(Prepared by the author based on data from Qichacha)

Table 4-2. Financial Data of the China Integrated Circuit Industry Investment Fund Phase II

(RMB hundred million)

	2019	2020	2021	2022
Operating revenue	0.0	0.0	4.2	4.2
Net profit	0.0	14.8	52.2	− 1.7
Total assets	90.9	427.0	888.8	1196.7
Total liabilities	0.0	4.6	21.4	19.3
Shareholders' equity	90.8	422.4	867.4	1177.3
Capital stock	90.8	407.6	800.7	1112.6

(Prepared by the author based on data from Qichacha)

Meanwhile, Phase II of the Fund (a joint stock company called "China Integrated Circuit Industry Investment Fund Phase II" to be exact) had a capital of RMB 9.08 billion as of the end of 2019, but as shown in Table 4-2, it has been expanding rapidly since then. Phase I was funded by 16 state institutions and enterprises, whereas Phase II is funded by 27 state institutions and enterprises. The total committed capital is RMB 204.15 billion; therefore, it is expected that the capital will gradually increase to that level going forward. According to Qichacha, the number of investment recipients and the amount of investment is currently expanding, from RMB 53 billion in 19 companies in January 2022 to RMB 77 billion in 38 companies in September 2022, RMB 83.5 billion in 43 companies in August 2023, and RMB 105.2 billion in 46 companies in January 2024.

Next, let us look at the types of companies in which Phase I and Phase II invested, respectively. Table 4-3 provides a breakdown of the investment recipients of the two Phases by business sector as of September 2022. The investment recipients of Phase I of the Fund are characterized by a total of RMB 24.5 billion being invested in 25 companies specializing in the IC industry and operated by local governments and other entities. These investment companies are seen to be making relatively small investments in a wide range of areas. These range from the upstream stage of the IC industry, such as manufacturing equipment, materials, design and software, to the midstream stage, such as foundries and integrated device manufacturers (IDMs; i.e., manufacturers with in-house front- and back-end processes that produce IC products such as memory and CPUs). The downstream stage (packaging, etc.) is also covered. In some cases, the recipient further invests in another company. The 25 investment companies invested in a total of 267 companies, with an average investment of slightly less than RMB 150 million.

Table 4-3. Investment Destinations of the National IC Industry Investment Fund

(Investment amount: RMB 10,000)

Field	Investment Fund Phase I		Investment Fund Phase II		Portfolio Company Investments in Phase I	
	Number of companies	Amount invested	Number of companies	Amount invested	Number of companies	Amount invested
Investment	25	2,452,653	0	0	26	520,209
Foundries	5	3,290,786	5	2,928,995	6	2,045,824
Packaging	6	209,472	2	105,287	4	9,905
Design	17	137,957	7	75,252	98	188,532
IDM	7	2,875,956	10	4,446,655	7	94,022
Material	8	354,370	7	66,646	16	44,664
Equipment	6	27,449	5	33,367	23	52,133
Discrete semiconductors	1	28,981	0	0	15	17,564
Software	1	4,821	3	33,375	5	102,396
Manufacture of electronic and electrical products	0	0	1	636	14	13,602
Other	3	100,394	1	11,765	53	910,131
Total	79	9,482,839	38	7,701,978	267	3,998,981

Note: Some companies have received investments from multiple funds. There are three companies in which the National IC Industry Investment Fund has invested in Phase I and Phase II, and 31 of the recipients in which Phase I has invested have in turn received investments in Phase II.

(Classified and compiled by the author based on data from the Qichacha (for Phases I and II of the Fund, accessed on September 19 to 21, 2022; for investment recipients, accessed on January 20, 2022) and statements on company websites.)

The largest investment recipient of the Phase I Investment Fund in terms of investment amount was Tsinghua Unigroup, a semiconductor manufacturer affiliated with Tsinghua University. Specifically, the Fund has invested RMB 14.1 billion in Hubei Zixin Technology Investment Co., Ltd., a subsidiary of Tsinghua Unigroup, RMB 13.6 billion in Yangtze Memory Technologies Corp., and RMB 700 million in Tsinghua Unigroup Ziguang Zhanrui (Shanghai), a company formed by the merger of fabless companies Spreadtrum and RDA. The second-largest investment recipient is SMIC, which has received investments of USD 1.536 billion (RMB 10.75 billion at RMB 7 to the dollar) in Semiconductor Manufacturing North China, USD 947 million (RMB 6.6 billion) in Semiconductor Manufacturing South China, and RMB 600 million in SMIC Ningbo Semiconductor, all under the SMIC umbrella.

The Phase II Investment Fund is also making a large investment in Tsinghua Unigroup and SMIC[4]. In other words, it has invested another RMB 189 million in Ziguang Zhanrui (Shanghai), along with RMB 18 billion yuan in Yangtze

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[4] Tsinghua Unigroup was 51% owned by Tsinghua University and 49% by a company owned by Zhao Weiguo, an entrepreneur from Tsinghua University. However, after the company went bankrupt in July 2022, it was taken over and became a wholly owned subsidiary of Beijing Zhiguangxin Holding, which is controlled by an entrepreneur named Li Bin. After the bankruptcy of Tsinghua Unigroup, Yangtze Memory was separated from the group and became a subsidiary of a state-owned company controlled by the Donghu New Technology Development Zone in Wuhan City. Yangtze Memory Technologies Phase II Corp. was absorbed by Yangtze Memory in May 2022. At that time, the investment from the Phase II Fund was cut from RMB 18 billion to RMB 12.89 billion .

Memory Technologies Phase II Corp., which was established in December of the same year after taking over Tsinghua Unigroup's memory factory in Wuhan after the latter went bankrupt in July 2021. The Phase II Investment Fund also invested USD 1.22 billion (RMB 8.6 billion) in SMIC Beijing, USD 1.5 billion (RMB 10.5 billion) in SMIC South, USD 530 million (RMB 3.7 billion) in SMIC Shenzhen, and USD 920 million (RMB 6.5 billion) in SMIC East. In total, for Phase I and II, RMB 46.6 billion was invested in Tsinghua Unigroup (and its successor companies) and RMB 47.2 billion in SMIC, meaning that 55% of the total investment in the two Phases was invested in these two groups.

Tsinghua Unigroup is an IDM that manufactures flash memory and DRAM, and SMIC is a leading foundry in China. It can be understood that the main goal of the fund was to make these two companies stronger and larger. Thus, the bankruptcy of Tsinghua Unigroup in July 2021 was a major blow to the fund and China's semiconductor industry policy.

Replacing the bankrupt Tsinghua Unigroup as the new largest investment recipient in the Phase II Investment Fund is ChangXin Memory Technologies, a DRAM manufacturer headquartered in Hefei City. In addition to its RMB 5.26 billion investment in ChangXin Memory Technologies, the core company of the group, the fund has rapidly expanded its stake in ChangXin Power Company (Beijing) to RMB 12.55 billion and in ChangXin Xinqiao to RMB 14.56 billion.

However, except for large investments in three IDMs: Tsinghua Unigroup (and Yangtze Memory), ChangXin Memory, and the foundry SMIC, Table 4-3 shows that the fund has invested small amounts in numerous upstream and downstream companies in the IC industry. Excluding the 25 investment recipients from the Phase I Investment Fund and the investments in SMIC and Tsinghua Unigroup, the average investment per company was RMB 460 million in 49 companies. Excluding investments in Tsinghua Unigroup, ChangXin Memory, and SMIC from the Phase II Investment Fund, the fund has invested an average of RMB 370 million per company in 37 companies.

Looking at the investment recipients, Phase I invested 20.64% of the capital, or RMB 567 million, in National Silicon Industry Group, and Phase II invested RMB 72.12 million in the company. (The firm is a manufacturer of silicon wafers, the material used in ICs)[5] China's domestic production rate for wafers is estimated to be less than 10%. After receiving investment from the Phase I Fund, National Silicon Industry Group began production of 12-inch wafers, obviously suggesting that the company is aiming for domestic production of wafers, a weak point of the Chinese IC industry.

IC manufacturing equipment is another weak spot for China, and as noted above, the U.S. government's restrictions on exports of manufacturing equipment have curtailed the development of China's IC industry. The inclusion of six and five companies, respectively, in Phases I and II indicates the intention to strengthen production of manufacturing equipment. Manufacturing equipment manufacturers funded by Phase I include NAURA Technology Group (producing physical [PVD] and chemical [CVD] vapor deposition, etching, and cleaning equipment), Piotech (CVD), and Hangzhou Changchuan Technology (metrology equipment). Phase II has invested in AMEC (etching equipment and CVD), NAURA, and Hangzhou Changchuan Intelligent Manufacturing. Apparently, China's medium-fine etching equipment is capable of processing at the 5-nm level[6], but, of course, etching equipment alone is not enough to make ICs. At present, without access to the all-important EUV lithography equipment, it is difficult to make 5-nm-level ICs.

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[5] However, as of January 2024, the Phase II fund no longer appears to be investing in the firm.

[6] "The Effectiveness of U.S. Semiconductor Restrictions on China: The Rapidly Growing Power of Chinese Manufacturing Equipment Producers," *Nikkei Business*, July 31, 2023; https://business.nikkei.com/atcl/gen/19/00485/071800043/

While it is possible to produce ICs with the manufacturing equipment produced by firms supported by the Fund, the maximum that can be manufactured is the 90-nm level[7].

Looking at the Fund's Phase I and Phase II investments by sector, the largest number of investments in firms other than investment companies was in the design sector, that is, fabless. Including indirect investments via investment companies, the fund has invested in 122 companies in total, with an average investment of RMB 400 million. China is estimated to have a total of 2,218 fabless companies, which are very competitive. However, only Huawei's HiSilicon and Tsinghua Unigroup's Ziguang Zhanrui are major players. Therefore, it seems that the fund's investments are spread over a number of fabless companies in small amounts with the hope that one of them will grow to a large size. Looking at the ICs produced by fabless firms, many of them are power-management, fingerprint and other sensors, mobile baseband, and memory. It appears that the fund is diversifying risk by investing in multiple companies in the same product area.

During the 16-month period between September 2022 and the time of writing this chapter (January 2024), there has been some turnover among the investment recipients. In the first phase, China Resources Microelectronics (CR Micro), an IDM, was newly added, and two design companies, two packaging companies, one equipment manufacturing company, and one investment company were removed from the portfolio, indicating that the Phase I Fund is beginning to move toward dissolution.

Furthermore, nine companies were removed from the Phase II Investment Fund, and 17 companies were newly added. However, in many cases, the investors in companies removed from the list of investment recipients under the Phase II Investment Fund have simply changed the company name (e.g., "Huaxin Investment Management Co., Ltd.: Phase II Fund") and it appears that they have not withdrawn their investments but have instead transferred them to another company. The largest of the new additions to the investment portfolio is IDM, which has RMB 19.42 billion invested in five companies. In addition to a RMB 14.56 billion investment in the aforementioned memory-chip manufacturer ChangXin Xinqiao, the Fund has also newly invested in two LED chip companies and two power semiconductor companies. The next-largest investment in terms of value is in foundries, with RMB 8.16 billion invested in Hua Hong Semiconductor Manufacturing (Wuxi) and RMB 2.91 billion in Shanghai Huali Microelectronics. Beyond this, small new investments were made in five design companies, three materials companies, and two equipment companies. In general, looking at the investment recipients of the Phase II Investment Fund, there is a tendency to invest in companies whose products are sure to be in demand in China's domestic industry, such as LED chips, power semiconductors, and foundries, with the aim of ensuring profits rather than catching up with advanced IC countries in cutting-edge fields.

The National IC Industry Investment Fund was established under the leadership of the central government. In addition, there are several semiconductor-industry investment funds established under the leadership of local governments. The largest of these is Shanghai Integrated Circuit Industrial Investment Fund Co Ltd., which was established in 2016 with capital of RMB 28 billion. Investments were sourced from state-owned enterprises under the Shanghai municipal government (such as SAIC Motor Corporation) and the Phase I Fund. The investment recipients of this investment fund are included in Table 4-3, "Investment Companies Invested in by Phase I."

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[7] China Investment Industry Research Institute (2021) "2021-2025 China Semiconductor Industry Chain Depth Study and Investment Outlook Report"

Under the umbrella of the Suzhou municipal government in Jiangsu province is a company called Suzhou Integrated Circuit Industry Investment Co., Ltd., which claims to be involved in the semiconductor industry and has invested the entirety of its capital of RMB 1 billion in Jiangsu Jiangquan Integrated Circuit Industry Investment Co., Ltd. The latter is a company with a capital of RMB 10 billion, whose largest shareholder is the investment fund of the Jiangsu Provincial Government; besides Suzhou, the cities of Nanjing, Wuxi, Yangzhou, and Nantong have also invested in the company. However, Jiangsu Jiangquan has invested all of its capital in the Phase II Fund and has not conducted any investment activities of its own.

In 2015, the Wuhan municipal government established Hubei Integrated Circuit Industry Investment Fund Co., Ltd. with a capital of RMB 6.05 billion. The firm has investments in 11 other investment companies, but those investments are concentrated in Yangtze Memory. Also under the Anhui Provincial Government, the Anhui Integrated Circuit Industry Investment Partnership Enterprise was established in 2017 with a capital of RMB 1 billion. However, the investment company that invested RMB 500 million of that amount has already been dissolved. Under the umbrella of Xi'an City, the Shaanxi Provincial Integrated Circuit Industry Investment Fund was established in 2016 with a capital of RMB 3.63 billion. It has made small investments in 13 local semiconductor-related companies.

While huge investments by local governments have played an important role in the development of the LCD industry, in the semiconductor industry, the central government's investment is overwhelmingly large, and the role of local government is relatively small. Important investment entities other than the central government are the 25 investment companies in which the Phase I Investment Fund has invested, of which only the Shanghai Investment Fund is under the local government, whereas the others are investment companies independent of the central and local governments.

4.4 Semiconductor Industry Policy Outcomes

How should we evaluate the outcome of the semiconductor industry policy in which the Chinese government has invested significant funds since 2014? It is quite clear that the Chinese government's industrial policy aims are the domestic production of ICs and manufacturing equipment and materials. The domestic production rate, calculated as the ratio of domestically produced ICs to domestic IC demand, should therefore serve as an indicator to determine the success or failure of the policy. However, the fact is that widely differing figures are being bandied about regarding China's IC domestic production rate. The "Made in China 2025 Technology Roadmap" assesses the current situation of IC domestic production; according to its 2017 edition, the domestic production rate was 33% as of 2016. By contrast, according to IC Insights, the numbers are much lower and not showing any significant increase. IC Insights gives the IC domestic production rate as 15.1% in 2014, 13.8% in 2016, and 15.7% in 2019. If the latter figures are to be believed, China's IC industry policy has not produced any results at all. However, considering that the "Technology Roadmap" is the only source that indicates target values for IC domestic production rates, it would appear appropriate to evaluate the results based on the Roadmap's definitions and calculation methods. It makes little sense to claim that "the target was not achieved" by presenting figures calculated by completely different methods. Unfortunately, however, the Roadmap does not divulge its calculation method and is no longer being updated. Therefore, in this chapter, the focus is not on whether the goals of the "Technology Roadmap" have been achieved or not, but whether the rate of domestic production has actually increased.

A major problem in estimating China's IC domestic production rate is that IC trade statistics are difficult to use.

According to Chinese customs statistics, IC imports in 2021 were valued at USD 432.6 billion, and exports at USD 153.8 billion. However, the World Semiconductor Trade Statistics (WSTS) estimated the size of the global IC market in 2021 at USD 555.9 billion. This would mean that China alone imports nearly 80% of the ICs produced in the world. It is likely that ICs cross borders several times as they pass through the front- and back-end stages and imports and exports are declared each time.

Therefore, the WSTS estimate (USD 192.5 billion in 2021) for the size of China's semiconductor market was used. This figure was also given by the Chinese Semiconductor Industry Association, the trade association of Chinese semiconductor manufacturers. With regard to the production scale of China's semiconductor industry, the Chinese Semiconductor Industry Association reported that in 2021, the industry's revenue was RMB 1045.83 billion, of which RMB 451.9 billion came from the design industry, RMB 317.63 billion from the manufacturing industry, and RMB 276.3 billion from the packaging industry. However, simply adding up these three segments would result in triplicate counting of sales of the ICs designed, manufactured, and packaged in China. Given that some of the ICs designed in China are manufactured domestically, some are manufactured by overseas foundries such as TSMC and some of those manufactured domestically are packaged domestically. Therefore, the domestic production value that should be compared with the size of the semiconductor market should not be the total of design, manufacturing, and packaging but only one of them.

Table 4-4 took the value of semiconductor manufacturing sales and compared it with the size of the Chinese market as estimated by WSTS. Using this method to calculate the percentage of semiconductors produced domestically, an increase from 12.7% in 2014 to 25.6% in 2021 can be estimated. China is the world's largest exporter of personal computers, smartphones, tablets, and home appliances. One cannot imagine that the Chinese government is aiming to domestically produce the ICs used in these products; there is no point in doing so and it is inconceivable that the domestic production rate would reach 70%. Given the above, the 25.6% domestic production rate is not a figure that would lead one to conclude that China's industrial policy has failed. In fact, the rate should be evaluated as having steadily increased.

Table 4-4. Percentage of Domestically Produced ICs in the Chinese Market (Estimated)

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
IC manufacturing in China (RMB hundred million)	601	712	901	1127	1448	1818	2149	2560	3176
China's IC market size (USD hundred million)	883	915	986	1076	1315	1584	1446	1515	1925
Domestic production rate (%)	11.0	12.7	14.7	15.8	16.3	17.4	21.5	24.5	25.6

Source: Chinese Semiconductor Industry Association, World Semiconductor Trade Statistics

4.5 Summary

The rivalry between the U.S. and China over Huawei's acquisition of 7-nm-class ICs, which was mentioned at the beginning of this chapter, is only a small part of the turmoil in China's semiconductor industry as a whole. Most

Chinese companies other than Huawei have so far been able to obtain 5G-compatible ICs designed by the U.S. firm Qualcomm and manufactured by TSMC without any particular obstacles. This has made China the world's largest market for 5G communications equipment. In China, the U.S. is often described as "strangling" the Chinese IC industry by exploiting its weaknesses; but for all that, the Chinese electronics industry is breathing normally, and only a few Chinese companies (such as Huawei) have suffered.

The U.S. government's efforts to strangle Huawei have had the effect of making the Chinese government and other Chinese companies more wary, leading the Chinese government to launch Phase II of the IC Industry Investment Fund. However, selecting investment recipients has been no easy task. If imports are disrupted for a particular product, it will create an opportunity for Chinese manufacturers; conversely, if imports are not disrupted, domestic IC users will have no incentive to use uncompetitive domestically produced ICs. There are no leading-edge foundries such as TSMC in China, and no domestic manufacturers can compete with foreign manufacturers such as Samsung and Intel in general-purpose ICs such as memory chips and CPUs. If China can develop domestic manufacturers that are capable of substituting for these important sectors, it can prepare for the risk of imports being blocked. However, the gap between Chinese and foreign companies in these fields is large, and even with huge investments, they may not be able to catch up due to the U.S. government's restrictions on the export of semiconductor manufacturing equipment. Meanwhile, China has a wide range of industries that use ICs, such as home appliances, automobiles, and various types of cards. There is enormous demand for low-end memory and power-management ICs, power semiconductors, sensors, MCUs, and other ICs for these industries. A number of domestic IC manufacturers are targeting such demand. Investments in these areas are likely to pay off.

The National IC Industry Investment Fund has been struggling to strike a balance between huge investments in cutting-edge areas and investments in low-end areas where Chinese manufacturers are more likely to be competitive. Although the former strategy failed due to the bankruptcy of Tsinghua Unigroup, the accumulated profits from the latter will enable the Phase I Fund to not only recover its initial investment but also distribute a substantial surplus to its investors. Since the Phase II Fund has only been in existence for a little more than four years, the accumulation of internal reserves is still small, but it is still believed that the Fund is trying to strike a balance between cutting-edge and competitive sectors.

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5 The Industrial Robot Supply Chain and Economic Security

5.1 Overview of the Issues

In recent years, there has been a great deal of interest in supply chains and economic security, especially with regard to semiconductors. In addition, machine tools and industrial robots[1] are utilized in the production of diverse industrial products such as automobiles, aircraft, and electrical goods, making them indispensable to economic security. The share of industrial products and industries where the use of machine tools and industrial robots is essential in the manufacturing process is estimated to account for about 50% of the nominal GDP of the Japanese manufacturing industry (2020)[2]. In Japan, the Act on the Promotion of Ensuring National Security through Integrated Implementation of Economic Measures (Economic Security Promotion Act)[3] was enacted in May 2022. It designated industrial robots as a specified critical product and began to implement policies to ensure their stable supply.

Japan's robot industry has traditionally been highly competitive internationally, but it is China that has been rapidly emerging in recent years. The industrial robot market in China is quickly expanding; it has already surpassed Japan to become the world's largest in terms of the number of robots installed and in operation (stock) per year. China designated computer numerical control (CNC) machine tools and industrial robots as one of the 10 key strategic industries in "Made in China 2025," and has set a goal of 70% self-sufficiency in core components by 2025. The public and private sectors are working together to rapidly catch up with other countries, including through industrial subsidies. However, while Chinese companies are currently catching up with Japanese companies in terms of R&D intensity and labor productivity, the supply chain for industrial robots remains heavily dependent on imports and local production by foreign companies. Core technologies and core parts remain choke points for Chinese companies[4].

This chapter focuses on the supply chain for industrial robots and discusses the relationship between economic security and the supply chain, providing observational facts about its structure using data to the furthest extent possible. Robots can be broadly classified into industrial and service robots. This chapter focuses on industrial robots because they are closely related to economic security. In some cases, the term "industrial robots" is given simply as "robots."

Section 5.2 provides an overview of the status of China's industrial robot market, industries, and companies in comparison to Japan. Section 5.3 describes the structure of the industrial robot supply chain, and Section 5.4 analyzes

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[1] According to the Japanese Industrial Standard JIS B 0134:2015 "Robots and Robotic Devices - Vocabulary," a robot is an automatically controlled, reprogrammable, versatile manipulator, programmable in three or more axes, with a fixed or mobile function in one place, used in industrial automation applications, primarily for the production of industrial products.

[2] Ministry of Economy, Trade and Industry (2023) "Policy on Measures to Ensure Stable Supply of Machine Tools and Industrial Robots" https://www.meti.go.jp/policy/economy/economic_security/robot/robot_hoshin.pd

[3] Act on the Promotion of Ensuring National Security through Integrated Implementation of Economic Measures (Act No. 43 of 2022) https://elaws.e-gov.go.jp/document?lawid=504AC0000000043

[4] Zhang, Hongyong (2023) "Trade Investment, Catch-up and Industrial Policy in China's Robot Industry," in *Policies, Key Industries and Science and Technology underlying China's Manufacturing Power Strategy*, JST Asia and Pacific Research Center https://spap.jst.go.jp/investigation/report_2022.html#fy22_rr03

the characteristics and issues of Chinese companies. Section 5.5 discusses the relationship between economic security and the industrial robot supply chain.

5.2 Overview of the Industrial Robot Market

According to the International Federation of Robotics (IFR)[5], the number of industrial robots installed per annum worldwide grew from 159,000 in 2012 to 553,000 in 2022, with a 7% annual increase from 2017 to 2022. China is the world's largest market for industrial robots, with its share of the world's total annual industrial robot installations growing dramatically from 14% in 2012 to 52% in 2022. Furthermore, in terms of the number of industrial robots in operation (stock), China surpassed Japan in 2016 to become the world's largest practitioner, with approximately 783,000 units in operation as of 2019. This is more than double the number of robots in operation in Japan (355,000), the second-largest market.

Figure 5-1 presents the production and installation of industrial robots in China and Japan during 2014-2022. This figure clarifies the following points.

(1) In terms of new installations, China will reach 290,300 units in 2022, a 5% increase over the previous year and an average annual increase of 13% from 2017 to 2022. In contrast, Japan ranks second, with a 9% increase to 50,400 units in 2022, up from 49,000 in 2019 before the pandemic. Between 2017 and 2022, Japan's annual installations increased by an average of 2% per year, a much lower annual increase than China's 13%.

(2) In terms of production, according to China's National Bureau of Statistics (NBS), industrial robot production reached 443,000 units in 2022, up 21% from the previous year, and nearly double the 139,000 units produced in 2017. Meanwhile, according to the Japan Robot Association (JARA), Japan only produced 280,000 units in 2022. However, according to the International Federation of Robotics (IFR), Japan remains the world's largest producer (280,000 units in 2022). While IFR's data do not show China's production in 2022, a comparison of NBS and JARA data suggests that China is actually ahead of Japan.

(3) If, in the number of units to be exported, the difference between the number of units produced and those installed is considered, it can be said that although most industrial robots produced in China are shipped domestically, robot exports have been increasing sharply since 2019. Meanwhile, in Japan, the number of robots exported far exceeds domestic shipments, with the majority going overseas.

It is difficult to simply compare the IFR, NBS, and JARA figures because their statistical standards and survey coverage can differ slightly. However, there is no doubt that China's production capacity is rapidly expanding, and its international competitiveness increasing.

In recent years, along with the expansion of the Chinese robotics market, the Chinese robotics industry and companies have grown rapidly and caught up with the global leaders, which are Japanese companies. JARA[6] notes that China is becoming a threat to the Japanese robotics industry as it has increased its domestic manufacturing rate under

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[5] International Federation of Robotics (2023) World Robotics 2023
https://ifr.org/img/worldrobotics/2023_WR_extended_version.pdf

[6] Japan Robot Association (2023) *Robot Industry Vision 2050*; https://www.jara.jp/publications/visionver0.html

the "Made in China 2025" policy while strengthening its export capabilities. In addition, an analysis by the author[7], using financial data (2012-2021) for a total of six listed Chinese and Japanese companies, reveals that the Chinese companies (Siasun, STEP Electric, Estun Automation, and EFORT) still had lower labor productivity levels and return on sales than the Japanese companies (Fanuc and Yaskawa Electric). However, they were already equal or superior to Japanese companies in terms of sales growth rates and R&D intensity.

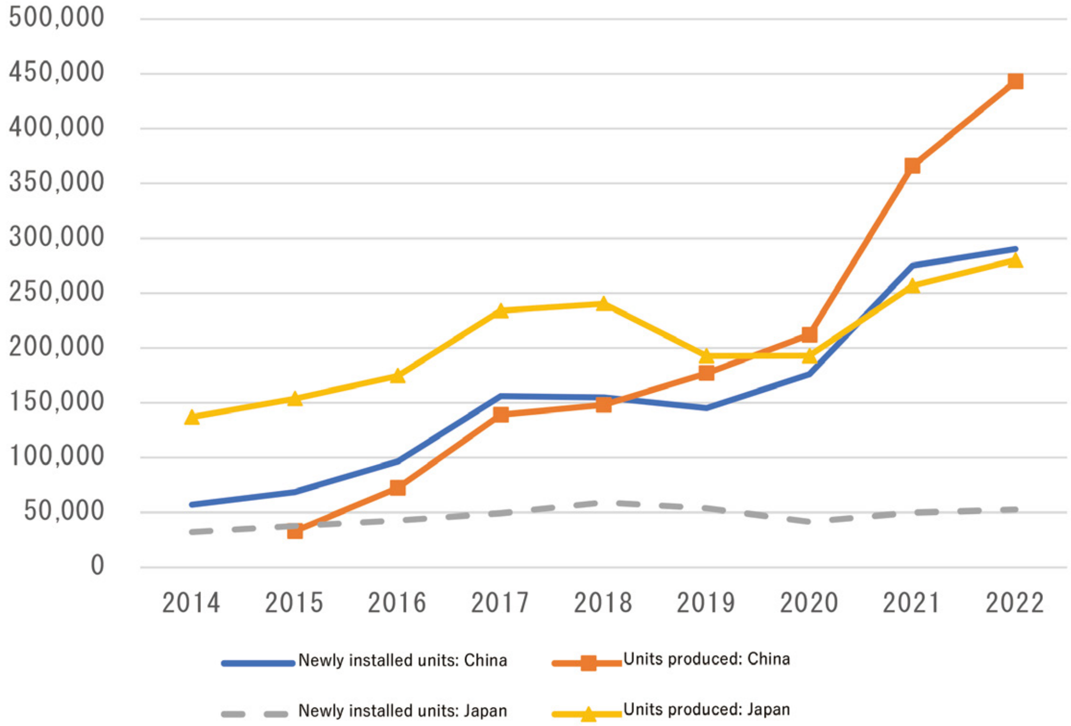

Figure 5-1. Industrial Robot Market: China vs. Japan

(Figures for new installations are from the annual IFR World Robotics report; production figures are from the NBS "Statistical Communiqué of the People's Republic of China on National Economic and Social Development" annual report, and from the JARA *Robot Industry Supply-Demand Trends 2023 (Industrial Robots)* report; compiled by the author.)

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[7] Zhang, Hongyong (2021) "Industrial Subsidies and Listed Firms' Innovation Activities in China: A Microdata Analysis"; https://www.rieti.go.jp/jp/publications/dp/21j052.pdf

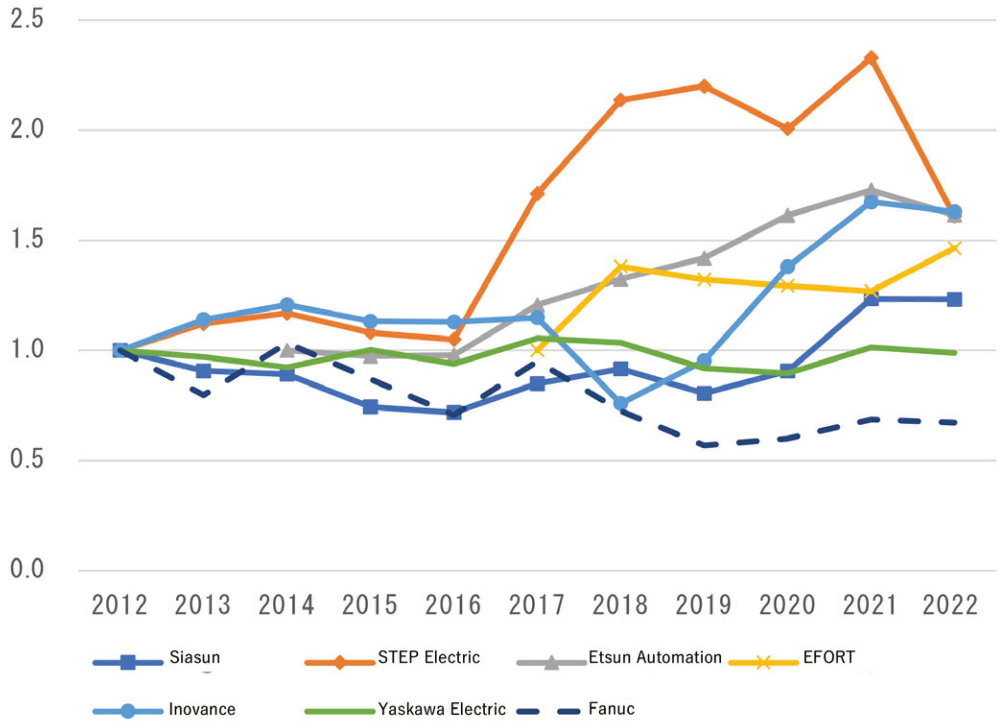

Figure 5-2. Labor Productivity of Robot Manufacturers (2012 = 1): China vs. Japan

(Compiled by the author from the Orbis database)

Figure 5-2 compares the labor productivity growth rates of Chinese and Japanese firms from 2012 to 2022, with 2012 set as 1. Labor productivity is sales divided by the number of employees. The labor productivity growth rate for Chinese firms as a whole is much higher than that of Japanese firms. In 2022, the labor productivity of Chinese companies as a whole was about 1.5 times higher than in 2012, whereas the labor productivity growth rate of Japanese companies was almost zero (Yaskawa Electric) or negative (Fanuc). Among Chinese firms, private firms (STEP Electric, Estun Automation, and Inovance) had higher productivity growth rates than state-owned firms (Siasun, EFORT). Although not shown here, Japanese firms were still performing higher than Chinese firms in terms of labor productivity levels (USD 1,000/capita) as of 2022. Specifically, the average for Chinese firms was 152 (138 for Siasun, 169 for STEP Electric, 155 for Estun Automation, 145 for EFORT, and 166 for Inovance), whereas the average for Japanese firms was 496 (315 for Yaskawa Electric and 677 for Fanuc); this was about three times higher than for Chinese firms.

5.3 The Industrial Robot Supply Chain

In examining the relationship between the robotics industry and economic security, understanding the industrial robot supply chain is crucial. In Japan, the Cabinet Secretariat's Expert Committee on Economic Security Legislation stated, "Supply chains are becoming increasingly complex against the backdrop of progress in globalization and changes in international affairs. To ensure the stable supply of critical commodities, it is necessary to look at the supply chain as a whole and determine what risks exist." The report also states that it is important to visualize the entire supply chain, identify and analyze risks, identify issues, and consider how to respond.

Figure 5-3 shows the full supply chain of industrial robots. The uppermost segment of the upstream stage includes general-purpose parts materials such as semiconductors, permanent magnets, and foundry substitutes. These materials are known to be widely used in industrial products, but they are also important materials for equipping industrial robots. The upstream stage includes control-related equipment such as CNC, servo mechanisms (servo motors, amplifiers, etc.), reduction gears, and programmable logic controllers (PLCs). PLCs are indispensable for precisely operating industrial robots. They constitute a strategic commodity that greatly influences robot performance and international competitiveness. The CNC calculates the information required for processing and assembly by the industrial robot, converts it into numerical information, and gives control instructions. The servo mechanism converts the information into the necessary output and performs the actual drive, while the reduction gear, in combination with the motor, generates more torque (force). The PLC also performs calculations and gives control instructions to ensure smooth operations of the production line or factory as a whole, where industrial robots are incorporated simultaneously and continuously. Upstream materials include PLCs as well as specialized materials such as ball screws, linear guides, linear scales, spindles, and cast parts. In the midstream stage, manufacturers of industrial robot bodies manufacture the main bodies of industrial robots (joints, arms/wrists, actuators, etc.) and assemble these with PLCs and specialized part materials. The downstream stage involves robot system integrators, which propose the introduction, design, and assembly of machine systems using robots. Robot system integrators analyze the on-site issues faced by companies considering introducing robots, and build the optimal robot system by selecting the necessary items from a variety of machines, devices, and parts and integrating these items into the system. After integration, the manufactured industrial robots are introduced further downstream into the automotive, electronics, metalworking, and other industries for use by end customers.

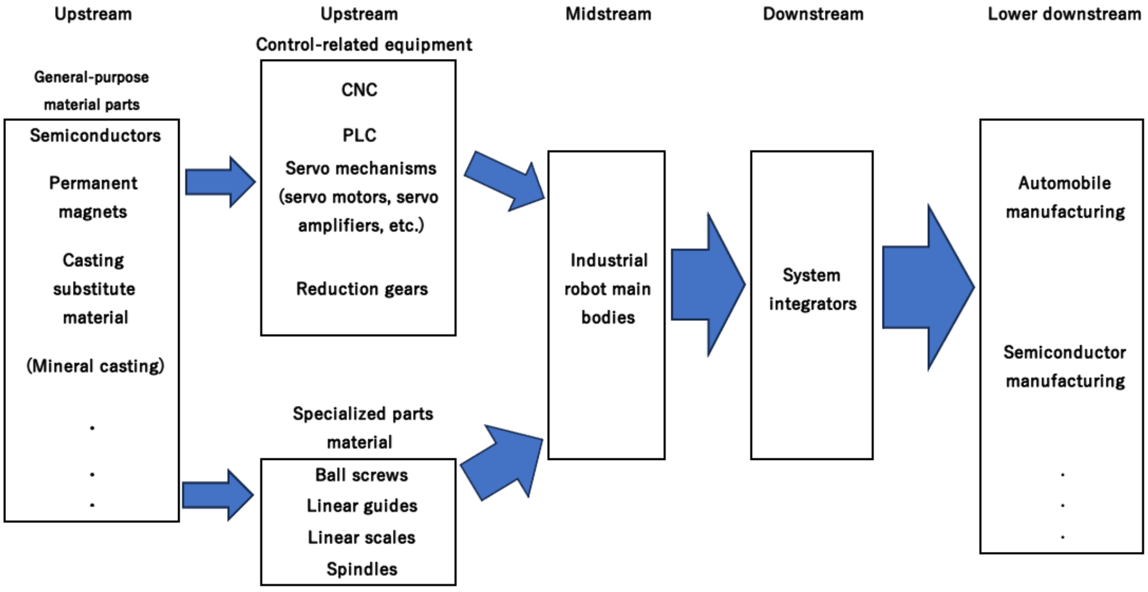

Figure 5-3. Full Supply Chain of Industrial Robots

(Compiled by the author from various sources)

In the production of industrial robots, upstream materials such as CNC, reduction gears, servo mechanisms, and PLCs account for about 60% of the total cost and the largest cost share. Looking at the global market share of PLCs by manufacturer, Japanese companies are very competitive internationally[8]. For example, in 2017, Japanese companies' global market share of CNC and PLCs was 65% and 37%, respectively. European firms, like Japanese firms, are highly competitive internationally. Their global market share of CNC and PLCs was 30% and 57%, respectively. In addition, comparing the global market share of major manufacturers in 2019, companies from Japan ranked first (16%) and fourth (12%) in the world for servo mechanisms, and European companies came second (13%) and third (13%). Furthermore, Japanese firms ranked first (41%), second (28%), third (7%), and fifth (5%) in the world for reduction gears, and the fourth-placed firm (5%) was a Chinese-registered manufacturer. For China, where the public and private sectors are cooperating to rapidly catch up, domestic manufacturers' share of the domestic market for precision reduction gears for industrial robots increased from 11% in 2014 to 28% in 2018.

Table 5-4 lists the major companies participating in the Chinese industrial robot supply chain. This section focuses on the upstream, midstream, and downstream of the supply chain. All domestic and domestically funded firms are publicly traded. Traditionally, the weak technological capabilities of domestic brands have been an issue, and core components for industrial robots depend heavily on imports and local production by foreign firms. In particular, the four major foreign companies—Fanuc, Yaskawa Electric, ABB, and KUKA—have strong market dominance and strong technological and competitive advantages upstream in the supply chain. The market share of domestic brands is low even in core components, such as reduction gears, servo mechanisms, and controllers, that are indispensable for the manufacture of advanced robots. Although many domestic brand-name companies have entered the market for these core components, there remains a large gap in technological capabilities between them and foreign firms. A survey showed that the proportion of domestic brands among these core components was 22% for servo mechanisms, 28% for reducers, and 30% for controllers[9].

Table 5-4. Companies Participating in the Industrial Robot Supply Chain

		Domestic/domestically funded	Importer/foreign-funded
Upstream	Reduction gears	Qinchuan Machine Tool, Zhejiang Shuanghuan Driveline, Leaderdrive	Nabtesco, Sumitomo Drive, SPINEA
	Servo mechanisms	Inovance, STEP Electric, Estun Automation	Yaskawa Electric, Delta Electronics, Mitsubishi Electric
	Controllers	Siasun, STEP Electric, Estun Automation, Wasu	ABB, Yaskawa Electric, Fanuc, KUKA
Midstream	Robot bodies	Estun Automation, Inovance, Siasun, EFORT, STEP Electric	ABB, Yaskawa Electric, Fanuc, KUKA
Downstream	System integrators	Siasun, EFORT, Bozan, Estun Automation, SanFeng Intelligent Conveying Equipment, Wasu	ABB, Yaskawa Electric, Fanuc, KUKA, Siemens

(Compiled by the author from various sources)

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[8] Same as [2]

[9] New Energy and Industrial Technology Development Organization, "Trends in China's Robotics Industry," July 2020 https://www.nedo.go.jp/library/ZZAT09_100014.html

For industrial robots, foreign brands have a high market share (about 80% as of 2018), especially for multi-joint robots with 6 or more axes, which require high technological capabilities. Domestic brands are concentrated mainly in the mid- to low-end areas of palletizing (loading pallets for temporary storage of pre-packed finished products), loading and unloading, and handling. Currently, listed companies are aggressively trying to develop full industrial chains. For example, Etsun Automation exclusively uses proprietary products with the exception of reduction gears. Siasun also has a full industrial chain, outsourcing reducers and starting to manufacture motors in-house. Currently, there is a concentration of industrial robot-related companies in Guangdong and Jiangsu provinces, and the supply chain is relatively complete. In Guangdong, there are 12 listed companies including Inovance, Everwin Precision, and Han's Laser; in Jiangsu, there are 8 listed companies including Etsun Automation and Leaderdrive. In the future, such industrial clusters are expected to help companies expand procurement and sales and improve productivity.

5.4 Supply Chain and Company Characteristics

This section discusses how Chinese firms are characterized from a supply chain perspective. Specifically, Chinese firms' R&D, subsidies, and profit margins using financial data from listed companies are analyzed, dividing the supply chain into upstream, midstream, and downstream stages.

The analysis covers the following companies: 16 upstream materials companies (INVT, KCFA, Moons', Kinco, Leadshine, Keli Motor, Leaderdrive, Zhejiang Shuanghuan Driveline, Ningbo Zhongda Leader, Qinchuan Machine Tool, Haozhi Industrial, Hanyu Group, Shanghai Mechanical, Creatoo Intelligent, NRB, and Guomao); 16 midstream industrial robot body manufacturers (Siasun, STEP Electric, Etsun Automation, EFORT, Inovance, Kaierda, Topstar, HGZN, CSG Smart Science, Huazhong, CRP Robot Technology, Han's Laser, Boomy Intelligent, Yijiahe, Risong, and Everwin Precision); and 10 downstream system integrators (Huachangda, SanFeng Intelligent Conveying Equipment, Kelai Mechatronics, Bozan, UFA, Jiangsu Beiren, BOZHON, Colibri Technologies, TORRAS, and Keda Automation Control). Of these, the main business of four companies—Siasun, STEP Electric, Estun Automation, and EFORT—is industrial robots themselves, these companies are considered midstream in the supply chain.

In terms of company characteristics, the focus is on R&D, subsidies, and profit margins. As R&D plays a central role in innovation, in the long run, the accumulation of R&D may contribute to Chinese firms catching up and domesticizing their products. Subsidies are an important industrial policy tool to promote domestic production, and this section examines how subsidies are actually allocated along the industrial robot supply chain to encourage firms to invest in R&D. In addition, the profit margin indicates where profits are allocated along the supply or value chain. R&D investment, current profits, and sales data are from the China Stock Market & Accounting Research Database of companies listed in China (CSMAR). In analyzing subsidies, the Wind China database of companies listed in China is used. The analysis timespan is divided into three periods: 2010-2014 (before "Made in China 2025"), 2015-2017 (after "Made in China 2025"), and 2018-2022 (during the U.S.-China trade conflict).

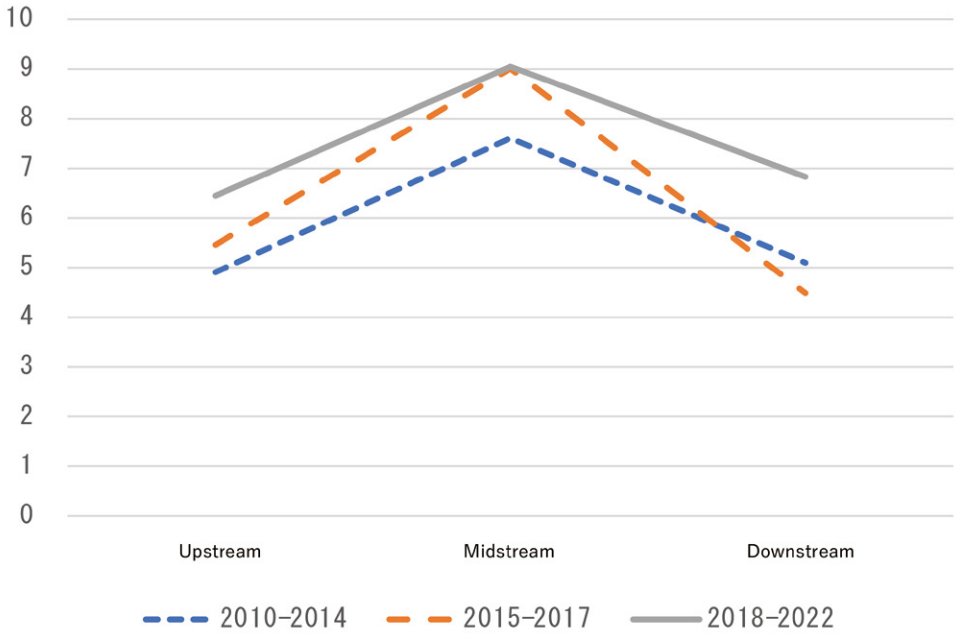

Figure 5-5. R&D Intensity (%)

(Compiled by the author from the CSMAR database)

Figure 5-5 divides the firms participating in the supply chain into three groups: upstream, midstream, and downstream, and shows the average R&D intensity of each group. "R&D intensity" refers to the ratio of R&D investment to sales. First, the R&D intensity of the entire supply chain was about 1.5% higher in 2018-2022 than in 2010-2014, indicating that R&D investment was expanding. Second, the R&D intensity of midstream robot-body manufacturers is consistently about 2% higher than upstream parts and materials manufacturers and downstream system integrators. Upstream and downstream R&D intensity at both ends of the supply chain is about 5%-7%; meanwhile, in the midstream, it is about 7%-9%, resulting in an inverted U-shaped supply chain. This is a matter of considerable interest. Upstream materials such as CNC, servo mechanisms, reduction gears, and PLCs are the core technologies and core components of industrial robots and greatly affect robot performance and international competitiveness. Therefore, if the goal is for China to achieve domestic production, it is advisable to invest more in R&D upstream and be more R&D-intensive in the upstream than in the midstream. However, at present, most R&D investment goes toward the midstream, and resource allocation is not always rational. However, listed companies such as Siasun are actively expanding their upstream operations. Upstream R&D investment may increase in the future.as they move to strengthen their supply chains,

Figure 5-6 gives the average subsidy intensity for the upstream, midstream, and downstream supply chains. "Subsidy intensity" refers to the ratio of industrial subsidies to sales. First, by period, the subsidy intensity of the entire supply chain was noticeably higher for 2018-2022, whereas it was almost unchanged from 2010 to 2014 and from 2015 to 2017. This appears to reflect industrial policies targeting industrial robots in recent years. Second, interestingly, as with R&D investment, the subsidy intensity is higher in the middle and lower at both ends, creating an inverted U shape. In 2018-2022, the subsidy intensity in the midstream reached about 5%, whereas the figures for upstream and downstream were under 3%. To achieve domestic production of core technologies and core components, a large amount of subsidies need to be invested upstream to support innovation activities such as capital investment and

R&D investment. However, at present, it appears that large amounts of subsidies are being invested in the midstream stage of robot manufacturing. As core technology and core components are the choke points of the Chinese robotics industry, such subsidy allocations do not seem appropriate from an economic-security and supply-chain perspective.

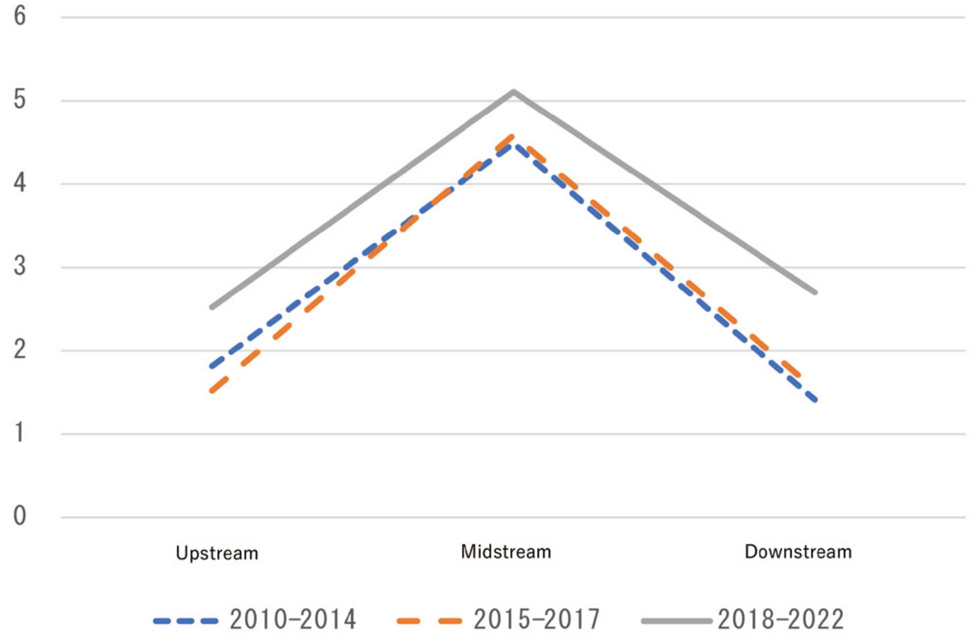

Figure 5-6. Subsidy Aggregation (%)

(Compiled by the author from the WIND database)

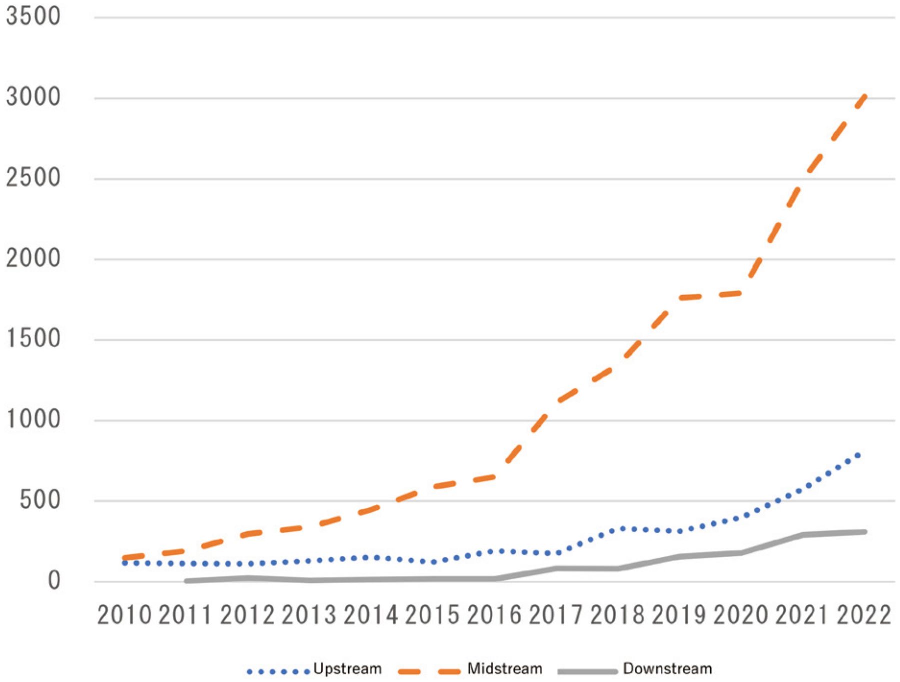

Figure 5-7. Subsidy Amounts (RMB million)

(Compiled by the author from the WIND database)

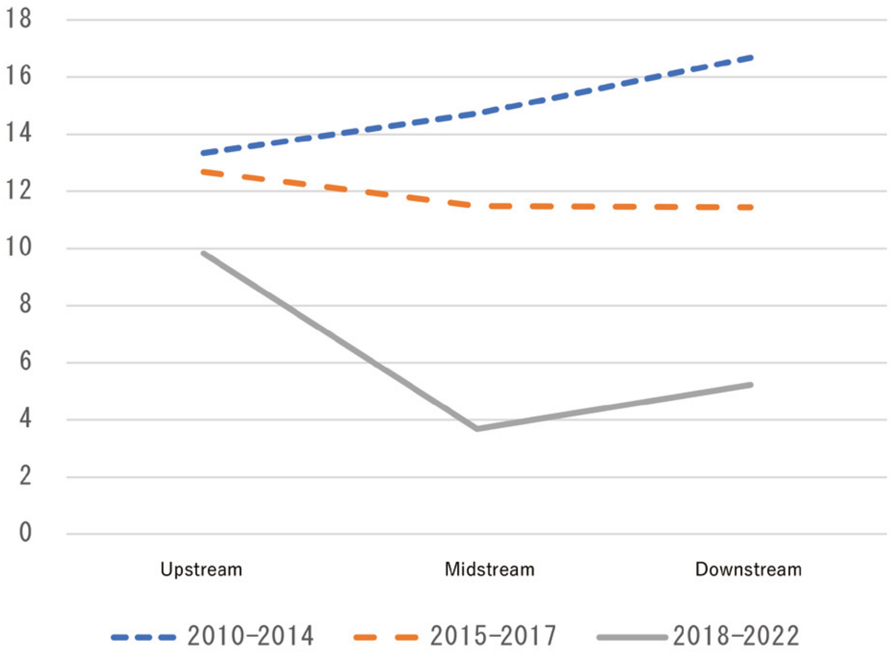

Figure 5-8. Profitability on Sales (%)

(Compiled by the author from the CSMAR database)

As indicated in Figure 5-7, the subsidies given to midstream firms are far more substantial than those given to firms in the upstream and downstream. In 2022, subsidies to the upstream stage amounted to RMB 810 million, whereas more than three times this amount (RMB 3.01 billion) was given to the midstream stage. Such distortions in subsidy allocation are likely to reduce the effectiveness of industrial policies aimed at domestic production of core technologies and core components.

Figure 5-8 gives the average profit margin on sales for the upstream, midstream, and downstream supply chains. The profit margin on sales is calculated as the ratio of current profits to sales. First, the return on sales for the entire supply chain declined from 14% in 2010-2014 to 12% in 2015-2017 and then to below 10% in 2018-2022. This suggests that the market for industrial robots is rapidly expanding and simultaneously becoming more competitive. Second, from 2010 to 2014, the profit margin was higher further downstream, but from 2015 to 2017, there was no significant difference between the upstream, midstream, and downstream stages, although the upstream figures were slightly higher. The value chain in industries such as electronic devices can divided into three overall stages: upstream (planning, development, parts manufacturing); midstream (product assembly); and downstream (sales, maintenance, etc.). If a graph is drawn with the stages on the x-axis and the business profits and added value for each stage on the y-axis, the result is known as a "smile curve"; profit rate and added value ratio are low in the middle and high at the upstream and downstream ends. However, no such phenomenon is observed here. Between 2018 and 2022, profit margins were highest upstream, followed by downstream, and then midstream; although downstream profit margins were still low, the supply chain was approaching a smiling curve shape.

Table 5-9. Correlation Coefficients between R&D Investment, Subsidies and Profit Margins

		R&D intensity	Subsidy aggregation	Ratio of profit to sales
Panel A: Upstream	R&D intensity	1		
	Subsidy aggregation	0.757*	1	
	Ratio of profit to sales	− 0.070	− 0.127	1
Panel B: Upstream	R&D intensity	1		
	Subsidy aggregation	0.709*	1	
	Ratio of profit to sales	− 0.252*	− 0.129	1
Panel C: Downstream	R&D intensity	1		
	Subsidy aggregation	0.625*	1	
	Ratio of profit to sales	0.094	0.144	1

(Compiled by the author from CSMAR database and WIND database)

Note: 42 Chinese companies, 2010 to 2022 there are 110 upstream, 121 midstream, and 55 downstream samples. * indicates statistical significance at the 1% level.

Table 5-9 shows the correlations between three indicators by supply-chain stage, R&D intensity, subsidies, and profit margins, using information for each company rather than averages by supply-chain stage. Panel A is upstream, Panel B is midstream, and Panel C is downstream. At all stages, there is a positive correlation between subsidies and R&D investment; in other words, the higher the subsidy intensity, the higher the R&D intensity. The correlation coefficients are all statistically significant at the 1% level, but the largest correlation coefficient is found upstream. If subsidies encourage more R&D investment in the upstream than the midstream and downstream stages, one can expect to see more domestic production of core technologies and core components. However, as indicated by Figure 5-6, subsidies are neither highly concentrated upstream nor are the subsidy amounts high. To promote domestic production of core technologies and core components in the future, it would be advisable to invest more subsidies upstream in the supply chain. The correlation between subsidies and return on sales is not statistically significant; hence, it cannot be said that the Chinese government is providing subsidies to firms to make up for losses.

5.5 Economic Security and the Industrial Robot Supply Chain

This section discusses the position of industrial robots in Japan's economic security policy and then examine the challenges for China from the perspective of economic security and international supply chains.

Under the Economic Security Promotion Act, the Ministry of Economy, Trade and Industry (METI) provides support for initiatives to ensure a stable supply of specified critical products under its jurisdiction. These include permanent magnets, machine tools and industrial robots, aircraft parts, semiconductors, storage batteries, cloud programs, combustible natural gas, and important minerals. Various measures are in place, such as the development of production bases in line with the characteristics of each material, diversification of supply sources, and stockpiling. Production technologies are introduced, developed, and improved, and alternative materials are developed. For industrial robots, in January 2023, METI announced a set of plans to ensure stable supply of machine Tools and

Industrial Robots[10] METI pointed out that Japan's industrial robot industry has traditionally been highly competitive internationally. However, the global market is expanding in response to medium- to long-term irreversible megatrends. These include digital transformation (DX) and carbon neutrality (CN). Europe is also highly competitive internationally; in addition, the public and private sectors in China are working together to rapidly catch up under the "Made in China 2025" initiative. Other countries are also making efforts to strengthen their international competitiveness. Therefore, the public and private sectors in Japan must also cooperate to ensure stable supplies in this area. Otherwise, there is a risk that supplies will become unstable; ultimately, the business foundation of Japan's manufacturing industry will become overly dependent on external sources. Under these circumstances, if a supply disruption were to occur, it would have a major impact on economic activity. According to METI, to strengthen domestic production capacity so as to maintain and enhance Japan's international competitiveness, the state will promote initiatives to increase the number of industrial robots to approximately 260,000 units in 2025 and 350,000 units in 2030.

In an effort to ensure a stable supply of industrial robots, in June and July 2023, METI decided on a plan to ensure a stable supply of four PLC-related equipment items: CNC systems, servo mechanisms, PLCs, and reduction gears. The goal in regard to securing stable supply of specified critical products, etc., is to strengthen domestic production capacity for machine tools and control equipment for industrial robots. A total of six companies, including Fanuc (CNC), Yaskawa Electric (servo mechanisms), and Mitsubishi Electric (CNC, servo mechanisms, PLC), were selected as certified supply assurance businesses. The maximum subsidy amount totals approximately JPY 39.5 billion.

Most recently, in November 2023, the Cabinet Secretariat's Expert Committee on Economic Security Legislation released a policy document: "Direction of Efforts Concerning Specified Critical Products." Among the pointers given, the revised policy for ensuring stable supply of machine tools and industrial robots states that the goal for ensuring stable supply is to maintain and strengthen Japan's international competitiveness by enhancing domestic production capacity and technological capabilities to reduce the risk of overseas dependence on the part of the Japanese manufacturing industry's business base in the future. To achieve this goal, the state will ① strengthen Japan's domestic production capacity for PLCs, which will contribute to achieving the goal of ensuring a stable supply of industrial robots by 2030 (approximately 350,000 units/year) and ② promote R&D to meet growing needs for control-related equipment in light of megatrends such as DX and CN.

This section will focus on the international supply chain for industrial robots. Japan's domestic industrial robot supply chain, including industrial robot production and installation, is discussed in Section 5.2, and the core components, PLCs, are discussed in Section 5.3. To ensure a stable supply of industrial robots, METI's policies set a target of approximately 260,000 units of domestic production in 2025. This target was set based on the production volume in 2021 (256,000 units). In fact, as of 2022, Japan's industrial robot production reached 280,000 units, already exceeding the target. The domestic procurement rate is estimated at 97%,[11] and the figure has remained broadly stable for the last 10 years. Japan's imports of robots have traditionally been negligible, with only 1,343 units imported in 2022, amounting to 3% of total units installed. Of these imports, 36% originated in China, 14% in Denmark, and 13% in Taiwan. Therefore, at this point, even if there is a disruption in industrial robot imports, it is unlikely to have any

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[10] Same as [2]

[11] Japan Robot Association (2023), Robot Industry Supply-Demand Trends 2023 (Industrial Robots)

major impact on domestic manufacturing production in Japan. In contrast, in exports, Japan's robot industry is highly competitive internationally. The number of industrial robots exported in 2022 was 207,737 units, up 12% from the previous year, making Japan the largest exporter in the world[12]. However, the global share of Japanese-manufactured new units installed worldwide declined from 62% in 2013 to 51% in 2022[13].

Turning to China, robot exports have expanded rapidly in recent years. The value of exports (number of units exported) increased from USD 140 million (11,000 units) in 2015 to USD 340 million (55,000 units) in 2021. However, the value and volume of exports to Japan are quite small, around 6%. Importantly, in China, the average price of imported industrial robots was USD 13,000, whereas the average price of exported industrial robots was only USD 6,000 (both in 2021), suggesting that China is importing higher-end products while exporting lower-end products. Therefore, the current situation is that Chinese and Japanese companies are segregated in the global market.

While China has no law exactly commensurate with Japan's Economic Security Promotion Act, economic security is clearly positioned as part of China's national security. The emphasis on "economic security" expressed in the 2014 "holistic national security concept" implied the goal of upgrading the manufacturing industry set out in "Made in China 2025," which was announced in 2015. Article 19 of the National Security Law, subsequently passed and enacted in 2015, stipulates that the role of the state is to "maintain the basic economic system and order of the socialist marketplace, completing institutional mechanisms for prevention and resolution of risks to economic security," and China began to integrate economic and security measures under state direction. China has launched a series of industrial policies for the robot industry, including the "Robotics Industry Development Program (2016-2020)" in 2016, the "14th Five-Year Plan for the Robotics Industry" in 2021, and the "Robot + Application Action Plan" in 2023, to vigorously promote the development, production, installation and application of industrial robots, including core parts.

Compared with Japan, China's industrial robot supply chain is heavily dependent on imports, which may pose significant economic security issues. According to the IFR[14], in 2020, imports and local production by foreign companies will account for about 73% of industrial robot installations, or 122,605 units. Table 5-10 provides data on China's robot imports in recent years. Import values and volumes have been increasing every year since 2015 and are expanding significantly, reaching approximately USD 1.5 billion in imports and 110,000 imported units in 2021. Importantly, China's robot imports are heavily dependent on Japan. In 2021, Japan accounted for 74% of China's imports in terms of value and for 84% in terms of volume. In terms of import value in the most recent period, 2022-2023, China's dependence on Japan for imports of industrial robots was 77%. From China's perspective, this means that it must urgently expand domestic production of high-end industrial robots as the international supply chain for industrial robots is dependent on Japan alone, which could pose an economic security risk.

As China's robot imports are heavily dependent on Japan, from an economic-security and supply-chain perspective, it is important to understand the industries and work processes in which robots are used. Detailed data on specific clients (suppliers) in China for industrial robots imported from Japan and other foreign countries are not available. Therefore, here, the annual number of industrial robots installed by the manufacturing industry is examined.

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[12] Same as [5]

[13] Authors' estimates based on [5][11]

[14] International Federation of Robotics (2021) World Robotics 2021;
https://ifr.org/downloads/press2018/2021_10_28_WR_PK_Presentation_long_version.pdf

According to the IFR[15], the top three industries in terms of industrial robot installations are electrical and electronics, automotive, and machinery. The number of installed units in the electrical and electronics industry is growing rapidly from 66,000 units in 2020 to 100,000 units in 2022 and from 30,000 units in 2020 to 73,000 units in 2022 in the automotive industry. The electrical and electronics and automotive industries will account for as much as 60% of China's total installed units (290,000 units) in 2022. It is assumed that many imported robots are heavily utilized in these industries. These industries are also key for realizing China's goal of becoming a "manufacturing superpower"; as industrial robots are a critical commodity, it is extremely important to ensure their stable supply.

Table 5-10. China's Robot Imports

Year	Monetary amount (USD 1000)	Volume (Units)	Price (USD 1000 / unit)	Japan's share (Monetary amount)	Japan's share (Quantity)	Japanese price (USD 1000 / unit)
2015	804,834	46,819	17	57%	79%.	12
2016	875,522	52,200	17	62%	75%	14
2017	1,326,503	84,226	16	61%	77%	12
2018	1,144,285	100,349	11	63%	57%	13
2019	989,855	60,723	16	61%	77%	13
2020	1,042,448	76,342	14	71%	83%	12
2021	1,535,467	114,698	13	74%	84%	12
2022	1,375,124			77%		
2023	1,183,958			77%		

(Compiled by the author from the Global Trade Atlas database and the China Customs website)

Note: Data for 2023 are from January to November.

In terms of shipment value, industrial robots are mainly used for electronic component mounting, cleanrooms, welding, painting, assembly, and material handling. According to JARA (2023), mounting electronic components are the largest application of industrial robots, accounting for 26% of Japan's total shipments and 31% of exports in 2022. Robots for mounting electronic components are broadly classified into those for inserting electronic components and those for mounting electronic components; these are fixed robots that mount electronic components on printed circuit boards. Robots for mounting electronic components are indispensable manufacturing equipment for the production of electronic devices in a wide range of fields, including information communication devices, mobile information terminals, and the electrification of automobiles.

In China, the robotics market has expanded rapidly as EMS and ODM[16] companies have grown, and domestic companies have become more competitive. Cleanroom robots are broadly classified into those for flat panel displays,

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[15] Same as [5]

[16] "EMS" stands for "electronics manufacturing services," i.e., contract manufacturing services for electronic equipment. "ODM" stands for "original design manufacturing," i.e., the design and production of products under the commissioning party brand.

semiconductors, and others (hard disk drives, solar panels, etc.), and they are used for transporting glass substrates and semiconductor wafers in the manufacturing process in a cleanroom environment. In the case of robots for semiconductors, investments in 5G and IoT, electric vehicles, and infrastructure to handle increasing data traffic have boosted demand for semiconductors.

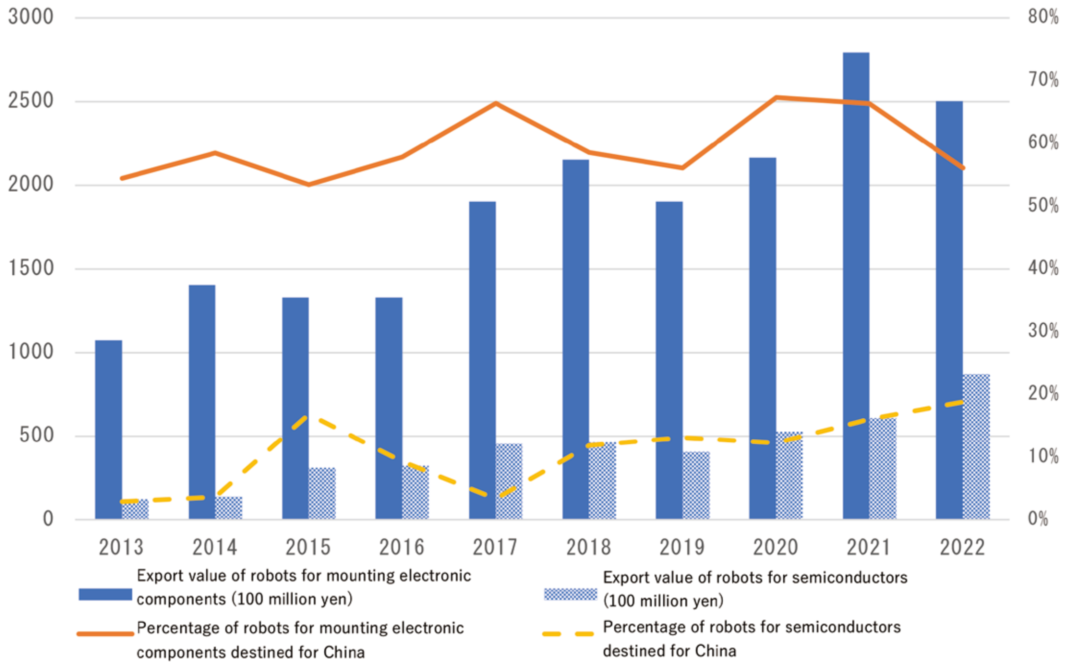

Figure 5-11. Japan's Robot Exports by Application

(Compiled by the author from *Robot Industry Supply-Demand Trends 2023 (Industrial Robots)*, Japan Robot Association)

Among the various robots for mounting electronic components and for cleanroom use, let us focus on robots for semiconductors. These are considered the most important for Chinese companies. Statistics on the work processes the robots are used in cannot be obtained from China; therefore, Japanese statistics are used to confirm exports to China. Figure 5-11 shows the value of Japan's exports of robots by application and the percentage of these exports destined for China. In 2022, exports of robots for mounting electronic components amounted to 250.2 billion yen (16,000 units), the second-highest level ever. Over the past decade, exports to China have accounted for more than half of total exports. Meanwhile, demand for robots for semiconductors is expanding, with domestic shipments and exports reaching record highs. Exports increased 42.9% year-on-year to JPY 87 billion in value (23,783 units, up 28.1% year-on-year). The major export destinations are the U.S., China, Taiwan, and South Korea, which are important semiconductor manufacturing bases. In recent years, the share of exports to China has been expanding, reaching 19% by 2022. Upstream, Japanese robots for mounting electronic components and semiconductors are essential intermediate inputs and capital goods for the downstream Chinese electronics and semiconductor industries. From the standpoint of strengthening China's economic security and supply-chain resilience, there is a need to promote domestic production and reduce dependence on Japanese imports. Conversely, Japanese exports are heavily dependent on the Chinese market, and with geopolitical risks and the growing international competitiveness of Chinese firms, the future challenge for Japanese firms is to diversify their export destinations for robots for mounting electronic components.

5.6 Conclusion

In recent years, supply chains and economic security have received a great deal of attention both in Japan and internationally. Due to the promotion of DX and the growing need for a wide range of industrial products for the realization of CN, including electric vehicles, the use of industrial robots at manufacturing sites in Japan and abroad will expand qualitatively and quantitatively in the mid to long term, and it will do so irreversibly. In both Japan and China, the population is aging and labor shortages are progressing. Industrial robots contribute to higher precision and the automation of manufacturing processes and are thus indispensable goods for the manufacturing industry, and a stable supply of industrial robots is extremely important for economic security.

In recent years, Chinese companies have been catching up with Japanese companies. However, control-related equipment (such as CNC systems, servo mechanisms, PLCs, and reducers) constitute core components of industrial robots, and Chinese companies' technological capabilities and competitiveness are weaker than those of Japanese companies. This makes control-related equipment a choke point in the supply chain. In Japan, under the Economic Security Promotion Act, domestic production capacity and R&D are being strengthened to ensure a stable supply of industrial robots and related commodities. Meanwhile, China has implemented a series of industrial policies targeting the robotics industry, strongly promoting domestic production and strengthening its international competitiveness. Competition between Japanese and Chinese firms is expected to intensify in the field of industrial robots, including core components, Industrial robots are also used for military purposes, depending on their performance, and are therefore strongly characterized as strategic goods. As of now, there has been no tightening of export controls against China as seen in the semiconductor industry. However, if export controls were to be tightened for reasons of economic security, it could have a major impact on the global supply chain of industrial robots. There is thus an ongoing need to continue monitoring trends in the robotics industry.

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Pacific Research Center; https://spap.jst.go.jp/investigation/report_2022.html#fy22_rr03

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Japan Robot Association (2023) *Robot Industry Supply-Demand Trends 2023 (Industrial Robots)*

6 A Grassroots Science and Technology Superpower: Innovation and Flexible Supply Chains in Cross-Border E-Commerce

6.1 Introduction

While the Chinese economy in 2023 was generally a source of negative news, one of the few bright spots was cross-border e-commerce exports. The value of exports grew a high 19.6% over the previous year to RMB 1.83 trillion. The momentum is even more striking when one considers that overall export growth was sluggish at 0.6%. Cross-border e-commerce accounted for 7.7% of total exports. The CCP has also strongly supported this development of cross-border e-commerce. At the Central Economic Work Conference in 2023, cross-border e-commerce was mentioned as a new driver of overseas trade along with trade in intermediate goods and services and digital trade[1]. At a 2023 presentation on the import/export situation by the General Administration of Customs, the government's support for the handling of returns, an issue facing the industry as a whole, was highlighted. A new system was promoted to allow returns from overseas to be repackaged and sold in China's bonded areas[2].

"Cross-border e-commerce" refers to e-commerce transactions transcending national borders. Some transactions are undertaken in the form of personal imports (business to consumer [B2C]), whereas others involve importing by retailers (business to business [B2B]). Cross-border e-commerce has a considerable history. Alibaba.com, a platform that matches Chinese manufacturers and wholesalers with overseas retailers, was the first service launched by the Alibaba Group after its founding in 1999. Alibaba is known as the largest e-commerce company in China, Many of the products sold in online stores in Japan are imported from China via B2B cross-border e-commerce. It is so widely used that some specialized companies exist to assist small and medium-sized Japanese retail businesses that lack Chinese language skills and customs-clearance processing know-how[3].

While cross-border e-commerce initially developed with a focus on B2B, recent years have seen rapid growth driven by B2C. The four major cross-border platforms are Shein (which focuses on women's apparel), Temu (the overseas version of leading e-commerce platform Pinduoduo), TikTok Shop (an e-commerce function added to the TikTok video app) and AliExpress, (the overseas consumer platform of the Alibaba Group, one of the largest e-commerce companies in the world). These platforms are known as the "four little dragons going overseas."

Shein is a start-up company that was founded in 2012, but it only adopted its current business model in 2015. Its rapid growth began in 2020. In 2022, gross merchandise value (GMV) was estimated to have reached USD 29 billion,

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[1] "Central Economic Work Conference Held in Beijing; Xi Jinping Delivers Important Speech," Xinhua, December 12, 2023; http://www.news.cn/politics/leaders/2023-12/12/c_1130022917.htm

[2] "The State Council Information Office Holds Press Conference on 2023 Import/Export Situation," China Government Network, January 12, 2024;
https://www.gov.cn/lianbo/fabu/202401/content_6925700.htm

[3] Kouta Takaguchi (2018) "The Transformation of China's 'Home of the 100 Yen Shop': A Giant Market Becomes a World Showroom" https://news.yahoo.co.jp/feature/1133/

about three times the figures in 2020[4]. While Temu only launched in the fall of 2022, its GMV in 2023 reached USD 14 billion. TikTok Shop is a start-up service launched in 2021; the target GMV for 2023 appears to be set at USD 20 billion. AliExpress, the only long-established company among these companies, was launched in 2010. However, following in the footsteps of other cross-border e-commerce export companies, it has been rapidly reforming itself in recent years.

Of the "four little dragons going overseas," TikTok Shop has not yet been launched in Japan, but the other platforms are expected to attract large numbers of users, especially young people, in Japan. Shein is particularly well known, having been selected as No. 1 in the app category in the JC & JK Buzzword Award 2022 First Half. This a trend ranking of junior-high and high-school girls conducted by the Japanese marketing company AMF[5].

What has brought about this new B2C cross-border e-commerce boom? Initially, there was a strong belief that "cheap or cheaply made" Chinese goods were simply gaining temporary momentum, but gradually the strength of the business model became clear. Chinese innovation is apparent in all areas of marketing, market insights and supply-chain management. This chapter will clarify the Chinese technology behind the B2C cross-border e-commerce boom.

6.2 History of Cross-border E-Commerce

6.2.1 From "Overseas Shopping" to the Bonded Model

Before proceeding to the main discussion, let us briefly examine the history of cross-border e-commerce. Currently, in discussions of Japanese cross-border e-commerce directed at China, the focus is on cases where products made by Japanese companies are sold in China. As mentioned earlier, China's cross-border e-commerce exports started with B2B, whereas imports began with B2C. In the mid-2000s, a business emerged whereby foreign students, overseas Chinese, and other overseas residents were asked to purchase goods from overseas and send them to China. This practice was called "substitute purchasing" or "overseas Taobao." (Taobao is a shopping platform owned by the Alibaba Group)[6]. What started as an extremely small-scale private import practice quickly became an industry. In 2007, Taobao launched Taobao Global Open Platform, a special website for overseas residents to sell to Chinese consumers. In addition to Taobao, a number of independent cross-border e-commerce import platforms have emerged, such as Ymatou (founded in 2009). Businesses known as "personal import agency services" have also sprung up in countries other than China. In Japan, tenso.com (now tenso) was established in 2008. This service supports overseas delivery of products purchased from Japanese online shopping sites. According to the company, many Chinese consumers use the site.

However, China cross-border e-commerce imports have scaled up while retaining the simple format of sales by individuals living overseas. According to interviews during a 2017 visit to the Shanghai headquarters of Ymatou, 40,000 sellers worldwide sell to 40 million users in China. The main products are branded goods, clothing, cosmetics,

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[4] "Overseas E-commerce Battle: Temu Doubles GMV Target, Shein Protects Profits, and TikTok Goes on All-Out Attack in the U.S.," LatePost, November 20, 2023;
https://www.latepost.com/news/dj_detail?id=1974

[5] AMF Inc. "JC & JK Buzzword the Year," June 30, 2022; https://jcjkaward.com/

[6] "2021 China Cross-border Shopping Industry White Paper," iResearch, June 15, 2021;
https://pdf.dfcfw.com/pdf/H3_AP202106151498097680_1.pdf

baby products, and hygiene products, but the store also handles many niche products such as Japanese Nambu ironware. The sellers typically introduce what products are available in their area of residence, and after an order is placed, the product is purchased at a local retailer and shipped to China. While there may seem something idyllic about asking friends living abroad to do some shopping for one's personal imports, this simple format is now being scaled up into an industry. The final sales price of goods so imported is higher because shipping costs to China and profit for the cross-border e-commerce seller are added to the overseas retail price. However, there are no tariffs or other taxes. (Although import taxes are legally imposed, the goods are rarely detected by customs, and in many cases there are virtually no taxes.) With no fixed costs such as stores either, these "self-imported" goods often have a price advantage over the same goods conventionally imported into China. In addition, warehouses are now located in the U.S., Japan, and other countries, and overseas deliveries are made in large shipments to reduce costs.

Cross-border e-commerce importing reached a major turning point in 2014. A new legal system was put in place, allowing for purchases of up to RMB 20,000 per person per year for registered goods at a reduced tax rate. (The limit was raised to RMB 26,000 in 2019.) A "bonded area" scheme has also been developed to ship to consumers from bonded warehouses in China[7]. In terms of logistics, these transactions are general e-commerce, whereby goods stored in China are sold to Chinese customers; however, in terms of taxation, they are treated the same as overseas imports. The bonded area scheme has enhanced convenience by allowing customers to purchase overseas products with next-day delivery and other conditions comparable with those of domestic e-commerce. With the legalization of cross-border e-commerce imports, which had been a gray zone, foreign manufacturers are now able to engage in cross-border e-commerce themselves. Major IT companies, such as Alibaba Group's Tmall Global (established in 2014), JD.com's JD Worldwide (established in 2015), and NetEase's Koala Shopping (established in 2015, now acquired by the Alibaba Group), have launched platforms that allow overseas manufacturers to set up their own online stores. The largest, Tmall Global, has just under 40,000 brands opening directly managed stores as of February 2023.

When entering the Chinese market, complex procedures such as certificates of origin and safety certificates are required for some commercial products, but in the case of cross-border e-commerce, these procedures are simplified. For foreign firms, the advantage is that they can access the Chinese market with low entry costs. In addition, many companies use cross-border e-commerce as a trial marketing tool to test the response of Chinese consumers and gain a reputation through word-of-mouth and other means before entering the Chinese market on a full-scale basis through general trade.

2018 saw the start of a boom in live commerce (a service combining live video streaming and online shopping, allowing users to purchase products through the video streaming page of a smartphone app). Japanese manufacturers and major retailers began to sell to China through video streaming. In addition, product information can now be delivered in an easy-to-understand manner via video streaming to any Chinese consumer with a smartphone. Proxy purchasing by individual sellers continues to be in strong demand. The previously existing model of proxy purchasing, in which orders were distributed from Japanese retailers to China via smartphone and then purchased on the spot once the order is placed, is now merging with video distribution[8]. This sales avenue has become too large for Japanese

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[7] Kouta Takaguchi, "'I can't afford Mary's!': "Tracking Chinese Online Shopping Sprees; Word-of-Mouth Stealth Marketing Rampant in Cross-Border E-Commerce," Wedge ONLINE, April 29, 2016; https://wedge.ismedia.jp/articles/-/6670

[8] Kouta Takaguchi, "Net Live from Japan, China Buys: The Expanding Economy of Online Influencers," Yahoo News Special, June 27, 2018; https://news.yahoo.co.jp/feature/997/

retailers to ignore. In downtown areas with many Chinese proxy shoppers, such as Ueno in Tokyo and Shinsaibashi in Osaka, one can increasingly see stores with "Proxy Shoppers Welcome" signs.

According to the MITI "FY2022 E-Commerce Market Survey," B2C cross-border e-commerce exports from Japan to China will reach JPY 2.256 trillion by 2022[9]. B2C cross-border e-commerce exports from China to Japan totaled only RMB 39.2 billion, with the balance of this trade overwhelmingly in Japan's favor. However, it should be noted that many cross-border e-commerce transactions from China to Japan, which is discussed later, are not captured by research firms; therefore, it is necessary to take the Chinese export figures with a grain of salt.

6.2.2 From Chinese Amazon Sellers to China's Own Platforms

As seen in section 6.2.1, China's cross-border e-commerce imports, which began as simple personal import agencies, have taken on the form of an industry with the development of a national system and the active participation of Chinese companies. Although the primitive form of personal imports still remains, it is increasingly becoming an industry due to the involvement of IT platforms such as Taobao Global Open Platform and live commerce.

Meanwhile, cross-border e-commerce exports from China have also evolved from their "idyllic" form to a systemized industry. As mentioned earlier, China's cross-border e-commerce had its start in the B2B sector. Early platform services launched by the Alibaba Group, such as Alibaba.com and 1688.com, allowed overseas retailers to purchase directly from Chinese manufacturers and sales agents rather than traders. Small and medium-sized retail stores and online retailers selling in small lots are believed to have been the main customers. According to the author's research, many books on importing from China have been sold since the 2010 publication of *China "Taobao" Online Import and Sales*[10]. Looking beyond books, the sheer number of online promotional videos etc. is so vast that it would be impossible to research them all. In addition to pointers for selling on online shops such as Amazon and Rakuten, guides for more casual sales avenues such as Mercari appeared subsequently. The practice of small- and medium-sized businesses dealing in Chinese imports is commonly referred to as "Chinese reselling."

However, these "Chinese reselling" businesses began to struggle in the mid-2010s. The author interviewed one such operator in Shenzhen, Guangdong province, in 2019. The company had been importing cellphone accessories such as covers and cables but was hit hard when Chinese operators began selling them directly through Amazon Japan. When multiple businesses sell the same product on Amazon, the business with the cheapest price is displayed at the top of the results list. Naturally, price competition intensified, and many operators could no longer compete in this environment. Therefore, they switched to selling their products in online shopping malls run by Japanese companies such as Rakuten and Yahoo Shopping, where sales pages are divided by business and it is difficult to compare prices. After their success on multinational platforms such as Amazon and eBay, Chinese-owned businesses are now expanding into local online shopping malls in various countries. While the aforementioned operators changed the platforms on which they opened their stores, Chinese operators also joined these platforms soon after, and competition began again.

The expansion of Chinese companies has been supported by the development of IT services worldwide, especially

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[9] Digital Market Policy Office, Digital Economy Division, Commerce and Information Policy Bureau, Ministry of Economy, Trade and Industry (2023) "FY2022 E-Commerce Market Survey," pp. 10

[10] Masayuki Suzuki (2010) *China 'Taobao' Online Import and Sales*, PAL CHINA BUSINESS BOOKS

the growth of U.S.-based big tech. Chinese companies had acquired manufacturing capacity but lacked the means to understand, advertise, and actually sell to global consumers. They were unable to access the value-added ends of the "smile curve," that is, upstream planning and branding and the downstream sales equivalent. It is now possible to sell directly to overseas consumers through online shopping malls, such as Amazon, eBay, and even Rakuten Ichiba, and advertise through the search services and social media of U.S. IT companies such as Google, Meta, and X. This led to the global market entry of Chinese manufacturers via foreign-owned online shopping malls. This approach is commonly known as "Made in China, sold on Amazon." Many of these firms are small- and medium-sized enterprises, but some have grown to a level where their brands are recognized by foreign consumers. These include Patozon for portable audio equipment, AUKEY for smartphone accessories, and Sunvalley for home appliances.

Chinese companies have succeeded in developing a business ecosystem and the know-how to leverage the services of American IT companies. Robin Wu, an entrepreneur living in Shenzhen, Guangdong Province, exports digital devices such as stick PCs (computers contained in a housing small enough to be used by simply connecting to a display)[11]. According to Wu, the "democratization of overseas sales" has been realized, with the establishment of a large number of related companies that can outsource the services necessary for cross-border e-commerce. These include marketing, recovery of sales funds, after-sales services in the customer's language, and acceptance of returns. This "democratization" has significantly lowered barriers to entry. On asking why a returns agent was needed, Wu explained that for sales, Amazon offers fulfillment services (warehousing, picking, packing, and shipping) when vendors deliver products to Amazon warehouses. However, for returns due to initial defects or customer convenience, the vendor needs to set up their own collection points. This has created a demand for businesses that specialize in returns, which take on the responsibility of handling returns from multiple sellers.

In addition, a variety of business ecosystems have emerged, including sales tools that automatically research the sales prices of other vendors and automatically lower their prices if other vendors lower theirs, and businesses that recruit cherry-picked "users" to offer word-of-mouth evaluations.

China has always been a manufacturing base for foreign companies, and its cost advantage is obvious when selling directly to consumers via cross-border e-commerce. However, friction with the platform companies was a major bottleneck. Platform companies have the right to take actions such as deleting accounts or confiscating sales proceeds if vendors advertise or sell in violation of the platform's terms and conditions. Amazon, the largest sales platform, suspended the accounts of a number of Chinese Amazon sellers (including major vendors) in 2021, in its focus on combating fraudulent reviews[12]. While some businesses have been able to resume sales, many have yet to recover their previous sales volumes.

In this context, the "four little dragons going overseas," that is, cross-border e-commerce exports from Chinese companies to consumers around the world through Chinese corporate platforms, have increased their presence.

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[11] Robin Wu is discussed in detail in Kouta Takaguchi (2017) *Biographies of Contemporary Chinese Managers*, Seikaisha

[12] "Account Suspensions, Bankruptcies, Layoffs: A Tough 60 days for Amazon China Sellers," Time Weekly.com, July 10, 2021; https://www.time-weekly.com/post/283016

6.3 New Cross-Border E-Commerce Exports pioneered by Shein

6.3.1 Digital Marketing Innovations

Shein has been the leader in this model shift among the four cross-border e-commerce “little dragons.” The company’s founder, Chris Xu (Xu Yangtian), was born in 1984 in Shandong province. After graduating from Qingdao University of Science and Technology with a major in International Trade, he worked in overseas sales of Chinese goods and was involved in search-engine optimization[13]. In 2008, he went independent and became involved in businesses such as exporting Chinese goods and custom-made wedding dresses. In 2015, he arrived at his current business model, which focuses on cross-border e-commerce exports of women’s apparel. Although the company initially sold some products on Amazon and other international platforms, it has distinguished itself from other Chinese Amazon sellers by prioritizing sales through its own website and smartphone app.

He also worked on core business models in marketing and supply-chain management. Marketing can be divided into two aspects: promotion and research. Influencer marketing is central to Shein’s approach to promotion. “Unboxing” videos, which showcase products received from Shein, have become popular content in many countries around the world. According to Chinese influencers living in Japan, some are paid a promotional fee to have their videos filmed, but many proxy shoppers voluntarily post these unboxing videos as they become popular. Another promotional technique is to distribute discount coupons through popular influencers. The strategy of concentrated investment in influencer advertising was novel; there were few general web ad placements, let alone ad placements in legacy media such as television and magazines. The impact has been tremendous: according to Google Trends, which indexes the number of searches, the number of searches in the U.S. for “Shein” surpassed Uniqlo in January 2019 and Zara in January 2020[14].

The other aspect of marketing is research. By collecting and analyzing data from overseas sales sites and social media, this approach attempts to clarify what trends are becoming popular in real time, as they first emerge. Shein is known to be a secretive company and does not disclose specific marketing research tools, but the example of Zhiyi Tech, a marketing solutions supplier that works with the company, provides some insight[15].

Zhiyi Tech has the ability to collect and analyze apparel-related data (e.g., photos) from online stores in China and abroad, as well as from social media platforms such as Instagram, TikTok, and Pinterest, to discover the latest trends as quickly as possible. Using AI, the system automatically identifies and compiles data on what kinds of clothing are in a given photograph. Even in a group photograph of two or three people, the AI accurately recognizes what kind of clothing each person is wearing. Zhiyi Tech’s overseas product search function tracks 230 million products on 3,000 sites worldwide and conducts daily research on more than 250,000 social media influencers on Instagram and similar platforms. Today, 80% of major Chinese cross-border e-commerce exporters use Zhiyi Tech solutions.

Along with adopting Zhiyi Tech solutions, Shein is understood to have similar in-house marketing research tools.

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[13] “Decrypting the Unicorn Firm Shein,” Business Today, January 11, 2024

[14] Kouta Takaguchi (2021) “Do You Know the Apparel Store More Googled Than Zara?” NewsPicks; https://newspicks.com/news/5672236/

[15] Mainly drawing on the Zhiyi Tech official website; https://zhiyitech.cn/brandcase/all

The company's advertisements for employees reveal the extent to which the company devotes resources to this kind of research. Shein's recruitment website shows that at the time of writing (January 10, 2024), the company was offering openings in 1,199 mid-career positions, of which about half (597 positions) were for IT engineers. These included app development and server administration positions, as well as a significant number of posts in data collection and analysis[16].

Once an emerging trend is identified, determining how quickly it can be manufactured and sold becomes a matter of supply-chain management.

6.3.2 Innovation in Supply-Chain Management

Shein creates products according to trend data collected worldwide. However, its products are not always a commercial hit. Rather, Shein implements a "hit or miss" type of multi-product development while devoting a great deal of resources to research. According to a report by Zhongtai Securities, the company launches about 7,500 new products a day[17]. These are figures for 2021; therefore, the numbers are expected to have increased significantly because, given that the number of products handled has been expanded to include toys and daily necessities. Although there are many types of new products, the minimum order quantity (MOQ) is as low as 100 items. The system is designed to accept additional orders only for those products that sell well. The advantage of smaller MOQs is that almost an entire manufacturing run can be sold off, thereby reducing inventory holdings. According to an official Shein announcement, the company holds only 3% of its inventory, an order of magnitude less than the industry average. Meanwhile, costs for planning, design, and sample production are incurred for all products, regardless of the number of items produced. It therefore stands to reason that low-volume production will naturally be more expensive. Nevertheless, the secret of Shein's success lies in persuading suppliers to manufacture at low prices.

If the company makes and ships only 100 products at low prices, it can only lose money. However, if a blockbuster product emerges among the many products made, the company can realize a quick profit from it. Regular manufacturing is, in a sense, considered to be a part of the marketing process. The mechanism to quickly detect consumption trends and link them to manufacturing is called the "customer to manufacturer" (C2M) mechanism. In Japan, this often refers to on-demand production, in which production is done after actual orders are received. In China, however, C2M is understood as a method of linking online word-of-mouth and actual sales conditions to manufacturing.

For some time, various firms have been involved in initiatives to reduce inventory holdings and opportunity losses by increasing the speed of manufacturing. The "Tao" brands are particularly well known. This term refers to a group of "direct to consumer" (D2C) brands that have grown through online store sales on Taobao, the Alibaba Group's online shopping mall, without having any brick-and-mortar stores. Ming Zeng presents a 2015 case study of Lin Edition, one of the Tao brands[18]. When its new products were launched, the firm only had 1,000 units of 15 items available in inventory. They have adopted a sales approach whereby everything sells out in just one minute, and they

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[16] Shein mid-career recruiting website; https://talent.Sheincorp.com/SocialRecruitment.html

[17] "In-Depth Series on Brand Expansion Overseas: Shein, As Swift as the Wind, as Gentle as the Forest," Zhongtai Securities, December 14, 2021

[18] Ming Zeng, translated by Nami Hijikata (2019) *Alibaba: The World's Strongest Smart Business*, Bungeishunju

will then reproduce the product based on its sales and social media response. Consumers who are unable to buy an item from the initial lot have to wait until the next lot is manufactured; however, this is only seven to nine days away. Ming comments that this has "made garment retailing an almost on-demand business and at the price level of mass-produced goods"[19].

The idea of responding flexibly to sales conditions through fast-tracked, high-speed production can be traced still further to fast fashion. It can be seen as an extension of the business model invented by Inditex, the Spanish fashion chain that owns the brand Zara. In the apparel industry, the timespan from planning to sales usually requires a year or more; however, Inditex has shortened this period to a few months and prevented opportunity loss by repeating production runs of popular products that sell well within a short delivery time of about two weeks after ordering. This is made possible by close collaboration with suppliers clustered near Inditex's headquarters. Shein is located in Panyu District, Guangzhou City, The center of Chinese apparel. According to statistics from Guangzhou City, the district has a concentration of about 7,000 apparel factories. The best suppliers to cooperate with Shein are selected from among these firms. The core suppliers are 300-400 manufacturing businesses located in Nancun town, commonly known as "Shein Village." While Shein's business model is an extension of that practiced by Inditex, Shein has assembled a more elaborate model. The MOQ for Shein is 100 items compared to Inditex's 500 items, and the time required for production is as short as 3-7 days.

Shein has achieved a high-mix, low-volume production process that surpasses Inditex through adroit supply-chain management that oversees existing manufacturers in a fabless environment. The system of linking a vast number of suppliers in a flexible manner is called the "flexible supply chain" in China, and ultra-low volume, high-mix production is called "small order, fast reaction." While Shein is the most successful example, the flexible supply chain and low-volume, high-mix production initiatives are spreading to other firms in a wide range of sectors and are not limited to the apparel industry. Implementing digital solutions is essential to achieve this.

Shein is understood to have an in-house management system called the "manufacturing execution system." The details have not been disclosed but can be inferred from Chinese media reports covering Shein suppliers and from flexible supply-chain solutions sold by other Chinese system vendors.

All sorts of data from subcontracting factories are available, and Shein employees can easily check them. These data include what products are currently being made on the production line, how many items have been produced in the last hour, where the shipped products are currently located, what the defect rates are, and how much of each type of material is in inventory. The system also automates whether a product should be eligible for a repeat production run, based on the sales performance of the first shipment of the product. Shein suppliers are required to implement this system. Shein is thorough to the point that the firm provides suppliers with instruction courses on installing and operating the system.

Individual companies and factories are becoming increasingly digital and intelligent under the slogans of "the Industrial Internet" and "Industry 4.0." What is more difficult to grasp, however, is the supply chain. Creating a system that allows complete visualization of all relevant data—including the data of partner factories and suppliers—is no easy task. When different management systems and data formats are used, data integration requires time and effort for reconciliation. In the first place, firms would be resistant to allow any other company, even a customer, to

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[19] [18], p.30

see their data in the entirety. Japan's Digital Agency has pointed out that participating firms have concerns about data distribution through platform companies, including data misuse, companies' use of knowledge against competitors, the lack of a fair trading market, and the negative impact of companies hoarding their own data[20]. These misgivings are, no doubt, also felt by firms in China.

While there are opportunities for suppliers to Shein and the other "four little dragons going overseas," they also face a harsh environment. Firms that become suppliers need to undertake large numbers of small-lot production runs, which are not profitable. Shein has also adopted a selection system that sets strict conditions for sales and quality and terminates contracts with suppliers with poor performance. Furthermore, all four "four little dragons going overseas," including Shein, have adopted a "total outsourcing" system. Although the details of each company's system are not entirely consistent, the idea is that the platform is responsible for all operations other than manufacturing. Conventionally, the essential function of e-commerce malls was to simply provide a forum to match buyers and sellers; logistics, in-mall advertising, and supply-chain finance were secondary functions. However, the distinctive point about the "four little dragons going overseas" is that the platform company plays a role that is extremely similar to that of a seller.

From the manufacturer's point of view, this can be viewed as a positive, as the platform is commissioned to undertake all operations for which the manufacturer does not have the requisite know-how. However, they also have almost no autonomy and are left to simply await the platform's instructions. In the case of Temu, even the retail price is unilaterally determined by the platform[21]. Shein has attracted suppliers by offering shorter payment schedules (15 days instead of the 90-day industry average) and low-cost loans to finance the refurbishment of manufacturing facilities. Some suppliers have expanded their factories with Shein's financial support and introduced automated equipment such as automated guided vehicles and robots. However, such advanced production lines can only operate for mass-produced hot-selling products, and the first shipment of 100 products per lot is manufactured by old-fashioned manual labor[22]. The conditions under which suppliers operate remain very strict, and in recent years, some suppliers have been voluntarily terminating their contracts with Shein[23].

This business model continues (at least for now) despite the balance of power between platforms and suppliers being unduly skewed in favor of the former. This is understood to be due to the myriad manufacturing businesses in China, which have always had excess manufacturing capacity. Being a supplier to the "four little dragons going overseas" may be highly challenging, but the other options also involve intense competition. Against constant competition, manufacturers are faced with tough choices as to how best to survive.

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[20] Digital Agency, "Guidance for Implementing Data-Handling Rules on Platforms, ver. 1.0," March 4, 2022;
https://cio.go.jp/sites/default/files/uploads/documents/digital/20220304_policies_data_strategy_outline_01.pdf

[21] Shenzhen Yicang Technology "Temu, TikTok and Other Mainstream Cross-border Platforms: A Composite Analysis," Sohu, October 18, 2023;
https://www.sohu.com/a/727324170_609544

[22] "Uncovering the Secrets of Shein's Supply Chain: Can the Magic that Bested the Fast-Fashion Giants Now Beat Temu?" *The Paper*, August 18, 2023;
https://m.thepaper.cn/newsDetail_forward_24145441

[23] "Shein Suppliers, Trapped in the System," Huixu, May 18, 2022; https://m.huxiu.com/article/558259.html

6.3.3 Next-generation Chinese-style brands continue to emerge.

These business trends, such as flexible supply chains, high-mix low-volume production, total outsourcing, and C2M, are common to many companies other than the "four little dragons going overseas." Looking at cross-border e-commerce companies alone, there are countless follower companies. The "Chinese Global Brand Builders 2023" report by research firm Kantar BrandZ and Google lists 50 leading companies with strong brands outside of China. Ranked alongside Shein and AliExpress as e-commerce platforms are Costway and Homary, which specialize in furniture. In addition, LILYSILK for women's apparel, BloomChic for plus-size women's apparel, Luvme for wigs, and NEIWAI for innerwear have been identified as growing brands[24].

Similar manufacturing methods are also increasing their presence in China. Short-video apps, such as Douyin (the Chinese version of TikTok) and Kuaishou (a short-video app similar to TikTok), are not simply a replacement for text and long-form video; rather, they excel in capturing and spreading consumer interest with high precision[25]. The impact of this phenomenon appears in the retail sector as popular sales products that suddenly record explosive sales. These are known as "hot products" or "hot sales." How can firms discover "hot products" through repeated test-marketing sales? Once a "hot product" is created, competition ensues as to the expansion of production or the rapid imitation of other companies' successful products. In Japan, the birth of popular products via short-video apps has been recognized under the term "TikTok sellers," but this phenomenon is understood strictly within the framework of advertising. Rather, it could be said that China is exploring business models and manufacturing methods that are based on the premise of creating "hot products."

6.4 Conclusion

This chapter has discussed the emerging phenomenon of the rapid growth of Chinese B2C cross-border e-commerce exports and the innovations that support it. The Xi Jinping administration has made innovation a key national strategy. There is a growing tendency to place more emphasis on basic technology rather than applications and on developing new technologies from scratch. (In China, this is commonly referred to as "hard technology.") This is evidenced by the fact that "mass entrepreneurship and innovation," which was considered a key element in the 13th Five-Year Plan, is barely mentioned in the 14th Five-Year Plan. Hence, foreign attention to Chinese innovation is also turning toward that direction.

Meanwhile, many Chinese innovations that have been successful at the business level in the past have succeeded through the effective use of existing resources and rapid, low-cost social implementation, rather than through technological breakthroughs. By organizing self-employed people with electric scooters and bicycles, instant-delivery businesses have sprung up in a variety of fields beyond food delivery. The gig economy in transport, which matches drivers of passenger cars and trucks with buyers, has also become a big business. The car-dispatch app DiDi and the logistics version of Uber, Lalatech, are also making inroads into Japan.

The widespread use of cashless payments has led to the use of QR code-based formats rather than ICs or Near Field

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[24] Kantar BrandZ and Google "Top 50 Chinese Global Brands in 2023," June 15, 2023

[25] For more on innovations in TikTok's recommendation feature, see Matthew Brennan, *Attention Factory: The Story of TikTok and China's ByteDance*, translated by Yumiko Tsuyukubo (2022) as "Why Did TikTok Become a World-Beater?" Kanki Publishing.

Communication, which require dedicated readers. Shared bicycles, which have become an established part of the transportation infrastructure, became popular through the application of an old technology called remote locking over 2G communication. Ito and Takaguchi define this method, characterized by low cost and rapid social implementation, as a "light" approach[26]. Their report examines the IoT sector as a case study. Looking further back in time, it seems that a "light" approach by the private sector has been successful in many industries, including consumer electronics and cellphones.

Chinese science and innovation is expanding its domain toward "hard technology," but this does not necessarily mean that the "light" approach has disappeared. One example is the restructuring of existing garment supply chains while using state-of-the-art digital solutions, as seen with Shein. Indeed, this "light" approach has, at least for the moment, achieved results that rival those of "hard technology."

Alibaba Group launched Xiniu Zhizao in September 2020 as a model factory for "New Manufacturing"[27]. While this state-of-the-art factory is equipped with large numbers of robots in pursuit of manpower savings, its goal, like Shein's, is to realize a flexible supply chain. Required production volumes are determined based on analyzing social media and sales performance, and products are manufactured and shipped in a short period of time, approximately one week. Although the company is well known for its advanced technology, as evidenced by its selection as a World Economic Forum-certified Lighthouse factory, it still has only three factories after more than three years since establishment.

The "light" approach to developing business by seizing demand at the right time is completely different from the state-led planned economy. It is difficult to predict whether China, which is reported to be making dramatic progress at the province level, will switch to a "heavy" approach in the future, or whether the success of the "light" approach will continue. Even if it does make the transition, it will take considerable time for this to happen. As well as keeping a close eye on China's science, technology, and industrial policies, and studying the progress of "hard technology," the grassroots innovation that a "light" approach can achieve should not be overlooked.

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7 Comparison of Intellectual Property Strategies of Japanese and Chinese Firms During Technological Innovation: Analysis of Factors in Rise and Decline

7.1 Introduction: Did Japanese *Monozukuri* Work as a Strength in the Chinese Market?

In recent years, technology has rapidly become more sophisticated and complex, and R&D findings from many fields are needed to market a single product. It has become difficult for companies to invest extensively in R&D in all the technological fields required to complete their products. Accordingly, they have been forced to select and concentrate their R&D investment in those core skills and technologies that cannot be imitated by other companies. (These skills and technologies are also referred to as "core competencies.") In addition, they have to rely on outside sources for many of the other required technologies.

This has created an environment in which companies need to cooperate and complement each other in an ecosystem. It has become strategically important to understand supply chains in which products are processed and assembled at various companies before they are delivered to the consumer. Therefore, the value of the final product is not created by a single company, but is the sum of value added through the stages before the product or service reaches the customer. Awareness of the value chain is required to maximize this value.

Furthermore, this situation has been further articulated by new developments in technologies such as artificial intelligence (AI) and the Internet of Things (IoT). These have drawn in many industrial sectors in previously unimaginable ways, further expanding ecosystems and bringing together companies across industrial sectors in the supply/value chain. These developments have laid the groundwork for the creation of new solution businesses. However, not all firms have enjoyed the benefits. Because of the complexity of intellectual property (IP) and other rights to use the many skills and technologies deployed in the flow of supply chains, only those companies that can grasp this situation and implement IP and R&D strategies are emerging as the winners in their respective industries, resulting in a dog-eat-dog environment.

Economic globalization means that this trend has influenced companies worldwide. It has become a common, global trend for companies, especially manufacturing-related companies, to strategically shift from core competence (which emphasizes R&D through selection and concentration) to open innovation (which not only focuses R&D for core competencies but also focuses on creating new supply/value chains). In Japan, the timing of this shift corresponds to the "lost 30 years" since the collapse of the bubble economy, and Japanese companies faced an extremely urgent need to streamline excess facilities and equipment, giving them a stronger motivation to move from core competence to open innovation.

Until then, in Japan, electrical equipment companies (for example) had grown by offering a wide range of products to consumers, such as televisions, refrigerators, and washing machines. This is because Japan fostered companies that excelled in *monozukuri* (manufacturing with a Japanese approach). These firms were highly competitive internationally through synergies and efficiency gains among businesses, which they achieved by developing a wide range of businesses. Another factor was quality improvements and technological innovations, spurred on by inter-company competition in Japan's industries. However, the fact that each company offered a large number of products led to competition among Japanese companies for every product. As a result, a war of attrition developed among Japanese companies. With the progress of globalization, these companies found themselves losing their competitiveness against foreign companies, which also prompted them to undertake changes.

Due to its distinctive nature, IP should have required a strategy approach from a different perspective than investment in factory equipment or R&D, but it was swept up in the wave of business reform as a part of larger corporate strategies.

Open innovation was thus an inevitable trend. However, has it enabled Japanese companies to maintain their advantage against the rise of emerging economies, given Japan's strengths in *monozukuri* and the research investments it has made to market a wide product ranges? Here, let us summarize and examine the relevant developments, paying particular attention to China.

7.2 Structural Reforms in a War of Attrition: What Japanese Companies Have Abandoned Due To Changes in Their Core Competencies

Under the aforementioned circumstances, Japanese companies began to adopt a strategy of specializing in their core competencies, evaluating their own technological capabilities, and concentrating their R&D investments on those that were competitive. However, when they carried out these development and product strategies, most companies did not have a clear direction as to how they should respond in terms of IP. While some companies have certainly been successful, many have suffered significant setbacks in their international standing, due in no small part to their handling of IP.

When companies concentrate on their core competencies, they tend to shift to open innovation; in the areas where they have abandoned proprietary research, they introduce technology from other companies or universities. However, even in the fields that a company has abandoned, it retains IP rights for the exclusive use of the findings of the R&D it has conducted up to that point. Even if a technology is no longer used in a company's own business, there are many cases where it continues to be of value to other companies, for example, because some continue to conduct similar businesses. However, having lost out to competitors in a given business field, Japanese companies have also tended to treat the technology and IP rights in that field as having been lost, which contributes to their decline in status.

Specifically, Japanese companies have more IPs than those other countries (see Figure 7-1)[1], including many that startups would have preferred to transfer for a reasonable price. However, as it is, most of these rights have been extinguished. In the end, Japanese firms have gratuitously abandoned the tremendous value they had gained in the

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[1] Figure 7-1 shows the trend in the number of applications. In proportion to the number of applications, there are also trends in the following: the number of requests for examination (the number of applications for which a request for substantive examination by an examiner was made); the number of registrations (the number of applications that have passed substantive examination and been approved as a patent and registered as a patent right); and the number of existing patents (the number of patents for which annuities are continuously paid and rights maintained after registration). As shown in the graph on the left, the number of patent applications in Japan has remained flat. Meanwhile, the number of patent applications filed by electrical equipment-related companies, which are noticeably concentrating on the core competencies discussed in this chapter, has declined significantly (20%) over the past four years.

past by continuously investing in technology through R&D.

When firms are forced to turn to other companies for technologies under open innovation, they turn to those companies that are winners in their field, and these technologies command high prices. As a result, the costs of introduced technologies have been greater than the sums wasted on past investments, and this has been one of the reasons for Japan's loss of international competitiveness. Below, the details in relation to China are specifically examined.

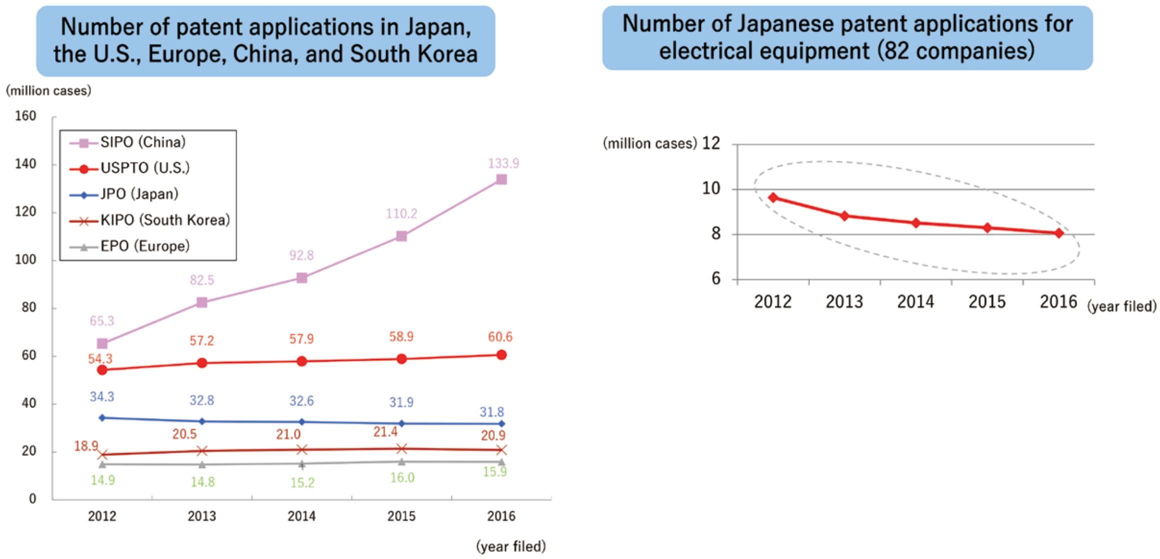

Figure 7-1. Number of Patent Applications During the Period of Transformation

(Compiled by the Japan Patent Office, based on the World Intellectual Property Organization's IP Statistics Data Center, *World Intellectual Property Indicators 2017*, and websites from relevant countries)

7.3 Open Innovation Unintentionally Promoted by Emerging Chinese Firms: The Japanese Corporate IP Strategies that Inadvertently Made a Success for Chinese Companies during Their Development

The changes in the environment that companies around the world have faced due to the increasing sophistication and complexity of technology have changed corporate strategies, especially in the manufacturing industry. During this time, Japanese manufacturing-related companies chose the strategy of shifting from identifying their core competencies to engaging in open innovation. Chinese companies, however, adopted a different strategy from that of Japan during this period. The Chinese strategy was designed to enable latecomers to catch up effectively with leading companies. As China's national IP strategy meshed with this Chinese corporate strategy, latecomers gained an advantage in the changing environment during this period of transformation. This was especially the case for Chinese companies that were able to introduce IPs with little investment.

As discussed in section 7.2, Japanese companies have been abandoning IP rights, the fruit of years of up-front research investment, under the trend toward open innovation. While it is certainly true that Japanese companies may not have required the technologies that fell outside of their core competencies, for Chinese companies, which were lagging behind at the time, these technologies were attractive for advancing new businesses. Moreover, when Chinese companies used such technologies, Japanese companies' patent rights had already expired, and the technologies were available for use free of charge. The details of these technologies were disclosed in official gazettes and other sources when Japanese companies obtained patent rights, and they could also be obtained by analyzing past Japanese products. In some cases, it was possible to acquire knowledge, including skills and know-how, by hiring researchers who had worked for Japanese companies. As a result, being latecomers, Chinese companies were able to develop rapidly because they were able to create products with less investments and reduced R&D costs under the trend toward open innovation.

At the same time, the Chinese government was changing its IP strategy to encourage the growth of Chinese manufacturing companies. The 12th Five-Year Plan, which began in 2011, strongly emphasized measures for startups and advanced policies to promote filing, such as acquainting companies with basic knowledge on IP[2]. The government provides supports such as granting companies various subsidies depending on the number of applications they file.

Coinciding with the development of open innovation by foreign firms, the 13th Five-Year Plan, which began in 2015, adroitly changed the provisions for subsidies and venture certification from merely promoting applications to requiring quality in research results, in order to lead to the next stage of development. These measures worked well, and a succession of new businesses took off as foreign companies used technologies abandoned through open innovation at no cost. They introduced minimal necessary paid technologies and conducted additional intensive R&D by foreign researchers and Chinese researchers who had returned after studying abroad.

7.4 Chinese Companies Using IP Strategies to Expand Their Business

The initiatives undertaken by Haier constitute a prime example of Chinese corporate IP strategy. Haier has leveraged its latecomer advantage to develop into the world's largest consumer electronics company through a strategy that maximizes the benefits of adopting open innovation. Specifically, in the early 2000s, the company adopted the following approach.

(1) It assigned numerous patent attorneys and other IP staff to research strategy departments. The company first ascertained its engineers' research proposals for product development. It then investigated whether or not companies in developed countries had already obtained results in similar or identical research. This was done using databases of papers and patent publications.

(2) If the investigation found that a company in a developed country had already researched the technology but not obtained patent rights in China, Haier avoided investing in R&D on its own. Instead, it used the technology disclosed in papers and patent publications as is and commercialized the product without investing in R&D. This allowed the company to conduct much more narrowly focused in-house R&D and develop products with less investments, thereby gaining in international competitiveness. Technologies for which rights have not

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[2] As Figure 7-1 shows, the number of patent applications by country has increased by more than 100% over the past four years.

been acquired in China are public property available to all, and there are no concerns about infringement.

(3) Under these circumstances, however, a Chinese company exporting products overseas faces the possibility that the IP rights of the predecessor company have been acquired in the export destination country. Exporting to such a country would result in an infringement of those rights and could result in the product being suspended or the Chinese company being liable to compensate for damages. Therefore, in deciding target export countries, Haier conducted rights investigations in advance, and exported only to countries where no rights had been acquired. Alternatively, to avoid infringement in the country concerned, the product was exported with the technology of the infringing portion replaced by other technology.

Meanwhile, despite the fact that China was expected to develop as a manufacturing base and market, Japanese and other foreign companies focused on acquiring IP rights in major countries and regions such as Japan, the U.S., and Europe, and did not register their IP rights in China. Furthermore, even if the rights were registered, they could not be effectively utilized to hinder the manufacturing and distribution of products by other companies in China due to a lack of understanding of the Chinese legal system and a lack of proper translations of the relevant documentation into Chinese. This made it easy for Chinese companies' IP strategies, such as that exemplified by Haier, to succeed.

7.5 New Technological Innovations Accelerate Open Innovation and Change Profit Structures

While many global companies, including Japanese firms, have shifted their strategies from core competencies to open innovation, the characteristics of technologies such as AI and IoT, which have developed rapidly in recent years, have not always been properly reflected in their strategies. Such companies have not fully grasped the fact that the use of these advanced technologies will accelerate the growth potential of latecomers and reduce the advantage of established market players. Recently, Chinese companies, which were latecomers to the market, have gradually gained the ability to compete on equal terms with companies from developed countries, even in industries and business fields where the Chinese firms have areas of weakness.

A specific example is the application of advanced technology to pesticides and their application methods. In the 2000s, Chinese companies gradually became able to produce pesticides with the same efficacy as those produced by companies in developed countries. However, they did not have the knowledge to develop technologies and services, including usage methods such as properly applying such pesticides to crops. As a result, even though domestically made products of the appropriate efficacy came onstream, consumers faced the possibility that crops grown using Chinese pesticides might contain more pesticide residue than permitted, with the concomitant health hazards. Furthermore, from the agricultural perspective, Chinese-made pesticides tended not to spray evenly throughout the crop, leading to the disease outbreaks, insect damage, and poor harvests.

Other cases in the automotive and motorcycle sectors are equally characteristic. In recent years, Chinese companies have become able to manufacture high-precision parts. However, because Chinese automotive and motorcycle companies had not yet developed the know-how to reliably incorporate the parts in vehicles, they could not assemble high-quality finished products, and their performance did not match that of Japanese and European automobiles and motorcycles.

In these fields, too, advances in AI and IoT technologies have led to the emergence of new solution businesses and products such as smart agriculture and electric vehicles (EVs). China's weaknesses have been eliminated in short order, and the new technologies have rapidly made it globally competitive.

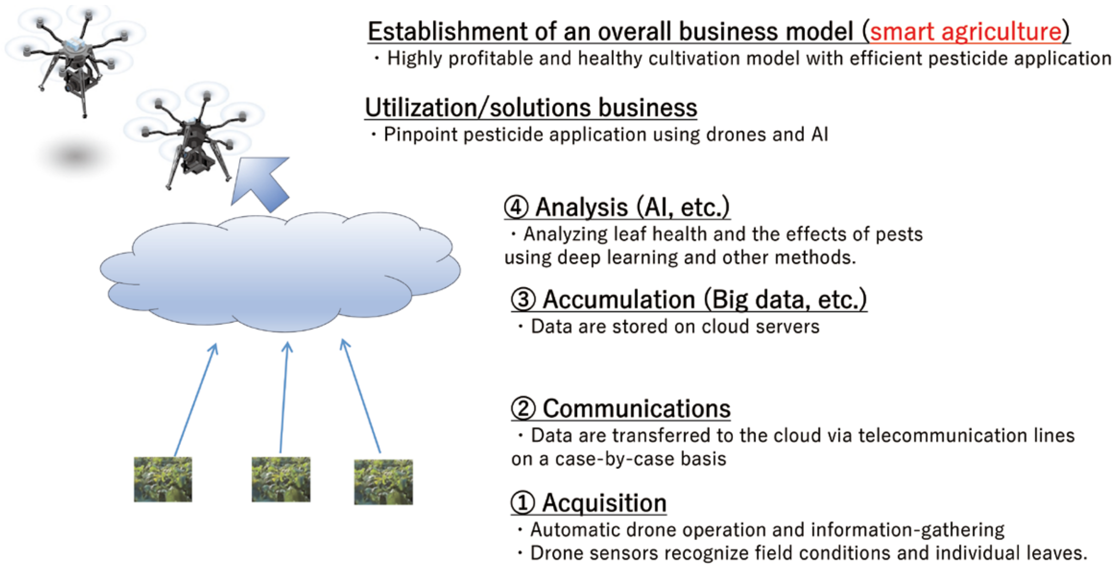

Figure 7-2. Pesticide Application in Smart Agriculture

(Prepared by the author)

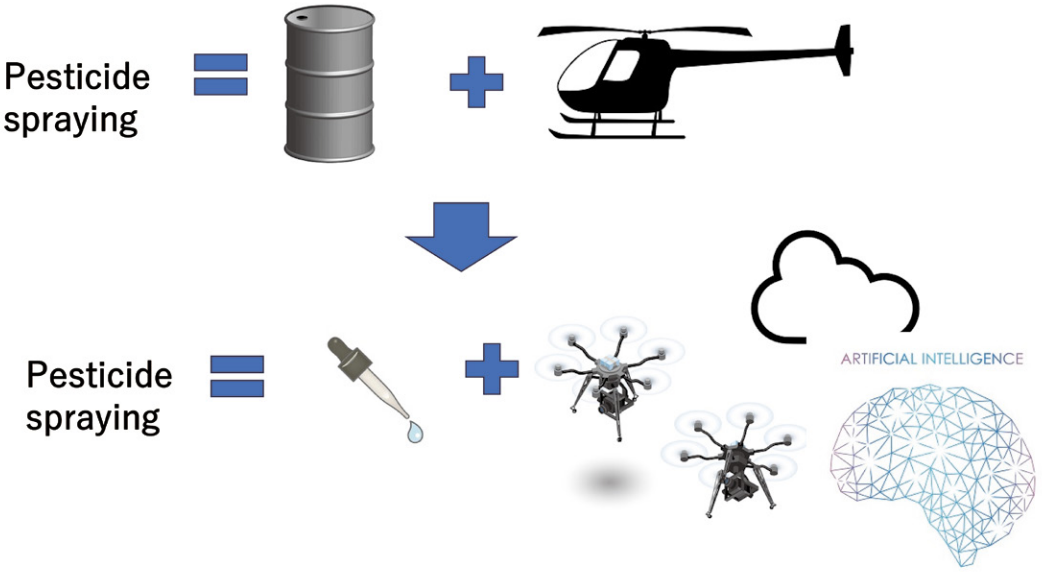

Figure 7-3. Changes in Pesticide Application Through the Use of IoT technology

(Prepared by the author)

Figure 7-2 gives an example of pesticide application in smart agriculture. Using the IoT, the system ① collects data on the condition of the field and individual leaves from above, using sensors installed on drones; ② gathers the data collected by communications lines; ③ transfers the data to a cloud server; and ④ analyzes the health of the leaves and the effects of pests using AI. It then uses the results of this analysis to control drones to spray targeted leaves with pesticides. The minimum necessary amount of pesticide is properly applied to the foliage in the field, leading to more efficient pesticide application and allows for more profitable and healthier cultivation. As a result, Chinese companies have gained access to spraying methods suitable for crops that they were previously unskilled in growing.

The development of such IoT-based solution businesses will also have a major impact on pesticide companies in developed countries that have traditionally manufactured and sold pesticides. As shown in Figure 7-3, conventional pesticide spraying uses a helicopter or similar means to apply the required amount of pesticides homogeneously over the entire field. With IoT technology, however, the minimum amount of pesticide is applied only to the necessary leaves. In other words, pesticide manufacturers face the possibility that pesticides that used to sell in large quantities will now sell in a few droplets. The realization of smart agriculture with IoT technology will be a game changer. The distribution of profits will shift dramatically from pesticide manufacturers, which had previously benefited, to companies that provide drones, AI, and communications technology. In fact, IoT communications protocols are now being discussed internationally as part of the fifth-generation (5G) standards. Huawei, China's leading telecommunications company, is playing a central role in leading discussions on standardization and standard technologies. Chinese companies are beginning to adopt IoT technologies. As a result, with the development of smart agriculture, most profits that traditional firms have been earning will flow to firms that have acquired IP rights to core IoT technologies, including Chinese firms.

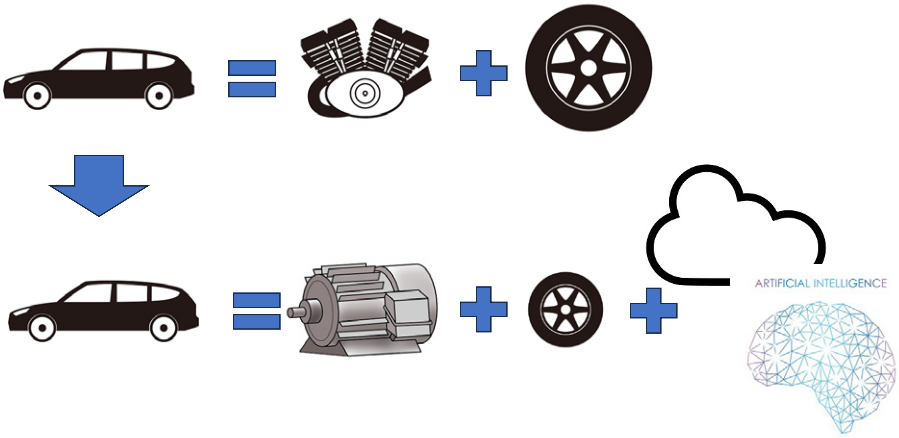

Figure 7-4. Changes in the Automotive Industry due to the Use of IoT Technologies

(Prepared by the author)

Similar cases have been seen in many areas of manufacturing in recent years. The EV sector is a notable example of a game-changer brought about by the IoT. Figure 7-4 shows the factors that determine the ride quality of an automobile. In conventional automobiles, ride comfort is determined by the technology for incorporating many machines and parts, such as the engine and tires. Therefore, as mentioned in Section 7.4, even if Chinese companies have become capable of producing some high-precision parts, it is difficult for them to improve the basic performance of automobiles, including ride comfort, if they lack the technological capabilities related to incorporating such pasts in vehicles. Under these circumstances, the Chinese government took an early decision to give up on international competition in gasoline-powered vehicles and to shift policy toward EVs. This decision proved effective. EVs make extensive use of electric technologies that are easy to incorporate, such as motors. By shifting to EVs, the gap in incorporated technology that prevented Chinese automakers from providing a comfortable ride was rapidly eliminated, and it became possible to produce vehicles of a standard acceptable to consumers.

Recently, AI and IoT technologies have been used more extensively in automobiles. For example, sensors are built into tires and other components and the information collected while driving is analyzed by AI to achieve optimal ride comfort. Thus, just as with the smart agriculture mentioned earlier, core IoT technologies such as sensors, communications, and AI are now impacting the automobile sector, controlling even vehicle ride comfort. It is possible that the advantages Japanese automakers have gained through the embedded technology they have accumulated over the years may be lost as these technologies are taken over by Chinese latecomer entrants.

The development of AI and IoT technologies is accelerating innovation more than ever before and is resulting in the mass production of game changers. While a company may evaluate a given technology as an area of weakness and exclude it from its core competencies, such technology may not necessarily lead directly to a decline in competitiveness. There is a good chance that the introduction of new AI or IoT technologies will result in it not being a weakness any longer. That is why companies must evaluate their proprietary technologies in light of new trends, rather than simply shifting to open innovation. Today, a company's failure to properly evaluate its proprietary technology will propel it toward a misguided corporate strategy.

7.6 How Will IP Strategies for Cutting-Edge Technologies Benefit Japanese Firms? The Need for New IP Strategies that Incorporate Environmental Changes

Advances in AI and the IoT have expanded ecosystems and eroded industry boundaries to a previously unthinkable extent. Seizing on these changes and formulating corporate strategies in light of them will provide opportunities to Japanese companies to appropriate the profits of other countries and industries. To achieve this, changes in IP strategy are required as well.

When entering into a new business, such as the solutions business described above, the need for an IP strategy integrated with corporate strategy goes without saying. Moreover, even if a company is forced to withdraw from a given field for business reasons, its relevant IP is the outcome of past R&D investments and has value in itself. Therefore, when a company draws up a strategy for withdrawal, it must also develop an IP strategy that does not waste such value.

Even if a company is exiting a given sector or a sector where it is losing competitiveness, the right IP strategy can still bring it reasonable profits, thus boosting its performance. Conversely, if the company abandons its IP when withdrawing, as mentioned above, it simply gives a free hand to late entrants in the field. In other words, companies should be aware that IP strategy can be used as an effective weapon, no matter what position the company is in.

7.7 Summary

Companies have continually revised their business strategies to adapt to changes in the business environment. Recent strategies such as concentrating investments on core competencies and open innovation are typical examples of business strategies adapting to changes in the environment. Unfortunately, however, a situation is emerging in which IPs are being abandoned due to changes in business strategy, thus erasing any advantage that companies may have had over latecomers.

One reason why IPs are not fully incorporated into corporate strategy is that the use of IP often requires timeconsuming negotiations with other parties, which cannot keep up with the speed of corporate reform. To speed up the process, companies try to select only those IPs in their portfolio that they truly need. But despite the fact that IPs are an important corporate asset, companies may be unable to properly grasp their value and end up in a situation where they are unable to even make a satisfactory selection. Further contributing factors are the lack of knowledge of IP at the corporate management level and the deep divide between those in charge of IP and the management.

IP must be incorporated into corporate strategy by constantly examining its contribution to business and evaluating its value, or else the investment will be wasted. Companies must understand that the value and valuation of IP varies depending on the country and corporate situation, and must also understand that other firms perceive their IP as valuable.

In Section 7.4, it is noted that Haier's strategy was to utilize technologies for which foreign companies had not obtained rights in China or those for which the rights had expired. Haier could then use these technologies in its own products, thereby gaining the advantage of not needing to invest in R&D. However, as Chinese firms expand their business, they have come to understand that what is freely available to themselves is available to all. This leaves the market open to entry by other companies, raising the risk of an unstable business environment. In line with this, there is an increasing need in China to license or transfer technology as IP rights to stabilize business operations, and the market for IP transfers is expanding rapidly.

Figure 7-5. China's IP Transfer Market

(Photo by author)

This chapter has discussed the rise and fall of firms in a developed country and China, using the failure to handle IP at the time of market exit as an example. It falls to a company's IP strategies to maximize business wins and minimize (or even eliminate) losses. This example of failure to handle IP applies to a wide range of situations. For example, in the case of start-ups, which have a less than 10% chance of going public, there are few cases where the IP rights acquired through R&D can be used within the company. However, if they were to abandon their IP rights simply because their business failed, they would be repeating the mistakes that Japanese companies have made when transitioning to open innovation.

Meanwhile, university R&D environments are gradually being incorporated into companies' open innovation strategies. This is because companies have begun to look outside beyond their core competencies for R&D and turned to universities, which are home to excellent research in a wide range of fields. In this context, national funding agencies will need to adopt strategies for targeting their grant recipients for global IP acquisition, in a manner similar to those required for businesses, as described in this chapter. Otherwise, the universities' research findings are provided free of charge to companies around the world. Although this may be considered a social contribution in some ways, research findings that are not protected by IP rights do not lead to business stability; ultimately, no one uses them.

Changes in the business environment brought about by new technologies such as AI and IoT are continually intensifying. For Japanese companies to become the next winner in this context, further integration of corporate business strategies and IP strategies is required.

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