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*The Strategic Value of China's High-Tech Drive*

AUTHOR
Scott Kennedy

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**Dedicated to Bruno Weinschel**

# Acknowledgments

This report reflects a body of work conducted over the past eight years aimed at understanding the trajectory of China's technological innovation and how these efforts have translated into various aspects of the country's international power. Central to developing this understanding have been interviews conducted in China, the United States, and other countries with business executives, technologists, industry association representatives, government officials, and international organization participants. Their perspectives were integrated into a broader overall picture. To facilitate frank analysis and because of the sensitivity of the issues discussed, the interview subjects were all granted anonymity.

This project would not have been completed without the contributions of many members of the Trustee Chair team over multiple years. Our research staff (in chronological order)—Mingda Qiu, Shining Tan, Maya Mei, and Ryan Featherston—has been second to none. Each of them is an excellent scholar in their own right; they were able to find data and information from a wide range of primary sources, utilize a variety of analytical tools, and cogently present their findings to me. Special thanks go to Ryan Featherston, who in the final months of the project helped pull together multiple threads of research and develop the figures for each of the chapters. The efforts of these fine individuals were complemented by a series of research interns who contributed in ways big and small to every chapter in this study. They include (in alphabetical order): Kevin Acker, Douglas Anderson, Audrey Fritz, Brian Hart, Jason Li, Wang Qiuyang, Joe Ue, Andy Yang, Ray Wang, and Yu Qingfeng.

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The primary funding for this project was provided by the Smith Richardson Foundation. I'm deeply appreciative of their support and encouragement throughout. Elements of the report also draw on other related projects, which were carried out with general funding to CSIS.

This report is dedicated to my maternal grandfather, Bruno O. Weinschel. He arrived in the United States from Germany in 1939 fleeing the Nazis. He became an electrical engineer and had his own firm in Gaithersburg, Maryland, for many years. An expert in microwave engineering, he had filed 50 patents and was an author or contributing author to 50 papers. He was a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and served as its president in 1986. Following a trip for

the IEEE to India and China, he suggested I study Chinese. Having been an admirer of Singapore's approach to development under Lee Kuan Yew, he believed China would follow a similar path. I'm glad I took his advice. At the time, I had little understanding of his company or the IEEE, which is a professional society, publisher, and a standards development organization. Learning about the world of standards has been intellectually fascinating because of how it brings together technology, business, and politics, but it has also been exciting to find this connection between my grandfather's contributions to technology innovation and my own professional focus.

Although many individuals and groups deserve credit for their respective contributions in the making of this report, any remaining errors of fact or judgment are solely the responsibility of the author.

# Acronyms and Abbreviations

AECC - Aero Engine Corporation of China
AI - Artificial intelligence
API - Active Pharmaceutical Ingredient
ASIPP - Chinese Academy of Sciences Institute of Plasma Physics
AVIC - Aviation Industry Corporation of China
BDS - Beidou Navigation System
BIS - Bureau of Industry and Security
BSIG - Bluetooth Special Interest Group
CASC - China Aerospace Science and Technology Corporation
CASIC - China Aerospace Science and Industry Corporation
CATT - Chinese Academy of Telecommunications Technology
CCP - Chinese Communist Party
CDMA - Code-division multiple access
CETC - China Electronics Technology Group
CMCFDC - Central Military-Civil Fusion Development Commission
CMXT - ChangXin Memory Technologies
COMAC - Commercial Aviation Corporation of China
CSET - Center for Security and Emerging Technology
CSSC - China State Shipbuilding Corporation
EASA - European Union Aviation Safety Agency
EV - Electric Vehicle
FAA - Federal Aviation Administration
FDPR - Foreign direct product rule
FYP - Five-Year Plan
GDP - Gross domestic product
GII - Global Innovation Index
GPS - Global Positioning System
GPU - Graphics processing unit
GSM - Global System for Mobile Communications
ICE - Internal combustion engine
ICT - Information and communications technology
IEC - International Electrotechnical Commission
IEEE - Institute of Electrical and Electronics Engineers
IoT - Internet of Things
IMF - International Monetary Fund
IP - Intellectual property
ISO - International Organization for Standardization

IT - Information technology
ITU - International Telecommunication Union
ITU-R - ITU Radiocommunication Sector
ITU-T - ITU Telecommunication Standardization Sector
JHICC - Fujian Jinhua Integrated Circuit Corp
JTC-1 - Joint Technical Committee-1
LEO - Low Earth orbit
LLM - Large language models
MC2025 - Made in China 2025
MCF - Military-civil fusion
MIIT - Ministry of Industry and Information Technology
MLP - Medium- and Long-Term Plan for the Development of Science and Technology
MNC - Multinational corporation
MOST - Ministry of Science and Technology
NASA - National Aeronautics and Space Administration
NDRC - National Development and Reform Commission
NEV - New energy vehicle
Norinco - China Northern Industries Group Corporation
OECD - Organisation for Economic Co-operation and Development
PCL - Peng Cheng Lab
PLA - People’s Liberation Army
PPP - Purchasing power parity
PRC - People’s Republic of China
R&D - Research and development
S&T - Science and technology
SAC - Standardization Administration of China
SAMR - State Administration of Market Regulation
SASAC - State-Owned Assets Supervision and Administration Commission
SDO - Standards development organization
SEI - Strategic emerging industries
SEP - Standard-essential patent
SMIC - Semiconductor Manufacturing International Corporation
SOE - State-owned enterprise
TC - Technical committee
STEM - Science, technology, engineering, and mathematics
TSMC - Taiwan Semiconductor Manufacturing Company
WIPO - World Intellectual Property Organization
WTO - World Trade Organization
YMTC - Yangtze Memory
ZJL - Zhijiang Lab

# Contents

# Foreword

## *Jumping Cars and Leaky Pens*

I like to joke with friends and family that my primary research method is "jet lag." I spend a great deal of time traveling in China doing field research. A constant interest over the years has been China's high-tech drive. I love visiting factories, looking at production facilities, and talking to entrepreneurs and engineers about technology and their businesses. In big cities, industrial zones, and at the edges of towns, I've visited factories for medical equipment, mobile phones, airplane components, cars, and a host of other products. Sometimes I walk away hugely impressed and other times leave disappointed and underwhelmed.

When returning to the United States a few years ago from one such tour, I slid into a cab at Dulles airport, muttered my address to the driver, and sat back hoping to catch a few winks on the way home. But the driver, who was from Ukraine, wanted to talk, and as a China expert—who talks to a lot of cab drivers—I took the opportunity to learn. He asked where I was coming from, and when I answered, "China," he instantly became very excited and exclaimed, "Wow, they're a superpower!" After a few moments it became clear that his conclusion was not based on the size or capabilities of the Chinese military, but rather on the country's growing success and prominence in commercial high-tech.

When I think of the Chinese auto sector, I can see what he means.

Over nearly four decades of travel, I've watched China go from having no private cars—or even much of an auto industry to speak of—to being miles (or kilometers) ahead of the rest of the world in electric vehicles (EVs) and their batteries. A recent trip, in July 2025, to the Shenzhen headquarters of BYD stands out. The company is not only the world's largest EV maker, but its distinctive LFP (lithium-iron-phosphate) blade battery technology gives their cars extended ranges of 500 to 600 kilometers and reduces their susceptibility to fires relative to NMC (nickel-manganese-cobalt) batteries. During the tour, I was introduced to an off-road SUV that features a drone, made by DJI (a firm on the United States' technology blacklist), perched on its roof. With the push of a button on the SUV's display panel, the drone's bay opened, the drone flew several hundred feet up into the air video-recording the car, landed back in the bay, and sent the video to the dash-screen—all while the car was moving. I also was shown a nifty sports car that literally jumps and another SUV that BYD claims can wade in deep water for up to 30 minutes. I'm not sure of the use cases for any of these features, but they are among the most obvious signs of advancement, alongside the innovations BYD has made in the motor, brakes, and interiors of the cars they produce.

As impressive as BYD and China's other EV makers are, there are areas where progress has been more difficult. Take, for example, the simple ball-point pen. China imports vast quantities of the tips—known as "nibs"—that go into the billions of pens produced each year in the country. In 2015, the same year the infamous industrial policy blueprint Made in China 2025 was released, then Premier Li Keqiang expressed exasperation that China was so dependent on Switzerland and Japan for nibs. His remarks translated into a massive industrial policy effort, with over $20 million given to Chinese producers to develop China's own high-quality nibs. Two years later, Taiyuan Iron & Steel Group (TISCO), a state-owned enterprise (SOE) in Shanxi province, announced that it had successfully mastered the high-precision machinery processes necessary to make excellent nibs. However, translating this supposed technical breakthrough into a successful product has been harder than expected. As of 2023, Chinese imports of nibs were still growing, and most domestic firms elsewhere in the supply chain were still using imported nibs, meaning TISCO had yet to conquer its foreign rivals. The trouble mastering nibs is the tip of a larger enduring challenge in China with high-precision machining.[1]

China clearly has ambitions to be a dominant global high-tech power. Chinese leader Xi Jinping has staked China's future on developing what he calls, "new quality productive forces."[2] Hundreds of speeches and policy documents make it clear that the high-tech sector is meant to replace real estate and infrastructure as the main driver of Chinese growth, as well as undergird China's national security by reducing its dependence on foreign suppliers and by facilitating the development of advanced systems that support its military and intelligence apparatus.

This study focuses on the issue of how China's technological trajectory—both its strengths and weaknesses—shapes the more tangible elements of its international power and influence in military affairs and commercial diplomacy.[3] Typically, discussions of China's high-tech drive and its international power occur separately. This study attempts to bridge these conversations, beginning with explaining the need for such an integrated study, before moving on to the substantive analysis and then considering the implications for U.S. foreign policy.

# Executive Summary

This report argues that China's advancement across high-tech sectors has directly strengthened the country's international power and influence, and that other governments need to respond pragmatically to reduce the downside costs and raise the upside opportunities to make the most of these developments. Based on several years of fieldwork and analysis of quantitative data and primary documents, the report first evaluates China's high-tech drive in general and with respect to specific industries. It then analyzes the effect of these developments on China's military capabilities as well as its role in shaping international technical standards. The study concludes with policy suggestions for the U.S. government and like-minded countries.

**Chapter 1** explains that this study bridges two scholarly debates about China, one concerning the extent to which the country is innovative and another about the economic foundations of China's international influence. Although few still hold that China cannot innovate, there is still disagreement about whether China is on a pathway to comprehensive high-tech dominance or whether the variation in its performance will continue indefinitely. International relations scholars themselves make wildly different assumptions about China's economy, with some stressing the country's growing economic might and others its substantial weaknesses and challenges. This study aims to bridge these debates by conducting original analysis on both questions.

The first half of the study analyzes the development of China's overall innovation ecosystem and patterns across multiple industries. **Chapter 2** explains that although China has aimed to domestically develop advanced technology for many years, there has been substantial change over time with regard to the targeted technologies, the party-state's institutional capacity, the primary tools of industrial policy, the relevance of national security concerns, and the country's posture toward the global economy as a resource and a market. **Chapter 3** shows that over the past two decades, whether analyzed historically or in comparative perspective, China has developed a stronger innovation ecosystem and made tremendous strides in both innovation inputs and outputs. At the same time, there are still persistent weaknesses in innovation due to the country's continued support for state-owned enterprises, an inefficient financial system, and weaknesses in human capital (especially in rural China). **Chapter 4** elaborates on this mixed picture by delineating among sectors that alternatively fit into four categories for gauging impacts from China's technological advancement: conforming success (e.g., pharmaceuticals), disruptive success (e.g., electric vehicles), conforming failure (e.g., commercial aircraft), and disruptive failure (e.g., advanced semiconductors). This study concludes that this pattern of varied success is likely to endure, as these outcomes are the product of broader underlying dynamics within China's innovation ecosystem and how they varyingly intersect with the global industries of which they are a part.

The second half of the report analyzes how China's technological progress translates into greater international influence and power. **Chapter 5** investigates the evolution of China's "military-civil fusion" initiative, which aims to harness China's commercial capabilities to enhance the country's military preparedness. The policy likely has not resulted in substantial improvements in Chinese weapons systems, but the report identifies several dual-use technologies–among them AI, satellites, reusable rockets, and drones–where commercial firms have likely made substantial contributions. At the same time, greater progress has been inhibited by mutual distrust between China's military authorities and commercial companies. **Chapter 6** documents how China's growing technological capabilities have directly translated into greater influence in the world of international technical standards, which is particularly visible in mobile broadband technologies. At the same time, despite investing massive resources and engaging in extensive coordination, the international standards system has a number of strengths that have kept China from being able to dominate the outcome in any single sector or undermine the overall system's governance norms. In fact, the largest threats from China to the system have only occurred when the United States has tried to block Chinese firms from participating and driven them to pursue setting alternative standards.

**Chapter 7** summarizes and synthesizes the findings of the report and discusses the policy implications for the United States and like-minded countries. The key thread tying together this report's policy advice is for the United States to develop a robust view of technology leadership, and then adopt a multifaceted policy approach, with focused efforts to promote its technological advancement as well as properly calibrate the extent and nature of interdependence with China, which this report summarizes as a strategy of "calibrated coupling." The precise mix of tactics needs to account for China's growing overall prowess, variation in performance across industries, and the mix of opportunities and risks that exist in different policy domains. Equally important, an effective strategy must be built on collaboration with many other countries.

Technological leadership does not only mean being at the cutting edge, but also having a vibrant innovation ecosystem, the ability to massively scale production, and well-developed pathways to diffuse the technology to users at home and abroad. Policymakers need to recognize that promoting these different components require different sets of policies and that they are not always mutually supportive. Relatedly, although it should be an important U.S. policy goal to achieve greater technology leadership relative to China, it is equally, if not more important for the U.S. to achieve as much absolute progress in technology leadership as possible.

U.S. industrial policy to promote technological advancement and protect a competitive landscape is most likely needed in areas where China has successfully disrupted an industry, such as the EV sector. It may also be helpful in areas such as semiconductors, where Chinese industrial policy may be creating global distortions without achieving significant success. However, industrial policy would be less valuable, and perhaps harmful, in sectors where China is progressing without causing major disruptions (e.g., pharmaceuticals) or is failing to make headway (e.g., commercial aircraft).

In response to China's military-civil fusion initiative, the United States needs to fine-tune risk mitigation policies that restrict technology transfer. By contrast, in the area of international technical standards, given the value of promoting common standards globally and the robustness of the standards system, the United States should pursue a strategy of vigilant and proactive openness. Efforts to isolate China will lead to fragmentation of international standards and guarantee China unchallenged technological leadership in a large part of the world.

Finally, regardless of the industry or policy domain, the more support the United States can attract from other countries, the greater the chance of U.S. policy success in advancing its technological leadership. Conversely, unilateral policies or ones that inhibit cooperation with a wide range of countries are far more likely to fail in achieving this mission.

# Chapter 1

## *Bridging the Technology and Power Debates*

### Technological Innovation: A Primer

To understand China's innovation challenge, one first needs to grasp the nature of innovation and the ecosystem that supports it. For the purposes of this report, innovation refers to the development of new technologies and their novel application to solving societal challenges.[4] Not all innovations are alike. Some are *revolutionary* and involve the creation and deployment of entirely new technologies (e.g., the automobile or the computer); others are *architectural* and involve new combinations of existing technologies that create previously unimagined uses (e.g., web browsers or the smartphone); still others are *disruptive* by applying new technologies to an existing issue (e.g., e-commerce); and some innovations are *incremental*, typically involving the repurposing or customization of a single technology for a new use (e.g., improved pens or running shoes).[5]

Equally important as understanding the concept of innovation is realizing what circumstances foster its emergence. An innovative society typically includes the following characteristics:

- A supportive ecosystem that promotes the development of well-educated human capital.
- A social climate that supports risk-taking by rewarding success and not overly stigmatizing failure.
- A vibrant financial system that effectively channels capital from investors to technology creators.
- A legal system that protects intellectual property (IP) rights, thereby rewarding novel creations and penalizing misappropriation.

- An environment that supports high-quality manufacturing at scale.
- Highly developed diffusion channels by which new innovations can easily reach the customers (in businesses, households, and governments) who need them.[6]

*Strong ecosystems do not emerge organically just because a country supposedly has the "right" culture; instead, they depend on supportive political institutions, regulations, and policies.*

There are several popular myths about innovation ecosystems that must be put aside. Strong ecosystems do not emerge organically just because a country supposedly has the "right" culture; instead, they depend on supportive political institutions, regulations, and policies. Even free-market economies must have capable governments that are able to effectively regulate markets and support technological upgrading for innovation to flourish. Moreover, a politically liberal environment may be helpful in fostering innovation, but the historical record demonstrates that such an atmosphere is neither necessary nor sufficient for innovation. Though difficult, it is far from impossible for an authoritarian political system to provide many elements of a supportive innovation ecosystem. Third, innovation often occurs through a spirit of cooperation, but just as often it emerges out of highly competitive environments. Fourth, although the market is a very important incentive to spur innovation, two other incentives—patriotism and an altruistic desire to learn—have also been common spurs to innovators.[7] Fifth, a country without all of the components of a healthy innovation ecosystem may be able to draw on or benefit from the ecosystems of other countries. In fact, most non-incremental innovations historically have been the product of contributions from multiple countries. And finally, a corollary of the first five insights is that this is not an either-or world; countries' innovation ecosystems exist along a spectrum, and as a result, certain countries may excel at different kinds of innovation more than others.

## The Debate Over Innovation in China

The scholarship on Chinese technology policy typically falls into two camps, neither of which is particularly helpful for understanding China's actual innovation performance. The first is a wholly descriptive approach in which policies are listed and analyzed for their content based on a reading of relevant texts and occasional interviews with officials.[8] The other approach is highly legalistic and specializes in documenting the ways in which Chinese policies are discriminatory and violate China's commitments to the World Trade Organization (WTO) or to specific countries such as the United States.[9] Whether focused on summarizing policy trends or analyzing if Chinese policies violate the country's international commitments, such studies rarely explicitly connect policies to actual performance. Moreover, it is worth stating that, despite the immense power of Chinese officials, their preferences do not automatically translate into their preferred outcomes.

More recently, researchers have focused on the empirics of innovation in China, with analyses becoming more optimistic over time.

The more critical assessments focus on weaknesses in China's ecosystem that act as a drag on innovation. These include an education system that encourages deference to authority and does not prepare students to be creative and to take risks; a financial system that disproportionately funnels resources to undeserving state-owned enterprises (SOEs); the weak protection of IP rights, which penalizes inventors; and a market structure where profits can be made through a low-margin, high-volume strategy or through political connections.[10]

The shift to more positive interpretations of China's innovative capacity has been gradual. There was a wave of research that highlighted China's intensive efforts to overcome these obstacles to innovation or to identify emerging areas of progress. For example, China graduates the world's largest pool of scientists and engineers each year, and though not encouraged to be creative in school, Chinese workers can learn creativity on the job, either through training by their employers or in their own startups. Bank loans are increasingly directed toward private companies, and new sources of financing, such as venture capital, have emerged within Chinese markets. Furthermore, the legal environment and funding to protect IP rights has expanded. Finally, China's large market size offers the economies of scale to reward successful innovation as well as to provide a large user base against which to test and refine products and services.[11]

Buttressing this positive shift is a view that China's various domestic problems have been ameliorated by the country's extensive engagement with the world economy, at least to some extent. The paths to progress via globalization have been many, including sending millions of students to study abroad; attracting foreign investors who share technology with local partners; creating research and development (R&D) centers and training their Chinese employees; having Chinese industry set up shop in Silicon Valley and other high-tech hubs; acquiring technology through mergers and acquisitions; and hiring talent away from Western competitors.[12]

These insights have led many observers to conclude that innovation success in China is partial and varied. Some scholars highlight the differences across regions, recognizing that variation in local industry structures (e.g., the types of firms and networks) yields different approaches to technology development and commercialization.[13] Other researchers emphasize the relative strength of multinational corporations, with particular emphasis recently being placed on transnational ethnic Chinese companies that help nurture local talent and technology development.[14] Equally common is the finding that Chinese industry has had more success with incremental innovations of surrounding technology applications and the integration of previously separate technologies—what some call "second-generation innovations"—than with original breakthroughs in basic technology.[15]

Since 2015, the pendulum has swung even further in the direction of recognizing that innovation is increasingly common in China. Many observers credit individual entrepreneurs who have found ways to innovate even in the face of significant political and economic obstacles. In fact, there has been a wave of deep-dive case studies examining China's most famous entrepreneurs and companies, including Alibaba, Xiaomi, Tencent, BYD, and Huawei, which provide support for the argument that China's approach is bearing fruit.[16]

Some studies have gone so far as to argue that China's stable political institutions and policies have finally shown their underlying value and yielded an ecosystem which may be superior to that of the United States and other market economies. Some of this work has focused on the Chinese system as a whole, while others have drilled down through case studies of companies, industries, and the consequent impact these developments have had on China and the world more broadly.[17] These in-depth studies are reinforced by what seem like daily reports about China's advancements, which leave some commentators wondering whether it is now the United States which has become "uninvestable."[18]

As real as China's progress has been, there remain reasons for skepticism and for holding off on declaring China to be a high-tech superpower on par with the United States. The overall political environment and macroeconomic performance of China do not align with the image of perfect achievement. Observers have noted that, although from an official perspective China is still in the period of "Reform and Opening," recent years have witnessed the opposite on the ground. Political power has become more centralized, the Chinese Communist Party (CCP) has become more directly involved in implementing policy, and ideological controls have expanded. This means less local experimentation and greater politicization of policy decisions.[19] Moreover, there are signs that economic liberalization and openness to foreign ideas and investment—elements central to China's rapid growth from the 1980s to the 2010s—have receded.[20] Relations between the party and the state have become more problematic, with crackdowns on parts of the private sector resulting in declining trust, which many analysts believe is necessary for policy proposals to translate into effective economic performance.[21] Some observers go so far as to argue that these changes indicate a shift in the logic of Chinese industrial policy in a direction that emphasizes security and that is less conducive to the technological upgrading that yields more efficient economic growth.[22]

These changes in the policy environment appear quite visible in China's slowing macroeconomic trajectory. Growing debt and overcapacity appear to be endemic structural problems. Moreover, it seems unlikely that China will retain its current technological trajectory without difficulties when the broader economy exhibits so many challenges. Therefore, analysts need to be attentive to variation in technological performance across industries and be open to the possibility that these increasingly negative patterns could endure.

## The Debates Over Chinese Power

The discussion above highlights how trends in innovation in China may affect the country's broader economic trajectory, its competitive position in specific industries, and the economies of China's trading partners. The next step, for this study's purposes, is to see how trends in China's economy, and its technological innovation in particular, translate into Chinese international power and influence. There is a large literature on Chinese power and the country's international behavior, but the linkage backwards to the economic foundations of power are not strongly developed. This report aims to bridge that gap.

Though many experts write about China's hard military power, the literature on the economic foundations of the country's international capabilities and influence is much smaller.[23] There was a nascent effort in the early 2010s by experts within the People's Republic of China (PRC) to quantify its "comprehensive national power," but such studies have been discontinued.[24]

Many international relations scholars embed a positive view of China's growing economic and technological capabilities into their analyses. For example, those analyzing the impact of a "rising China" often begin with the assumption of a strengthening and growing Chinese economy.[25] Some analysts attempt to empirically describe China's economic policies and the country's performance, including in the realm of technological advancement.[26] This is particularly true for those who examine China through the lens of a shifting balance of power in China's favor, that is, scholars engaging with the "power transition theory" or the "power cycle theory." However, these analyses tend to be brief and depend on very general metrics, such as GDP and some anecdotal examples of technological progress.[27]

Although less common, at the other end of the spectrum, some international relations experts have a much less sanguine view of China's economy. Despite technological progress, these scholars focus on China's structural problems—including its graying population, horribly inefficient financial system, rising debt, low productivity growth, and various other challenges. Some analysts go as far to argue that China's share of the global economy has "peaked" and that in relative terms its power is beginning to wane. As a result, rather than facing an increasingly formidable country whose influence is expanding on the foundation of greater capabilities, the world's challenge will be managing a China that tries to expand its external influence before its economic fortunes and power further recede.[28]

Sitting between these two poles are analysts who see a more muddled picture, an economy with both significant strengths and weaknesses. Bates Gill highlights technological progress but also "long-standing structural challenges," for example, an aging population, growing inequality, and declining productivity.[29] Similarly, Ryan Hass also points to substantial economic "headwinds."[30] Scholars who reach this mixed conclusion about China's capabilities tend to also see China's influence as growing, but not to the extent that optimists assert. This is why David Shambaugh concludes that China is a "partial power."[31]

## Linking China's Tech Prowess to Its International Power and Influence

The above discussion suggests that more needs to be done to establish an accurate baseline of China's economic strength, particularly in advanced technology. Such an understanding would provide valuable insight into determining China's relative strength and international influence. Effectively building this connection requires additional efforts in two directions.

The first is more analysis that concretely links China's economic progress to its hard-power capabilities. For the first half century of the PRC's existence (1949-2000), China's military and civilian technological systems were essentially separate. Since 2000, however, that wall has begun to fall as China has gradually attempted to build a system for transferring technologies between the civilian and military realms.[32] In fact, one of Chinese leader Xi Jinping's top priorities has been the restructuring of the People's Liberation Army (PLA), explicitly including greater collaboration between civilian and military technological systems. In 2016, China created the National Commission on Civil-Military Integration Development, and Xi himself became its chairman. This effort, often called "military-civil fusion," or MCF (*junmin ronghe*, 军民融合), has been integrated into a variety of formal programs and forms the basis for more generally trying to link the civilian and defense sectors.

*Understanding the [military-civil fusion] initiative is an essential part of understanding the relevance of China's high-tech development to its external posture.*

MCF has drawn the attention of other governments, and experts have begun to attempt to evaluate its effectiveness. Doing so, however, is challenging because of the difficulty obtaining relevant data and information. Nevertheless, understanding the MCF initiative is an essential part of understanding the relevance of China's high-tech development to its external posture and pursuit of global influence.

A second way to connect China's technological development to international affairs is to examine Chinese diplomatic behavior in realms where technology plays a central role. One of the key areas of both cooperation and contestation, particularly in the digital era, is the world of technical standards and standards development organizations (SDOs). Standards are a critical means to facilitate cooperation in industries that integrate hundreds of technologies and that involve companies and institutions from around the world. Some standards are de facto, imposed by the widespread adoption of technology and related follow-on services and platforms. A typical example is "Win-tel," the Windows operating system long powered by Intel's logic chips. Android has served a similar function for smartphones. But most standards are formally adopted through SDOs. Early on, most standards-setting work occurred in official state-based organizations such as the International Telecommunication Union (ITU) and the International Organization for Standardization (ISO), but an emerging complex of private industry standards consortia has taken the lead in setting technical standards for a growing proportion of technologies, such as cloud computing, local area networks, and car batteries. The participants in both the state-based and private SDOs are essentially engaged in industrial diplomacy, trying to promote their own interests while also seeking to advance technological progress, maintain their relationships with others, and safeguard the legitimacy of the organizations themselves.[33]

China's emergence as a larger player in technological innovation has occurred alongside the growing importance and transformation of technical standards and SDOs. In fact, one could trace China's original interest in "indigenous innovation" to its involvement in standards wars in the late 1990s, involving multiple efforts to develop alternative products to the DVD player. This was then followed in the early 2000s by a failed effort to have the world switch from using Wi-Fi in their local area networks to a Chinese alternative, WAPI. Since these early days, China has ramped up its own domestic SDOs, and Chinese companies have become leading participants in international SDOs on hundreds of topics.[34]

Surprisingly, scholarly attention to China's role in SDOs has declined in the last decade. Theoretically, it should be the opposite, given that there likely is a link between a country's technological capability and its potential influence in SDOs. As an example of how important this topic is, the ITU and other organizations in the mid-2010s started issuing standards for fifth-generation (5G) cellular network technology. China may end up dominating this industry, as Chinese companies such as Huawei claim to hold over 20 percent of IP related to 5G, meaning that companies worldwide using 5G technology will be paying Chinese companies for the rights to do so.[35] In contrast, when China adopted 2G for its cellular networks in the late 1990s, it simply paid royalties to U.S. and European patent holders. The ITU and other organizations are beginning work on standards for 6G mobile telecommunications, as well as for AI. Understanding China's role in this arena is crucial to measuring how its technological capabilities translate into international influence.

## Research Design

The purpose of this study is to understand the linkages between China's evolving innovation ecosystem and capabilities and its international power and influence. To tackle this subject, the study begins by examining the first half of this equation, China's technological abilities. To do so, it first summarizes Chinese industrial policy and where technology fits into the picture. Since policy reflects aspirations, not results, Chapters 3 and 4 shift to discuss the results. Chapter 3 documents developments across the entire innovation ecosystem, including both inputs (e.g., R&D funding) and outputs (e.g., patents and licensing royalties). The data facilitates examining China in detail as well as placing the country in a comparative perspective. This broad analysis identifies areas of progress as well as continuing challenges.

*The purpose of this study is to understand the linkages between China's evolving innovation ecosystem and capabilities and its international power and influence.*

The second step is to dig deeper into China's innovation ecosystem by searching for sustained patterns of variation across industries. There are certain sectors where China has performed remarkably well and others where progress has been much slower. It is necessary to explain the reasons for successes and failures. In addition, it is important to examine the influence China's performance has had on global industries as a whole. In some sectors, one might expect Chinese involvement to be "conforming," in which China's efforts at innovation and expanding production have had incremental and constructive effects on sectors as a whole. There are other sectors, in contrast, where China's behavior is more disruptive to global industry, possibly the product of steep rises in investment buttressed by industrial policy support, which then leads to a substantial increase in global supply. Another source of disruption could be technological innovations in the products themselves, particularly innovations that upset the original structures of the sector or that potentially change production processes and result in substantial shocks to the industry as a whole.

### Table 1.1: Chinese Innovation and the Economic Effects on the Global Industry

| | **Success** | **Failure** |
|---|---|---|
| **Conforming** | Conforming success | Conforming failure |
| **Disruptive** | Disruptive success | Disruptive failure |

Source: CSIS Trustee Chair in Chinese Business and Economics.

Combining these two issues—performance results and effects on global industry—yields four alternative outcomes (see Table 1.1).

Chapter 4 will examine sectors that fit each of these categories and determine which factors are most responsible for any particular outcome. There are broadly two sets of variables to consider. The first group is rooted in China's distinctive innovation ecosystem, including the systems for human capital and financing, the social climate for risk-taking, the IP rights regime, and product diffusion channels. Although this system is in some ways uniform, there are likely systematic differences in how the environment is experienced by state-owned and private companies. The second set of variables involves global characteristics of different sectors, including the industry structure (e.g., concentrated or fragmented), the economic barriers to entry (e.g., the level of capital intensity), the relevance of economies of scale, and international regulatory barriers to entry.

The second half of this study evaluates how China's ability to innovate affects its strategic power in two very different spheres. The first is the degree to which civil and commercial technologies contribute to China's military preparedness. Thus, Chapter 5 looks at the evolution of China's MCF strategy, its institutional design, and its implementation in general and regarding specific technologies. The other area of attention is the extent to which technological progress has resulted in China having greater influence in shaping technology standards, particularly in information and communications technology (ICT). Chapter 6 lays out the evolution of China's standards strategy, its domestic standards system, and Chinese involvement in various areas of mobile broadband technologies. The discussion charts China's growing influence but also how it has been unable to change the fundamental operating norms of the global system.

This study tests the primary hypothesis that the greater China's success in technological innovation, the more power (measured by capabilities and influence) China has in any particular area. The alternative hypothesis is that factors outside of civilian technological proficiency—such as basic military power, China's political institutions, and diplomatic training and experience—are more important for strengthening China's power in any specific area.

The report concludes, in Chapter 7, by summarizing and synthesizing the findings of the report and discussing the policy implications for the United States and like-minded countries. The key takeaway is that the United States needs to adopt a multifaceted approach, with focused efforts to promote its technological advancement and to properly manage the extent and nature of interdependence with China, which this report defines as a strategy of "calibrated coupling." The precise mix of tactics needs to account for China's growing overall prowess, its variation in performance across industries, and the mix of opportunities and risks that exist in different policy domains.

# Chapter 2

## *The Evolution of Chinese Technology Policy*

Chinese technology policy, and the broader industrial policy system in which it fits, seems ubiquitous, as do writings about both. China's success in advanced technologies has prompted other countries to look to its economic planning system and industrial policy as models from which to learn. In fact, there is an increasing sense that countries cannot compete effectively with China without being equally organized and intentional about their own economic priorities and how to achieve them.

An understanding of Chinese technology policy is necessary to understand the linkages between China's evolving innovation ecosystem and capabilities and its international power and influence, the purpose of the larger study. This chapter's overview of Chinese technology policy aims to make several points.

*An understanding of Chinese technology policy is necessary to understand the linkages between China's evolving innovation ecosystem and capabilities and its international power and influence.*

First, although the Chinese Communist Party (CCP) has been engaged in planning for almost the entire time it has been in power, its technology policy has changed dramatically over the years. Throughout the Mao era (1949-76), when China had a centrally planned economy, five-year plans (FYPs) and the machinery of the party-state played central roles in setting mandatory targets that were implemented in a top-down manner, with large-scale projects implemented by party-state agencies at the national and local levels. Since the late 1970s, as China introduced market mechanisms into the economy, planning has shifted from mandates to indicative guidance, reflecting goals and targets that were supported by policies.[36] The label for FYPs in Chinese also changed in the 1980s to reflect this shift; the designation went from "plan" (*jihua*, 计划) to something closer to the English word "design" (*guihua*, 规划). Then, in the mid-2000s, industrial policy shifted to become far more focused on targeting specific industries to support technological upgrading. More recently, government policy has increasingly been implemented through the actions of government-supported research organizations and companies. This second transition was heralded by the 2006 issuance of the Medium- and Long-Term Plan for the Development of Science and Technology (MLP), which was followed by several large-scale engineering projects and then the 2009–10 launching of an initiative to identify and provide policy support for "strategic emerging industries."[37]

Second, it is crucial to understand that Chinese industrial policy cannot be divorced from China's national security environment and aims. Catching up with global leaders and moving up the technology ladder is not only meant to make China wealthy, but also to make it strong. This aim has become even more explicit under the leadership of Xi Jinping, whose "comprehensive national security concept" (*zongti guojia anquan guan*, 总体国家安全观) includes a specific role for technology.[38]

Third, the behavior and policies of the United States and other advanced economies have a substantial impact on the goals and content of China's industrial and technology policy. For many years, China has set the long-term aim of technological advancement, but the specific content of its focus, the level and direction of effort, and the results have all been driven by the technologies valued by other countries. In other words, the progress of other countries in developing and diffusing the technologies they consider of import and the extent to which those countries are willing to make the technologies available to China have determined not only China's specific industrial and technology policy foci, but also in what way, to what extent, and how quickly it will pursue those goals.

Finally, it is important to keep in mind that China's industrial and technology policy machine is complex and far from fully determinative. There is not a simple line from a leader's preferences to actual outcomes. Moreover, there are myriad weaknesses in the conception of policy, the policymaking process, and its implementation, all of which means that policy goals are just that, goals, not results. Understanding China's level of success in implementing its policy—and the effects of that success on the rest of the world—requires separate analysis.

With these premises in mind, this chapter will next look at the various components of Chinese industrial and technology policy under the leadership of Xi Jinping. It will then discuss to what extent observers should expect continuity or change due to China's evolving economic circumstances, relations with the United States, and the signals provided in China's initial proposal for the forthcoming 15th FYP (2026–30). This chapter will conclude by identifying several weaknesses in the system that may explain why Chinese technology policy does not consistently achieve its goals.

## China's Controversial Broader Goals

The starting point for China's technology policy system is its overarching goal of "indigenous innovation" (*zizhu chuangxin*, 自主创新), which was first articulated in 2006 as the core aim of the MLP. Chinese officials and scholars have consistently stressed that it is entirely normal and appropriate for a country to seek to develop technologies domestically and then to move up the value-added chain and reduce their dependence on technologies from others. Moreover, since the MLP's 2006 issuance, China has stressed a complementary economic security goal of having technologies in its ecosystem that are "secure and controllable" (*anquan kekao*, 安全可靠).[39] Chinese officials thus highlight that advanced information and communications technology (ICT) and other technologies developed beyond China—particularly by the United States and its allies—carry potential security vulnerabilities which can only be mitigated by developing domestic alternatives.

Critics have interpreted these two overarching goals as the foundation of a blatant import-substitution policy that violates the principles of comparative advantage, World Trade Organization (WTO) rules, and various bilateral agreements with the United States and others.[40] Some critics go further, charging that these principles and the actions based on them reflect a Chinese version of derisking or even decoupling.[41] Chinese defenders of its technology policy respond that these criticisms are self-serving, meant to justify continued Western technology dominance.[42] By this logic, if China were forced to only utilize the current globally best technology, it would not be permitted to develop its own, which would leave it at the lower end of the value-added chain and, thus, permanently vulnerable to various economic security risks.

## Technology Targets

China's more recent goals include, first, mastery of more advanced technologies and, second, reduced dependence on foreign providers, including ensuring that Chinese companies occupy the highest value-added parts of product value chains at home and abroad.

The most infamous, but not necessarily most important, plan for China's technological advancement is the Made in China 2025 (MC2025) strategy. Issued in 2015, MC2025 identified 10 technologies where China needed to become a leading innovator and manufacturer and raise its overall market share at home and abroad.[43] Beyond these headline-grabbing targets (which were actually in MC2025's appendix), the plan focused on China becoming proficient in advanced manufacturing across all sectors, both traditional and high-tech. Hence, the plan's first word (*zhizao*, 制造) is best translated as "manufactured," not "made."

China's comprehensive list of "strategic emerging industries" (SEIs) (*zhanluexing xinxing chanye*, 战略性新兴产业), created in 2009-10, has proven even more durable than MC2025. Following the creation of the SEI framework, authorities issued the first SEI Catalogue in 2012, which listed hundreds of specific technologies and products in seven broad categories that are meant to receive industrial policy support. Although the broad categories have only been adjusted slightly in the list's 2018 and 2023 updates, the specific technologies in the catalogue are increasingly advanced, reflecting success in technological upgrading and the aim of continuously moving toward the cutting edge. Table 2.1 shows how this upgrading looks through the lens of the SEI category "the new-generation information technology industry.

### Table 2.1: Selected SEI Catalogue Items Under "New-Generation IT Industry" Category

| IT Category | 2012 | 2018 | 2023 |
|---|---|---|---|
| **Mobile Communication Networks** | 3G and 4G network access equipment | 5G network access equipment | 5G and above mobile communication network control equipment |
| **Semiconductors** | Semiconductor manufacturing | Semiconductor manufacturing, including, specifically, lithography equipment | Semiconductor manufacturing (all technologies involved in semiconductor manufacturing are designated as SEIs) |
| **Artificial Intelligence (AI)** | — | AI, including software development | AI, including wearable smart equipment and a variety of applications across services, government, and manufacturing |
| **Advanced Energy Storage** | — | Advanced energy storage | Advanced energy storage, including advanced anode and cathode materials, and solid-state batteries |

Source: Derived from various SEI catalogue documents.[44]

China's various FYPs, which set goals for the country's economy and society as a whole, include references to key technologies, with each successive plan identifying increasingly advanced targets.[45] For example, the 14th FYP (2021-25) references the broad SEI categories given in 2018 and then identifies additional specific priorities within some of the categories. For example, the 2021–25 plan stresses the need to integrate life sciences and information technology, biopharma, biobreeding, biomaterials, and bioenergy. Furthermore, it encourages attention to science and technology (S&T) development to spur future industries, including "brain-like intelligence, quantum information, gene technology, future networks, deep-sea and aerospace development, and hydrogen energy and energy storage."[46]

Based on the initial "Recommendations" of the 15th FYP (2026–30), issued in October 2025, China has raised its ambitions still further. The country's latest plan suggests "adopting extraordinary measures" to achieve breakthroughs for several of the current SEIs, such as new energy, new materials, aviation and aerospace, and the low-altitude economy.[47] The future industries identified in the 15th FYP represent a step up from those identified in the 14th FYP and include quantum, biomanufacturing, hydrogen and nuclear fusion, brain-computer interface, embodied intelligence, and 6G. Furthermore, the plan's discussion of self-reliance stresses the digital economy, with a particular focus on the industrial internet and AI. Finally, the plan identifies several technologies—specifically, "networks, data, AI, biology, ecology, nuclear, space, deep sea, polar regions, and low altitude"—as important to support because of their explicit value to national security.[48]

Beyond these lists and overarching plans, China regularly issues sector- and technology-specific plans which reflect evolving priorities. In the latter half of the 2010s, several plans were issued for "Internet-plus," which includes the Internet of Things (IoT), big data, and various other applications.[49] In the 2020s, attention turned to AI.[50] Most recently, Beijing issued a new AI+ Action Plan in 2025.[51]

## The Wider Technology Ecosystem

Chinese technology policy is not only aimed at specific technologies and products but, equally importantly, at the underlying ecosystem that supports technological upgrading across sectors. Extensive efforts are being made to develop basic infrastructure that supports the entire economy, including transportation, energy sources, electricity transmission, and broadband connectivity. Chinese officials view supporting a wide range of inputs—including finance, intellectual property (IP) and technical standards, and education and talent—as central to the success of technology policy. At the production stage, there is policy support for manufacturing, assembly, and supply chain connectivity. And, of course, Chinese authorities promote the final stage of the product's life cycle by encouraging the comprehensive diffusion of technologies as widely as possible.

Beyond hoping to support the success of individual technologies, the CCP's aim for the overall ecosystem is to foster a range of spillovers, horizontally from one technology to another, vertically up and down the technology stack and value chain, and within the country's regions. This is one reason why China devotes so much attention to developing technology clusters, including a variety of technology zones and industrial parks, as will be discussed in Chapter 3.

## The International Context

Another critical component for understanding China's technology targets concerns how the country's policymakers aim to situate the country in relation to global industries; national security concerns seem to heavily affect their thinking on this. When first articulated in 2006, "indigenous innovation" was not envisioned as a comprehensive plan for outright self-reliance or autarky; instead, the aim was for China to be able to develop some technologies *within* the global innovation ecosystem. Even 2015's MC2025 began with the objective of raising China's position within international value-added chains, not replacing those chains with domestic ones. It was only in the 14th FYP (2021–25) that China made "self-reliance" an explicit goal. National security concerns were given a highly prominent position in this plan.[52] Based on its initial "proposal," issued in October 2025, the 15th FYP will go substantially further. In fact, an entire section of the proposal contains a strident term for self-reliance (*zili ziqiang*, 自立自强), which directly translates as "self-standing, self-strengthening." Moreover, the proposal's emphasis on the need to achieve advances across the entire supply chain (*quanliantiao*, 全链条) is likely based on the knowledge that China can no longer count on the availability of any important technologies from overseas.[53]

The growing emphasis on self-reliance in Chinese policy has occurred simultaneously with deteriorating relations with the United States and other advanced economies. In addition to the introduction of U.S. tariffs, the United States and its allies have imposed a wide range of restrictive measures on technology as part of an effort to deepen their own economic security. These steps have included actions such as placing ZTE and Huawei on the U.S. Department of Commerce's Bureau of Industry and Security (BIS) Entity List in 2018 and 2019, respectively, and the subsequent banning of both companies from many Western 5G networks; the launch of the China Initiative in 2018; the Biden administration's restrictions on semiconductors and semiconductor equipment initiated in 2022 (and expanded twice since); the executive order from January 2025 on connected and autonomous vehicles; and the addition of over 1,000 Chinese companies to blacklists maintained by the U.S. Departments of Commerce, Defense, and the Treasury.[54] China had set the broad goal of achieving greater self-reliance and had already taken many steps in that direction before these measures were enacted, but these Western actions clearly accelerated China's efforts to more assertively pursue these goals. Moreover, the restrictions provided a blueprint for where China should focus its efforts, for example, in specific areas such as advanced semiconductors and semiconductor equipment.

Equally important as how these measures have changed Chinese policy is how they have changed the calculus and behavior of Chinese industry. Though Chinese companies have long pursued technological upgrading and developing alternatives to foreign technology, many have been grudging partners in a conscious strategy of self-reliance because better foreign technologies have been available in their own markets and the companies are deeply integrated into global supply chains. The de-risking strategy of the United States and its allies has helped align the techno-nationalist approach of the Chinese government with the self-interest of Chinese industry. As Western technologies have become less reliably available at home and as Chinese companies have faced more obstacles in Western markets, Chinese companies have aggressively moved to fill existing and potential future vacuums.

*Instead of autarky, China is engaging with the rest of the world to raise and strengthen its position within global technology ecosystems and markets.*

At the same time, it is important to recognize this is not a strategy of autarky. Although China seeks to reduce its dependence on foreign technology, its policymakers and business community still view maintaining international connections and being embedded in the global economy as central to their success. Chinese companies and researchers continue to aim to learn from technology leaders around the world, participate in collaborative projects in the hard sciences and technology, and be involved in international technical standards organizations. China still uses the size of its market to induce foreign companies to share their technology and knowledge with Chinese counterparts and partners.[55] In addition, China proactively sends students abroad to learn at the best universities and research labs around the world. Moreover, Chinese companies collaborate with foreign industry, domestically and abroad, both to acquire IP and to gain the tacit knowledge that supports technological upgrading and improvements in manufacturing efficiencies. More recently, Chinese companies have expanded their outward investments in technology-intensive industries and established research and development (R&D) centers in advanced and developing markets around the world.[56] Instead of autarky, China is engaging with the rest of the world to raise and strengthen its position within global technology ecosystems and markets.

## Resources and Policy Support

To achieve its technology policy aims, the Chinese government has mobilized a vast array of policy tools and deep reservoirs of financial resources. The central government and local governments offer direct and indirect funding to support every step of the technology life cycle, from original innovation to production to diffusion. These include subsidies, tax breaks, inexpensive land and electricity, government guidance funds, low-cost bank credit, stock market listings, corporate bonds, and government procurement.

These various financing tools add up to a lot of money. Calculating each component and the overall totals is not easy, particularly because of the opacity of China's fiscal and financial systems and the lack of comprehensive public data. According to a 2022 CSIS study, China was first in global spending—almost $250 billion—on industrial policy in 2019, including direct subsidies, tax breaks, R&D support, below-market credit, debt-equity swaps, flexible arrangements for the net payables of state-owned enterprises (SOEs), and state investment funds. The United States came in second place, at almost $84 billion. When measured as a percentage of GDP, China's lead is even more striking: It spent the equivalent of 1.73 percent of its GDP on industrial policy in 2019, far ahead of others, including South Korea (0.67 percent), France (0.55 percent), Japan (0.50 percent), Germany (0.41 percent), Taiwan (0.41 percent), the United States (0.39 percent), and Brazil (0.33 percent).[57] When the assumptions were slightly loosened for China and more elements were included (such as government procurement), Chinese industrial policy spending rose to around 4.9 percent of GDP.[58]

In 2025, an International Monetary Fund (IMF) study, applying a similar methodology as the earlier CSIS study, found that Chinese industrial policy spending ranged between 4.0 and 5.5 percent of GDP from 2011 to 2023. Though the IMF study did not compute a parallel estimate for the United States, it did find that China's spending was over three times the amount spent by the European Union.[59] China continues to innovate in the ways it is mobilizing capital, for example, recently creating a new RMB 51 billion ($7.2 billion) fund for SOEs to invest in strategic emerging industries.[60] Given the growing ambitions of Chinese technology policy discussed above, one should expect such spending to grow in coming years.[61]

Beyond financial support of various sorts, the government has created a wide range of regulatory regimes to facilitate technological advancement. Although China is renowned for IP theft, since the early 2000s, regulators have developed a comprehensive IP system for trademarks, copyrights, and patents; a complex system for developing standards at home and for participating in international standards organizations, including to support the monetization of IP through standard-essential patents; and a wide range of licensing schemes and IP dispute resolution mechanisms. (These issues are discussed in detail in Chapter 6.)

Furthermore, China has built out a full-scale anti-trust and competition policy system. Its stated purpose is ensuring fair competition by opposing the abuse of monopolies and the creation of cartels or other horizontal anti-competitive behavior. However, China has on occasion used competition policy in the past as a tool to progress technology and industrial policy goals. This is most visible in instances when Chinese authorities have held up approval of major global mergers or acquisitions that potentially threaten Chinese interests and then used their doorkeeper position to aid domestic firms. The prime example of this dynamic is when Qualcomm abandoned its effort to acquire NXP Semiconductors in 2018 after failing to win Chinese regulatory approval.[62]

China's international economic policy also consciously supports its technology policy goals. For example, tariffs, non-tariff barriers, and investment catalogues that alternatively encourage or discourage investment in various sectors have been standard tools for decades. More recently, China established a full-scale export control regime and an investment security screening system borrowing heavily from the U.S. versions. As has been shown in the case of rare earths, these tools are regularly used to support China's technological advancement goals.[63]

The same mixed-use character of Chinese economic policy applies to rules and regulations regarding data security and privacy. To promote data security specifically, for example, China's cybersecurity regulator differentiates among five levels of risk based on the kinds of data involved, with different compliance requirements for each level. Depending on the designated risk level, compliance may include limiting the types of data one can collect and where it can be stored.[64] Furthermore, regulators have asserted the right to demand certain kinds of data in certain circumstances. Moreover, China's "Great Firewall"—the complex of technological restrictions and policies that block access to portions of the global internet within China—is designed to ensure that the CCP can control China's information landscape and maintain the dominance of its official perspectives. Such severe limits on foreign media and social media also simultaneously help local competitors.[65]

*China's economic governance system is heavily oriented toward supporting its industrial policy and technology goals.*

In sum, China's economic governance system is heavily oriented toward supporting its industrial policy and technology goals. Although many of the rules and policies are framed solely in terms of serving national security, these regulations also can be applied in a discriminatory way to foster technology self-reliance.

## Technology Policy Weaknesses

For all of its strengths and intimidating scale, Chinese technology policy, and the broader industrial policy system in which it sits, possesses several weaknesses, even pathologies, that systematically limit its effectiveness. This is not unique to China, as industrial policy has encountered problems everywhere, including in Japan, the quintessential developmental state from the 1960s to the 1980s.[66] Yet several of China's weaknesses are distinctive.[67]

First, though the Chinese policymaking process considers a great deal of information and views, at its core, its decisions still draw on ideological principles, not just rigorous, measurable criteria that are open to objective evaluation. Since about 2015, from a substantive perspective, industrial policy goals have shifted from being primarily based on improving the competitiveness of Chinese firms and industries to simultaneously strengthening China's national security.[68] This shift raises the priority of supporting technologies with clear national security relevance and reduces the value of economic cost-benefit analysis in policymaking decisions. At the same time, the decisionmaking process has become more centralized and has been moved from governmental to CCP organizations. This may have streamlined the overall process, but doing so also has reduced the scope for local adaptations and innovation and for input from central and local government bureaucracies with extensive knowledge of their areas of responsibility. Furthermore, greater centralization and a higher emphasis on political study have led to more performative behavior by local officials that limits policy effectiveness.[69]

The second weakness revolves around the scope of China's ambitions. While China has identified specific industries and technologies where it wants to excel, the breadth of those sectors and products is spectacular. Frankly, it is difficult to identify industries where China does not want to make significant advances. When one emphasizes everything, it is akin to emphasizing nothing because it makes it difficult to prioritize.

Third, despite there being meritocratic criteria for companies to receive industrial policy support, China's party-state often directs its attention toward certain kinds of firms for non-commercial reasons. For example, the central government continues to explicitly aim to protect and nurture SOEs, a goal found in successive FYPs, including the proposal for 2026–30. Moreover, regional governments throughout China regularly prioritize local firms, both state-owned and private enterprises, based in their own jurisdictions regardless of their capabilities. These predilections frequently result in wasted resources and over-investment in many sectors.

The fourth weakness of the Chinese innovation ecosystem centers on delayed industrial consolidation. Chinese technology policy has become better at supporting basic and applied innovation, and it is extremely well oriented toward translating innovations into production at scale and then diffusing them throughout society.[70] However, once a product is identified as high priority, not only does over-investment frequently follow, but also pressures for market exit by weaker firms remain insufficient. Consequently, the pace of industrial consolidation is typically quite slow. Since 2024, many industries have suffered from overcapacity, framed within China as "involution."[71] This is just the latest episode of a problem that has repeatedly occurred, including during the 1998-99 Asian financial crisis and the 2014-16 housing and securities markets crises. At the micro level, the problem of delayed consolidation results in additional waste and in delays in turning attention toward other future technology opportunities. At the macro level, this translates into larger booms and busts, resulting in fewer constructive innovative efforts and slower productivity growth, which undermines the original purposes of technology policy.

## The Policy-Performance Gap

As China's leaders try to make the country a leading technological power with innovative capacity that serves the country's economic and national security interests, Chinese technology policy has evolved dramatically, becoming both more focused on specific technologies and far more ambitious in its goals. The scale and breadth of the country's technology policy—together with regular reports of breakthroughs in AI, electric vehicles (EVs), biopharma, and a host of other technologies—paint a picture of consistent success that is the product of a highly rational policymaking process and smooth collaboration between the party-state and companies. However, while there are some elements of truth to this picture, it is a one-sided depiction of reality. The Chinese policymaking process has flaws, and China's actual place in the global technological ecosystem does not entirely correspond to the goals of its leaders. It is worth repeating that policy intentions do not automatically translate into outcomes. In fact, oftentimes, commercial successes occur in spite of government policies, not because of them.

*Oftentimes, commercial successes occur in spite of government policies, not because of them.*

Given the gaps between policy goals and commercial results, the two need to be analyzed separately. It is to the latter topic that this study now turns.

# Chapter 3

## *China's Great Tech Leap Forward*

Though China has a powerful party-state capable of achieving many of its goals, it is important to remember that policies, regulations, and speeches are expressions of intent, not actual results. The purpose of this chapter is to determine to what extent China's goals for technological innovation translate into actual performance. This begins with a simple side-by-side comparison of China's most general goals and actual outcomes. The discussion then shifts to a deeper examination of domestic developments of innovation inputs and outputs before turning to a comparative analysis of China and several other advanced industrialized economies and large developing countries.

The China-specific and comparative data both show substantial progress across a wide variety of metrics. At the same time, there remain areas of significant weakness in China's innovation ecosystem that appear likely to persist unless substantial changes are made to Chinese policies and institutions.[72]

### Five-Year-Plan Targets: Low-Hanging Fruit

The broadest targets are set in China's five-year plans (FYPs). Over the decades, the metrics related to science and technology (S&T) and innovation have changed, making it difficult to directly compare the results across years. Nevertheless, as Table 3.1 shows, there has been steady progress, though the metrics are neither terribly impressive nor conclusive.

Table 3.1: S&T Goals in China's Five-Year Plans, 2000–2025

**10th FYP (2001–05)**

| *Metric* | *Goal* | *Actual Outcome* | *Result* |
|---|---|---|---|
| R&D spending/GDP | 1.5% | 1.3% | Not met |
| Enrollment in higher education | 15% | 21% | Met |
| Enrollment in high school | 60% | 53% | Not met |
| Enrollment in middle school | 90% | 95% | Met |

**11th FYP (2006–10)**

| *Metric* | *Goal* | *Actual Outcome* | *Result* |
|---|---|---|---|
| R&D spending/GDP | 2% | 1.75% | Not met |
| Average years of schooling | 9 | 9 | Met |

**12th FYP (2011–15)**

| *Metric* | *Goal* | *Actual Outcome* | *Result* |
|---|---|---|---|
| R&D spending/GDP | 2.2% | 2.1% | Not Met |
| Enrollment in high school | 87% | 87% | Met |
| Completion rate of nine-year compulsory education | 93% | 93% | Met |
| Invention patents/10K people | 3.3 | 6.3 | Met |

**13th FYP (2016–20)**

| *Metric* | *Goal* | *Actual Outcome* | *Result* |
|---|---|---|---|
| R&D spending/GDP | 2.5% | 2.4% | Not met |
| S&T progress contribution | 60% | 60% | Met |
| Households with fixed broadband | 70% | 91% | Met |

**13th FYP (2016–20) (continued)**

| | | | |
|---|---|---|---|
| Mobile broadband | 85% | 96% | Met |
| Invention patents/10K people | 12 | 13.3 | Met |

**14th FYP (2021–25)**

| *Metric* | *Goal* | *Actual Outcome* | *Result* |
|---|---|---|---|
| R&D spending/GDP | >2.4% | 2.7% | Met |
| High-quality invention patents/10K people | 12 | 12.9 | Met |
| Digital economy/ GDP | 10% | ~10% | Met |

Source: CSIS Trustee Chair in Chinese Business and Economics.[73]

The most consistently used metric is research and development (R&D) spending as a share of GDP. Using China's officially reported data, R&D spending has consistently risen over time, from 1.3 percent of GDP during the 10th FYP to 2.7 percent halfway through the recently completed 14th FYP. During the 10th, 11th and 12th FYPs, an emphasis was also placed on expanding education. By the end of 2015, China reported that 93 percent of young people completed nine years of compulsory education and 87 percent had enrolled in high school. While seemingly impressive, these figures apply only to urbanites and do not include China's rural youth, where education attainment levels are much lower.[74]

The 13th FYP expanded the number of S&T-related targets. Authorities also inserted a new goal, the "science & technology progress contribution rate," a measure of how much of the economy was affected by S&T activity. According to interviews, this measure was used because it could show progress in gross *inputs* of S&T activity even if they did not translate into meaningful *outputs*, such as improvements in total factor productivity.[75] The other primary goals related to the expansion of access to the internet, targets that were easily achieved. Similarly, China was able to raise the per capita rate of registered invention patents.

The 14th FYP (2020-25) incrementally raised the goals still further, setting targets for high-quality invention patents and the size of the digital economy as a share of total GDP. As of late 2025, both of these targets had been reached. Nevertheless, given that real estate has comprised upwards of 30 percent of the Chinese economy, the digital economy—comprising just 10 percent—is not nearly large enough to compensate as an alternative driver of overall growth.

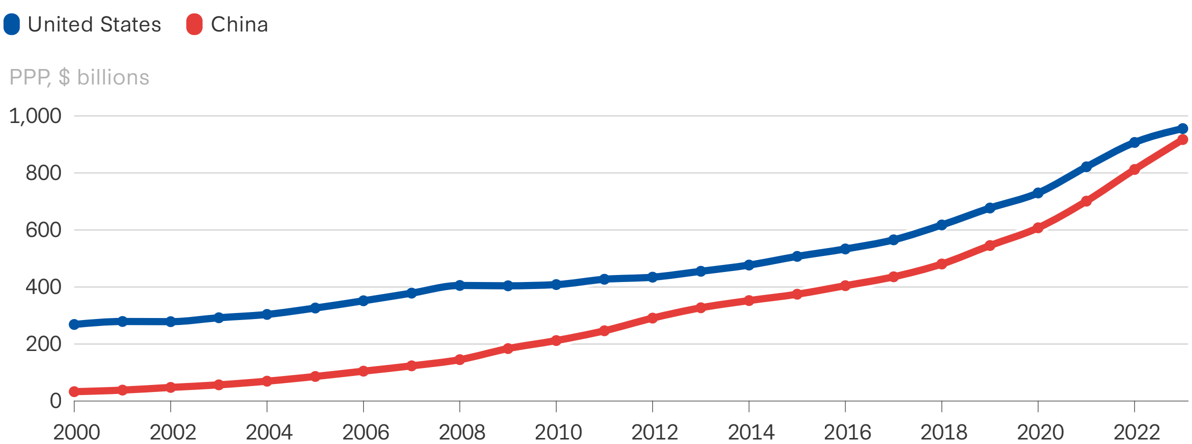
## The Impressive Growth of Innovation Inputs

A healthy innovation ecosystem requires sufficient funding (and other policy support) directed to the development of basic infrastructure. Funding enables the development of human capital, which is then translated into R&D that generates new knowledge, scientific inventions, and technological innovations. In turn, those inventions and innovations facilitate increased value added in goods that are produced for domestic and global markets. China shows broad progress at each of these stages of the innovation life cycle.

*No matter the metric, China has put enormous financial resources into promoting science and technology.*

No matter the metric, China has put enormous financial resources into promoting science and technology. According to the Organisation for Economic Co-operation and Development (OECD), and as shown in Figure 3.1, Chinese R&D spending has rapidly increased over the last quarter century in absolute terms, from almost nothing in 2000 to just under $1 trillion per year in purchasing power parity (PPP) terms in 2023 (the last year for which data is available), placing China just slightly behind the United States. Though China has overtaken the United States in terms of government R&D expenditure, the United States holds an overall advantage because of its higher corporate R&D levels.

### Figure 3.1: Total Chinese and U.S. R&D Spending, 2000–2023

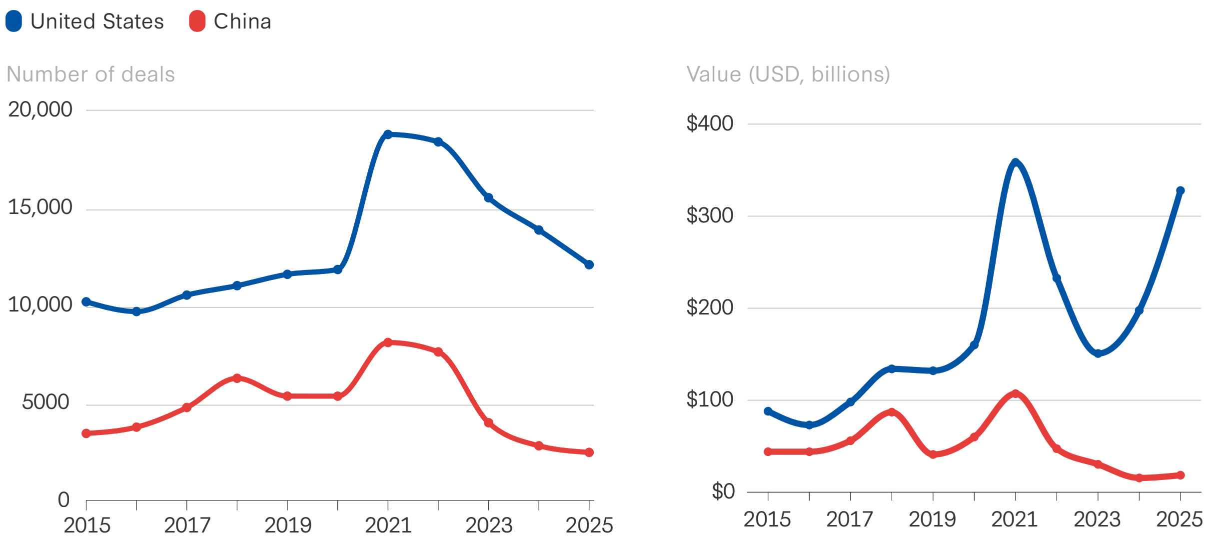



Source: "OECD Data Explorer," OECD, https://data-explorer.oecd.org.

One sign that China's R&D environment has truly improved is the growing importance that multinational corporations (MNCs) place on conducting R&D in the country. Around the same time that China joined the World Trade Organization (WTO) in 2001, MNCs began setting up R&D facilities within China. However, these approximately 200 facilities appear to have been meant merely to satisfy Chinese authorities' demands. Moreover, these early efforts were primarily focused on applications for the Chinese domestic market, as opposed to foundational research or even international markets.[76] Since then, sentiment and behavior have changed. The number of foreign-based R&D centers in China continues to grow despite growing geopolitical tensions, expanded export controls and investment restrictions, and a slowdown in the Chinese economy. Though there is no comprehensive data, these centers likely number well over 1,000, with over 600 in Shanghai and 100 in Beijing alone.[77] From 2013 to 2023, the number of technology researchers in MNCs in China grew from 629,000 to 838,000, and total R&D spending rose over the same period from RMB 201.5 billion ($28.4 billion) to RMB 375.8 billion ($52.9 billion).[78] A survey of MNC CEOs in 2025 indicated that these executives believe R&D in China is of growing importance to their corporations' global R&D activities and that they are likely to expand such efforts going forward.[79]

Venture capital is another reflection of investor confidence and interest, and can be a more productive matchmaker between profit-oriented investors and innovation-focused entrepreneurs than government fiscal outlays for R&D or commercial loans. As Figure 3.2 shows, China's venture capital sector grew until 2021-22, though the following two years saw a significant decrease in the number of deals and the value of venture capital activity. In the United States, the number of deals has also fallen, but the overall value has not dropped as precipitously.

### Figure 3.2: Venture Capital in China and the United States, 2015–2025




Source: "Venture Reports 2015-2025," CB Insights, https://www.cbinsights.com/research/report/venture-trends-2025/.

China continues to lag in venture capital, though it has caught up to the United States in overall R&D spending. Where China is clearly excelling is in the broad measure of its industrial policy spending. According to an earlier CSIS study, China spent almost $250 billion on industrial policy in 2019, including direct subsidies, R&D tax incentives, various other tax incentives, government funding for R&D, below-market credit, and state investment funds. The United States came in second place worldwide, with almost $84 billion in spending. However, when measured as a percentage of GDP, China's lead was even larger—1.73 percent compared to the United States' 0.39 percent.[80] When the assumptions were slightly loosened for China and more elements were included (such as government procurement), Chinese industrial policy spending was estimated to be 4.9 percent of

GDP.[81] More recently, an International Monetary Fund (IMF) study, applying a similar methodology to data from 2011 to 2023, found that Chinese industrial policy spending ranged between 4.0 and 5.5 percent of GDP. The authors did not compute a parallel estimate for the United States, but they found that China's spending was over three times the amount outlaid by the European Union.[82]

Much of these funds have gone into the basic infrastructure critical to innovation and manufacturing, including roadways and broadband. As of 2023, China had about 5.5 million kilometers of road, including 184,000 kilometers of expressways.[83] Although China opened its first high-speed rail line in 2008, it had 48,000 kilometers of high-speed rail crisscrossing the country by 2024.[84] As for broadband, less than 2 in 1,000 people had a broadband subscription in 2000; by 2024, that number had risen to 44.7 in 100 people, placing China ahead of the United States (38.1 in 100) and just behind much smaller, highly connected countries such as South Korea (46.6 in 100).[85]

*China has added more capacity in renewables, especially solar and wind, than the rest of the world combined, such that renewables accounted for 38 percent of China's electricity production by 2024.*

Investment in energy sources and the electric grid have been equally impressive in China. As a recent report by CSIS's ChinaPower Project shows, China consumes far more energy than any other country, with coal and other fossil fuels still the dominant sources of principle energy. Nevertheless, China has added more capacity in renewables, especially solar and wind, than the rest of the world combined, such that renewables accounted for 38 percent of China's electricity production by 2024.[86]

Another foundational element to China's efforts at fostering innovation is the proliferation of industrial development zones. According to one Chinese source, the total number of all such zones stood at 77,402 as of 2025, including S&T research parks and industrial zones dedicated to manufacturing. The province of Guangdong was in the lead, with 15,862, followed by Jiangsu (8,547), Zhejiang (7,032), Shandong (6,121), and Shanghai (3,422).[87]

In addition to infrastructure, another important investment destination to foster innovation is human capital. China has made tremendous strides in this area as well. China grants degrees to roughly 5 million undergraduates per year, with about 1.9 million of these graduates majoring in a science, technology, engineering, and mathematics (STEM) field.[88] This compares to the roughly 540,000 STEM degrees awarded in 2024 in the United States.[89] China also produces roughly 400,000 master's degree graduates in STEM annually, whereas the United States produced 139,900 in the 2021-22 academic year.[90] In 2021, for the first time, China produced more PhD recipients in STEM (44,819) than the United States (41,382), a trend that appears to be continuing.[91]

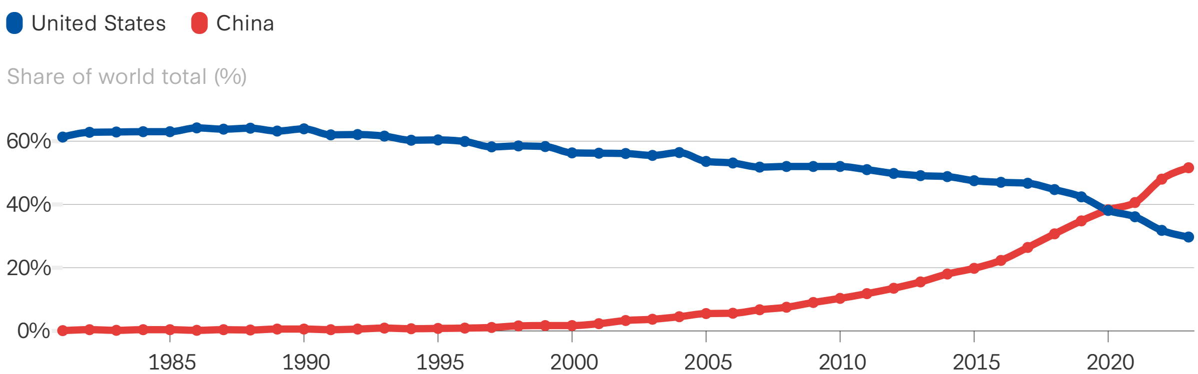
Equally important to domestic support, China's human capital stock receives a significant boost from international educational opportunities. In 2019, there were 369,000 Chinese students studying at U.S. universities, with just under half (46.3 percent) studying STEM subjects. Between 2015 and 2024, 1.42 million Chinese students studied STEM internationally.[92] The return rate to China used to be relatively low but has risen over time. Between 2015 and 2022, the return rate increased from 24.0 percent to 28.2 percent for science students and from 15.0 percent to 17.5 percent for engineering students.[93]

## The Meteoric Rise of Innovation Outputs

What has all of this investment in R&D, infrastructure, and human capital yielded for China in terms of innovation outputs? In a word, a lot. Whether measured by the generation of scientific knowledge, the creation of inventions and IP, or the levels of domestic technology-related production or exports, the figures reflect a comprehensive transformation of China's technology ecosystem and what it can produce.

In 2017, according to *Nature*, for the first time China's scientists published more papers than their U.S. counterparts.[94] As Figure 3.3 illustrates, by 2022, Chinese scholars had also taken the lead in the share of papers that are cited most often by other scholars.

### Figure 3.3: U.S. and Chinese Proportions of the Top 1-Percent of Cited Scientific Papers Worldwide, 1981–2023



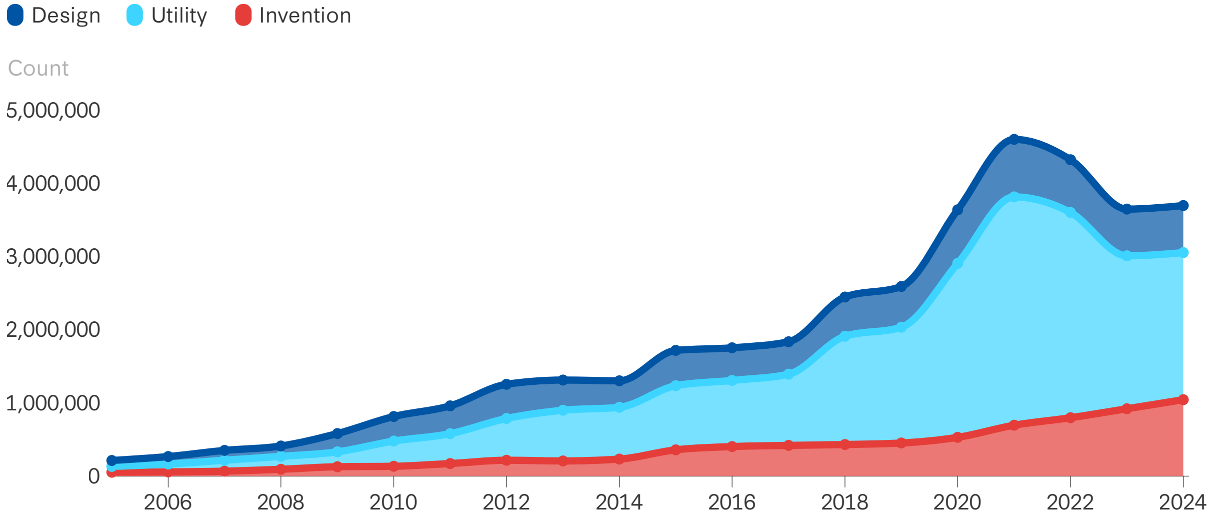

Note: If a paper has multiple authors from the same country, that country is counted only once.

Source: "NISTEP-RM350 Appendix 1," Japanese National Institute of Science and Technology Policy Library, https://nistep.repo.nii.ac.jp/records/2000231/file_details/NISTEP-RM350-Appendix1.xlsx.

Moreover, according to Ohio State University's Carolyn Wagner, the wide range of disciplines referenced in scientific papers by Chinese scholars is another indication that they are not merely imitating international counterparts elsewhere but rather developing genuinely novel ideas.[95]

China's creation of IP has also increased dramatically. The number of registered patents has steadily risen, as has the share of patents classified as "invention patents," reflecting more fundamental contributions to innovation (see Figure 3.4).

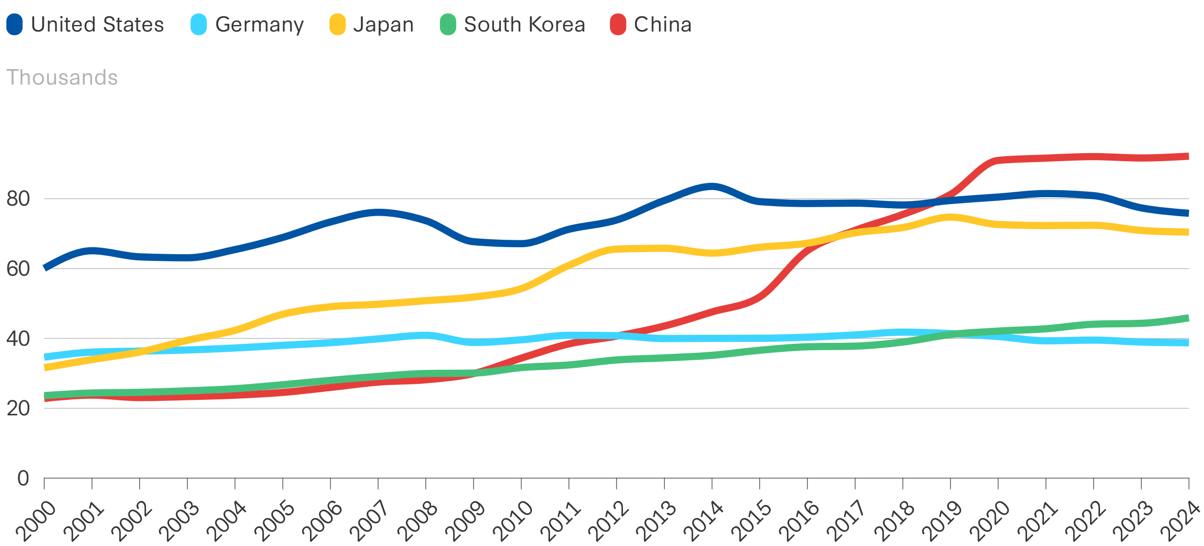
## Figure 3.4: Patent Filings in China, 2005–2024




Source: "National Data," National Bureau of Statistics of China, https://data.stats.gov.cn/easyquery.htm?cn=C01&zb=A0N0V&sj=2024.

China has led the world in the number of filed patents for well over a decade, but as Figure 3.5 demonstrates, the country has been the world leader since 2019 in patent filing through the Patent Cooperation Treaty (PCT) system as well, an objective sign of high quality.[96]

## Figure 3.5: PCT Patent Applications by Country, 2000–2024

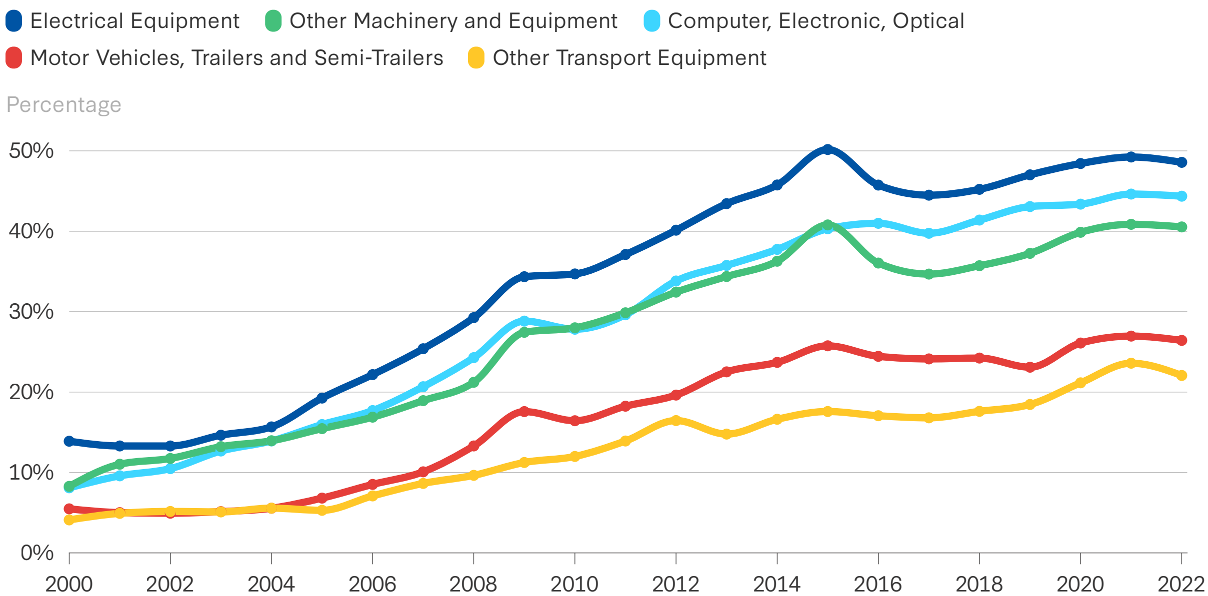



Source: "WIPO IP Statistics Data Center," World Intellectual Property Organization (WIPO), https://www3.wipo.int/ipstats/key-search/indicator?tab=pct.

IP quality can also be measured through its monetary value. In 2015, Chinese companies received roughly $1.1 billion in IP licensing royalties from entities outside of China. By contrast, in the same year, U.S. institutions received $111.2 billion in royalties. By 2024, the United States' licensing revenue had increased to $169.5 billion, roughly a 52 percent increase, while China's had increased tenfold, to $10.1 billion. As of 2024, China still provided more payments ($45.8 billion) than it received, but the revenue-payment ratio is gradually improving in China's favor.[97]

The final step in the innovation life cycle is production, and, once again, China has shifted its position dramatically over the past two decades. According to the World Bank, China contributed $625.2 billion in domestic value added to manufactured goods in 2004, just 8.5 percent of the world total. By 2024, China's output had jumped to $4.7 trillion, accounting for 28.0 percent of all manufacturing value added globally.[98] Moreover, as Figure 3.6 shows, China's share of domestic value added in manufacturing has risen across multiple industries since 2000.

### Figure 3.6: China's Share of Global Domestic Value Added in Selected Industries, 2000–2022




Source: "OECD Data Explorer," OECD, https://data-explorer.oecd.org.

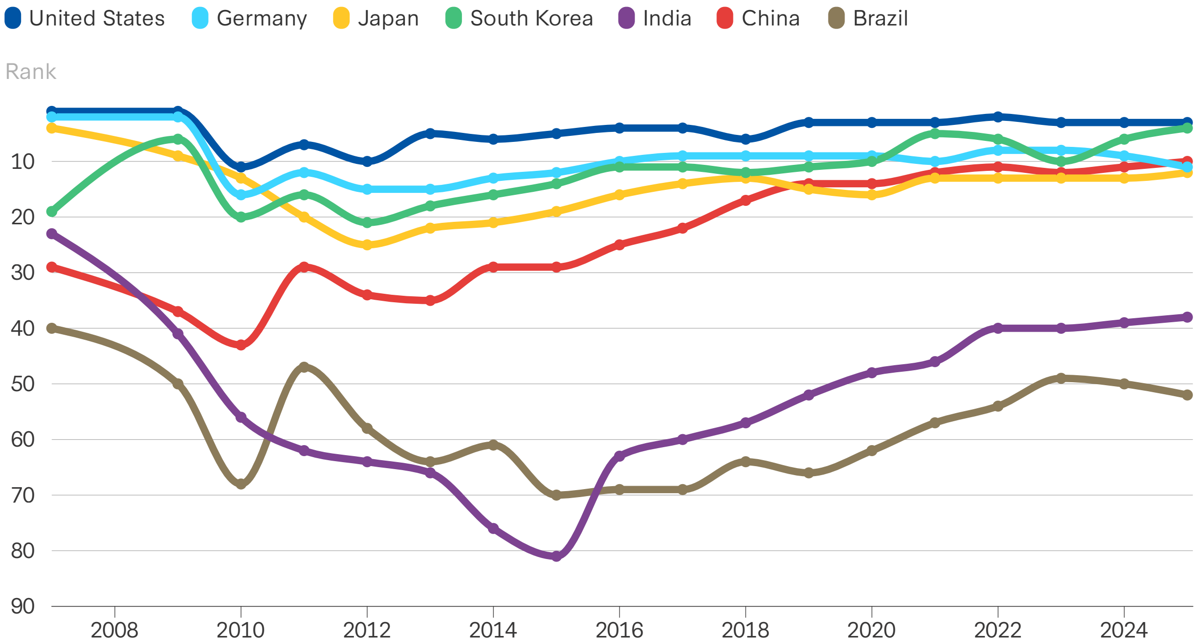
Not surprisingly, as CSIS's China Power Project reports, China's trade profile has shifted in the same direction over this period, with China becoming the dominant producer of high-value-added manufactured goods in sector after sector.[99] Critically, the share of China's exports by foreign-invested domestic firms has dropped over the same period, from nearly 60 percent to 27 percent, meaning that this shift toward higher domestic value added is not a reflection of the influence of foreign-invested firms in China.[100] In fact, foreign firms' contributions in terms of investment, jobs, IP creation, and exports have been gradually falling over time.

## The Comparative Perspective

The strengthening of China's innovation ecosystem looks equally impressive when placed in the broadest comparative perspective. The gold standard for overall comparative data on innovation is the Global Innovation Index (GII), maintained by the World Intellectual Property Organization (WIPO), Cornell University, and INSEAD.

China’s overall rank has risen from 43rd in 2010 to 10th in 2025 (see Figure 3.7). China now ranks the highest among all 36 upper-middle-income countries and is third in the Asia-Pacific, just behind Singapore and South Korea. It has entirely separated itself from developing countries such as India and Brazil.

### Figure 3.7: China’s Rise in Global Innovation Index Global Rankings, 2007–2025




Source: WIPO, Global Innovation Index 2025 (Geneva: WIPO, 2025), https://www.globalinnovationindex.org/.

The GII is comprised of over 100 metrics, divided into inputs and outputs. As Table 3.2 shows, China’s score and rank for inputs is 19th, weighed down by relatively low scores for its institutions (44th), which is a product of a weak regulatory environment and a wide range of challenges with human capital (20th), the result of having so many rural Chinese students who do not finish high school and the low number of inbound university students. By contrast, China now ranks 6th in infrastructure and 1st in knowledge and technology outputs due to the rapid growth in science publications, patents, and technology adoption in society (such as internet connectivity, robot adoption, and EVs).

Table 3.2: 2025 Global Innovation Index Rankings of Selected Countries

| | China | USA | Japan | South Korea | Germany | India |
|---|---|---|---|---|---|---|
| Overall | 10 | 3 | 12 | 4 | 11 | 38 |
| Inputs | 19 | 6 | 12 | 4 | 15 | 52 |
| Outputs | 5 | 3 | 14 | 6 | 8 | 32 |
| Institutions | 44 | 16 | 22 | 20 | 23 | 58 |
| Human capital & research | 20 | 13 | 18 | 1 | 4 | 54 |
| Infrastructure | 6 | 32 | 17 | 7 | 28 | 61 |
| Market sophistication | 13 | 1 | 10 | 5 | 22 | 38 |
| Business sophistication | 8 | 1 | 6 | 4 | 13 | 64 |
| Knowledge & tech outputs | 1 | 3 | 12 | 9 | 11 | 22 |
| Creative outputs | 14 | 5 | 18 | 4 | 8 | 42 |

Source: Compiled from the individual 2025 GII economy profiles. "GII 2025 Economy briefs and profiles," WIPO, https://www.wipo.int/web-publications/global-innovation-index-2025/en/gii-2025-economy-briefs-and-profiles.html.

A final sign of China's growing innovation ecosystem lies in the increasing importance of innovation clusters in China. In the 2025 GII data—which combines data on the locations of investors listed in patents, authors in scientific papers, and recipients of venture capital funding—two Chinese regions are ranked in the top five innovation clusters worldwide: the Pearl River Delta, which encompasses Shenzhen and Hong Kong, is first overall, and Beijing is fourth. Moreover, of the top 100 innovation clusters, China is home to the most (24), followed by the United States (22), Germany (7), India (4), and the United Kingdom (4).[101] These findings are similar to those in the Global Hub Innovation Index developed by Tsinghua University, which counts 19 mainland Chinese urban areas within its dataset. This data finds that Chinese hubs have relatively weak ecosystems but still generate high levels of technological innovations and high-tech economic output.[102]

## Continuing Weaknesses

The clear overall trend is in the direction of a strong innovation ecosystem in China, including intensive efforts to foster R&D, which is translating into progress in scientific discoveries, inventions, and high-tech production and diffusion. That said, it is important to recognize that the data analyzed above also reveals weaknesses, for example, in China's regulatory institutions, financial system, and human capital. The consequence of these weaknesses is that China's high-tech progress has not translated into higher economic growth. Instead, the data indicates that structural inefficiencies in the economy are leading to slower growth. Total factor productivity, which reflects that the contribution of improvements of capital, human capital, and technology to innovation, is essentially no longer a significant contributor the country's economic growth. China's financial system remains incredibly inefficient, leading to the rapid accumulation of debt. Moreover, though China has made clear progress in generating R&D and its manufacturing sector has an unrivaled ability to scale up production and diffuse technology in society, soft budget constraints and political incentives that inhibit creative destruction and consolidation mean that industries routinely suffer from bouts of overcapacity that generate additional debt challenges, which translates into low productivity and limits further innovation. Finally, although urban China has seen a huge improvement in human capital, there are hundreds of millions of rural Chinese citizens who do not finish high school and are unable to work in any high-tech sector, except perhaps as delivery drivers. These weaknesses are born of the same ecosystem that is responsible for China's technological progress.[103]

*China's high-tech progress has not translated into higher economic growth. Instead, the data indicates that structural inefficiencies in the economy are leading to slower growth.*

As a result, it is critical to maintain a balanced view of China's technological trajectory and its economy as a whole. One of the most valuable ways to appreciate this variation is by comparing and contrasting developments across industries, which is the task of the next chapter.

# Chapter 4

## *Systematic Sectoral Variation*

A few years ago, while on a research trip in China, I visited two Shanghai companies located within a few minutes' drive of each other, but which could not have been more different.

The first was a small upstart pharmaceutical firm focused on oncology therapies. As I listened to the head of research carefully explain the firm's specific niche in the vast array of efforts worldwide, their business model, and their efforts to raise funding, I was struck by how internationalized the company's staff was. Just about everyone, including this individual, had received their graduate degrees in the United States or Europe, and several had previously worked for larger Western pharmaceutical firms. These scientists had a crystal-clear understanding of the global industry and how to go through the U.S. Food and Drug Administration's certification process. The company even had an office in Bethesda, Maryland, precisely for this purpose.

A few days later, I arrived at the lobby of the state-owned Commercial Aviation Corporation of China (COMAC) to learn about its efforts to build the C919 jet. The first stop on my tour was jarring; it was an old-fashioned display of the CCP history of Chinese aviation and the firm's development. I wondered if I had been transported to an official museum in downtown Beijing, with photographs of Chinese leaders, including Xi Jinping, and official-sounding language used to describe the industry, instead of standing in a twenty-first-century office.

China's pharmaceutical industry is young and remains behind that of the United States, but its incredibly capable talent pool is enabling it to catch up fast. In contrast, while the country's commercial aviation sector is making incremental progress, its deep enmeshment in China's party-state means that the sector is not gaining ground on the world's leaders in any appreciable way.

Most analysts of China's technology sector recognize the variation in current circumstances. Despite this recognition, a common approach is to emphasize the overall progress and minimize the significance of any differences, which are usually chalked up to global industry dynamics or the extent of Chinese policy prioritization. Several studies on China's Made in China 2025 initiative and other cross-sectoral analyses are emblematic of this perspective.[104]

## *Sectoral variation is likely to be a persistent feature of China's technology drive going forward.*

This report challenges this conclusion and instead argues that not only are there large differences across sectors, but that these differences reflect the underlying strengths and weaknesses of China's innovation ecosystem and, additionally, that sectoral variation is likely to be a persistent feature of China's technology drive going forward.[105] This chapter makes this point by comparing performance across several sectors along two dimensions. First, it analyzes how successful Chinese firms have been in terms of innovation inputs and outputs, including research and development (R&D) activity, technological upgrading, and growing domestic value added, exports, and global market share. Second, the analysis examines the effect of China's tech activity on global industry in terms of whether China's behavior is gradually integrating into the sector as a whole or if it is a disruptive force. Disruption may be the product of unfair trade practices, such as industrial policy spending, but can also be the result of technological innovations and products that change the underlying dynamics of an industry overall.

These two dimensions (conforming and disruptive) yield four potential outcomes:

1. **Conforming Success:** Chinese companies effectively innovate and in turn generate new opportunities for innovation and growth in the global industry as a whole.
2. **Disruptive Success:** Chinese companies achieve substantial commercial success, yet they disrupt the industry due to either industrial policy spending that undermines original cost structures or due to achieving technological advances that challenge dominant technology platforms and business models.
3. **Conforming Failure:** Chinese companies pursue genuine innovation, yet they fail to achieve technological advancement and market progress, a reflection of standard "creative destruction," preserving the health of the sector's overall business model, supply chains, and business relationships.
4. **Disruptive Failure:** Chinese companies fail to successfully innovate and gain ground on their international competitors, yet they negatively influence the sector's overall trajectory through their behavior.

Table 4.1: Innovation Effects and Outcomes in Selected Industries

| | Success | Failure |
|---|---|---|
| **Conforming** | ▪ Pharmaceuticals<br>▪ Mobile phones<br>▪ E-commerce<br>▪ Social media<br>▪ Medical equipment | ▪ Commercial aircraft<br>▪ Advanced machine tools<br>▪ Healthcare services<br>▪ Education |
| **Disruptive** | ▪ Electric vehicles<br>▪ Steel<br>▪ Aluminum<br>▪ Solar<br>▪ Wind<br>▪ Telecommunications equipment | ▪ Advanced semiconductors |

Source: CSIS Trustee Chair in Chinese Business and Economics.[106]

To understand these patterns, this chapter will focus on four of the industries listed in Table 4.1: pharmaceuticals, electric vehicles (EVs), commercial aircraft, and advanced semiconductors. Since 2010, China's party-state has set increasingly ambitious goals for all four sectors, as listed in Table 4.2.

Each sector has been the recipient of substantial state-directed financial and policy support. In 2023, for example, government R&D funding included RMB 1.78 billion ($251 million) for medical equipment, RMB 1.64 billion ($231 million) for automobiles, RMB 7.2 billion ($1 billion) for large transport vehicles (including rail and aviation), and RMB 11.80 billion ($1.7 billion) for computer and communications equipment (of which semiconductors are a central component).[107] Broader annual industrial policy funding—including direct subsidies, tax breaks, below-market credit, government procurement, and government investment funds—totaled at least 10 times these amounts.[108]

Despite consistent and ample funding and regulatory support across all four sectors, outcomes in these sectors have varied dramatically. These differences are the product of broader underlying dynamics within China's innovation ecosystem and how they intersect with the global industries of which they are a part.

## Conforming Success: Pharmaceuticals

There are many examples of conforming successes from which to choose, among them mobile phones, e-commerce, and medical equipment. This report intentionally focuses on pharmaceuticals, a sector which by all accounts was highly unlikely to succeed in China. Historically, the industry in the country has been weak and plagued by lax standards, corruption, and scandals. Chinese vaccines, for example, have had extremely low efficacy, even in recent years. As a result, consumer trust in China's domestically made drugs has been quite low. Moreover,

## Table 4.2: Evolving Goals for Selected Priority Sectors

| | Strategic Emerging Industries (2010) | Made in China 2025 (2015) | 14th Five-Year Plan (2021) |
|---|---|---|---|
| **Commercial Aircraft and Engines** | ▪ Single-aisle regional and utility aircraft | ▪ Wide-body aircraft<br>▪ Independent and complete aviation industry chain | ▪ Key technologies for wide-body aircraft engines and key materials for advanced aviation engines<br>▪ CJ1000 turbofan engine and advanced civil turboshaft engines |
| **Biomedical Technologies** | ▪ Industrialization of biomedical engineering products, advanced medical equipment, and medical materials | ▪ New biomedical technologies: 3D bioprinting and induced pluripotent stem cell (iPSC) | ▪ Core biomedical technologies: lumpectomy robots and extracorporeal membrane lung oxygenators |
| **Electric Vehicles and Batteries** | ▪ Key technologies for batteries, drive motors, and electronic control<br>▪ Application and industrialization of plug-in hybrid vehicles and EVs<br>▪ Advanced technologies for hydrogen fuel cell EVs | ▪ EVs and hydrogen fuel cell vehicles<br>▪ Industrial and innovation system, from key components to complete vehicles | ▪ Key technologies for new energy vehicles, such as high-safety power batteries, high-efficiency drive motors, and high-performance power systems for new energy vehicles<br>▪ Intelligent and autonomous vehicles |
| **Semiconductors** | ▪ Integrated circuits (IC), new displays, high-end software, and servers | ▪ IC design and intellectual property (IP) design tools<br>▪ Core general-purpose chips related to national information and network security<br>▪ High-density packaging and 3D micro-packaging | ▪ IC design tools<br>▪ Advanced IC processors and special processors, insulated-gate bipolar transistors (IGBT), and micro-electro-mechanical systems (MEMS)<br>▪ Advanced storage technologies, broadband semiconductors, silicon carbide, and gallium nitride |

Source: CSIS Trustee Chair in Chinese Business and Economics.[309]

despite China's scale, the size of its domestic market for pharmaceuticals—typically a key incentive for companies—has been relatively small because of rigid price controls on drugs and healthcare services set by regulators that have emphasized patient access over corporate profits. To make matters worse, China's historically weak protection of intellectual property (IP) rights would seem to be a fatal obstacle for a sector where patents account for the largest share of a product's value.

Surprisingly, the pharmaceutical sector has overcome these problems and achieved a level of success no one would have predicted two decades ago. Some credit goes to Chinese regulators, which have provided financial and regulatory support for each component of the value chain: (1) basic and applied R&D; (2) active pharmaceutical ingredient (API) production; (3) clinical trials; (4) pathways for innovative drug development; and (5) drug manufacturing.

China's regulators adopted several key policies to promote each of these components:

1. A series of policies from 2015 to 2025 to support generic drug development.[109]
2. The 2020 creation by the National Medical Products Administration of four special drug approval pathways: approval for breakthrough therapy drugs, conditional approval, priority review and approval, and special approval procedures.[110]
3. The adoption of punitive measures for fraudulent clinical trial data and the encouraging of Chinese drug developers to participate in international clinical trials.[111]
4. Expanded protection of IP rights, including a drug patent linkage system in 2017 and data exclusivity rights in 2019.[112]
5. The "market authorization holder" system, introduced in 2015, which decouples manufacturing from markets and makes drug accountability clear.[113]

A move to open the industry to private and foreign-invested firms has been central to the effectiveness of these policies. The pharmaceutical sector's major players used to be various state-owned enterprises (SOEs), such as Sinopharm and Shanghai Pharmaceuticals. Since 2010, however, there has been a tidal wave of new entrants from the domestic private sector, including Jiangsu Hengrui, Fosun Pharma, Beigene, Yunnan Baiyao, and Zai Lab. Equally important is the industry's highly internationalized talent pool. Most of the founders of China's top pharmaceutical firms studied medicine or pharmacology in the West and previously worked for one of the world's leading pharmaceutical companies. Zai Lab founder Samantha Du, who worked for Pfizer before returning to China, is typical of this trend.[114]

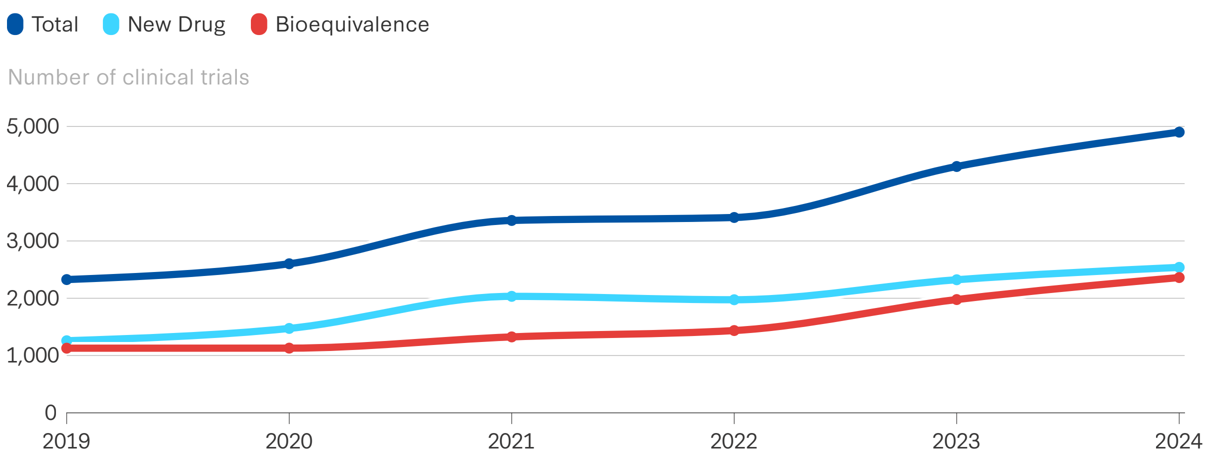
China's regulators have also expanded domestic market opportunities for Western pharmaceutical makers. As a result, these firms have increased their investments in China and now actively collaborate with domestic firms. Relatedly, they have expanded their R&D activity in China.[115] Because Chinese industry is relatively young and headed by people with deep international experience, Western pharmaceutical firms do not see their Chinese cousins as major threats but instead as helpful partners capable of carrying out trials in China and codeveloping drugs for global markets. Venture capital firms—composed of Western and Chinese partners and who serve as quality evaluators and bridges among scientists, innovators, manufacturers, healthcare providers, and market regulators—also play a central role in nurturing China's growing pharmaceutical sector.[116]

China's pharmaceutical industry may be more internationalized and open than just about any high-tech sector in China. Returned Chinese talent working in private firms and carrying out partnerships with overseas pharmaceutical companies and venture capital firms has been crucial to the development of China's pharmaceutical sector. These benefits include improving the industry's overall structure, transferring IP and tacit scientific knowledge, strengthening the R&D process, performing clinical trials, raising capital, improving the drug approval system, and developing product marketing and services.[117]

*In 2019, 25 percent of clinical trials worldwide were conducted in China; by 2023, the rate had risen to 39 percent.*

The intensive policy reforms and growing openness to private firms and the global industry have been transformational. As Figure 4.1 illustrates, the number of clinical trials in China has risen from under 2,400 in 2019 to 4,900 in 2024. Moreover, 92.8 percent of the trials in 2024 had domestic sponsors.[118] In 2019, 25 percent of clinical trials worldwide were conducted in China; by 2023, the rate had risen to 39 percent.[119] Wuxi AppTec has become the dominant provider of clinical trials in China, but it is not alone.[120]

Figure 4.1: The Growth of Clinical Trials in China, 2019–2024




Source: "Center for Drug Evaluation," Center for Drug Evaluation of the State Drug Administration of China, https://www.cde.org.cn/.

More impressive than the increase in the number of clinical trials is the recent—and apparently sudden—rise of China as a source of innovative drugs. The number of novel chemical drugs approved for clinical trials in China rose from 493 in 2019 to 1,247 in 2024. In 2024, the number of novel drugs that entered development (though not necessarily clinical trials) in China was over 1,250, just shy of the 1,440 that entered development in the United States. In 2020, 5 of the top 50 companies that developed innovative drugs were Chinese. By 2024, that number had risen to 20, with an earlier leading generic drug maker, Jiangsu Hengrui, topping the list.[121]

## Disruptive Success: Electric Vehicles

It would be an understatement to say that the EV industry has been even more successful than the pharmaceutical sector in China. In fact, the Chinese EV sector has achieved a globally dominant position, a major shock to the global auto industry in multiple ways.

This dominant position was not the product of China's original auto sector industrial strategy. From the mid-1980s to the mid-2000s, China's auto industry was centered around joint ventures between large SOEs and leading automakers from the United States, Europe, and Asia producing internal combustion engine (ICE) vehicles under the brands of foreign partners. Chinese policymakers had hoped that this would lead to extensive technology transfer and upgrading, thus paving the way for the local firms to develop their own models and displace their foreign partners in short order. But the result was the opposite: Chinese SOEs became deeply dependent on their foreign partners' technology and branding to maintain market share.

Four major shifts in China have led to a fundamental reordering of the EV sector. The first change was the entry of Chinese non-SOEs into the industry. Starting in the late 1990s, several Chinese companies—Geely, Great Wall, BYD, and Chery—jumped into the auto sector despite regulatory restrictions meant to block them from doing so. These companies quickly demonstrated their ability to learn and proved nimbler than SOE incumbents, leading central policy to eventually legitimize their growing role.

The second adjustment was China shifting the focus of industrial policy in the mid-2000s from the auto industry as a whole to new energy vehicles (NEVs), both plug-in battery-based EVs and hybrids. A central driving force behind this change was former Minister of Science and Technology Wan Gang, who had studied overseas in Germany and then worked as an engineer at Audi in the 1990s. He saw the potential for electrification as an alternative to ICE vehicles. Moreover, he believed that this shift would allow Chinese automakers to reduce their dependence on foreign producers by adopting a leapfrog approach to technological advancement. Policymakers also saw supporting NEVs as a way to reduce China's dependence on oil imports and address worsening air pollution.

The third shift was a quantum leap in the scale of Chinese government support—funding and regulatory changes—to massively boost both supply and demand for EVs. By CSIS's estimates, China's EV sector received at least $231 billion in industrial policy support between 2008 and 2023 (see Table 4.3), including funds for buyer rebates, a sales tax exemption, infrastructure, R&D, and government procurement. This estimate is conservative because it does not include a range of additional state support, such as local rebate programs, low-cost electricity, cheap land, below-market credit from banks, local government investment in private EV makers, and support for other parts of the supply chain (e.g., raw materials, chemical producers, and battery makers).[122]

The phalanx of policies to promote the technological upgrading, production, and diffusion of EVs has been accompanied by massive funding. Authorities have gradually increased the requirements for battery technology, including energy intensity, range, and safety. One of the most important policy changes was the 2018 adoption of the "dual-credit system," which set a target for the proportion of automakers' fleets that should be NEVs. Those producing above the target would receive credits, and those below it would be required to buy credits to avoid fines or other penalties. The rate was initially set at 8 percent and then increased annually.[123] Another important policy adjustment was to grant Tesla the right to open a 100 percent-owned subsidiary in Shanghai, the first wholly foreign-owned enterprise in the industry. The goal was both to prod domestic producers into improving their own capabilities and to support the development of the local supply chain for parts and components.

### Table 4.3: Industrial Policy Spending for China's EV Sector (USD, billions)

| Type of Support | 2009–2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|
| Sales subsidies | 37.8 | 4.3 | 3.3 | 3.5 | 7.4 | 9.2 | 0 | 65.7 |
| Sales tax exemption | 10.8 | 7.7 | 6.4 | 6.6 | 16.4 | 30.3 | 39.5 | 117.6 |
| Infrastructure subsidies | 2.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.6 | 0.6 | 4.5 |
| R&D | 2 | 3.6 | 3.4 | 3.5 | 4.3 | 3.9 | 4.3 | 25 |
| Government procurement | 7.8 | 1.6 | 1.4 | 2.9 | 1.7 | 1.8 | 0.8 | 18 |
| **Total** | **60.7** | **17.4** | **14.8** | **16.8** | **30.1** | **45.8** | **45.2** | **230.8** |
| **Significance** | | | | | | | | |
| Total value of EV sales | 143.1 | 76.6 | 63.7 | 66.2 | 163.9 | 302.7 | 395.6 | 1,211.7 |
| Government support as share of EV sales | 42.4% | 22.7% | 23.3% | 25.4% | 18.3% | 15.1% | 11.4% | 19.0% |
| Per vehicle (USD) | | 13,860 | 12,311 | 12,294 | 8,538 | 6,656 | 4,764 | |

Source: Adapted from Scott Kennedy, "The Chinese EV Dilemma: Subsidized Yet Striking," *Trustee China Hand* (blog), CSIS, updated June 28, 2024, https://www.csis.org/blogs/trustee-china-hand/chinese-ev-dilemma-subsidized-yet-striking.

The Chinese government has supported domestic consumers through various funding sources as well. For example, on the demand side, customers benefit from sizeable rebates toward their EV purchases to make the vehicles more affordable. In addition, the government restricted issuance of new license plates for ICE vehicles while making such licenses more readily available for EVs.

The fourth change critical to China's growing prowess in the industry is the entry into the EV sector in the late 2010's by a new wave of companies with origins in the information technology (IT) and internet industries. As a result of a range of policies demonstrating a strong policy commitment to the industry, NIO, Xiaomi, XPeng, and other companies with little previous auto experience dove into the market. These more recent additions have helped push boundaries in a number of ways. NIO has developed a battery-swapping system as an alternative to traditional charging; Xiaomi has integrated its other IT products into its vehicles and streamlined the manufacturing process; and XPeng has invested heavily in autonomous vehicle technology.

A focus on R&D and technological upgrading is now a built-in feature of the industry in China. However, although government support is substantial, it represents only a small share of total investment. The Chinese company BYD, for example, has 11 research institutes and labs and employs almost 110,000 engineers. As of the third quarter of 2024, BYD's total annual R&D expenditure was $21.9 billion.[124] CATL, which, held 38 percent of the global market share in batteries as of late 2025, has six R&D centers with over 20,000 staff, including over 5,000 individuals with master's degrees and 500 with doctorates. In 2024, it spent $2.6 billion on R&D, and the company cumulatively has been granted or applied for over 43,000 patents.[125]

*In bypassing ICE vehicles and focusing on EVs, China's top automakers have leapfrogged their chief rivals, who have wavered for decades on electrification.*

What have these four shifts and all of this effort achieved? Quite a bit. In bypassing ICE vehicles and focusing on EVs, China's top automakers have leapfrogged their chief rivals, who have wavered for decades on electrification. Chinese companies have continued to refine the technologies involved in batteries, motors, cockpits, infotainment systems, and other components. As a result, domestic firms' share of the Chinese market rose from 37.2 percent in 2015 to 64.8 percent in the first nine months of 2025.[126] Relatedly, EV sales went from around 5 percent of passenger car sales in China in 2019 to around 50 percent in 2024.[127] Moreover, Chinese EV-producing companies have gone from being irrelevant beyond China to becoming the world's leading exporters of EVs. In 2024, China made up 20 percent of global EV exports in value terms.[128] Equally important, Chinese EV and battery makers are investing heavily beyond China, including throughout Asia, Europe, and Latin America. As they do so, these Chinese companies are transforming the auto industry and supply chains globally.[129]

China's move into EVs has been both highly successful and highly disruptive, at least to the global industry, in two ways. First, by providing so much industrial policy funding and policy support, China has attracted hundreds of companies attempting to be auto producers and thousands more to fill out parts of the supply chain. The extent of subsidies has allowed automakers to price their vehicles far lower than EVs made elsewhere, making Chinese EVs price competitive with traditional ICE vehicles. Moreover, even with a large rise in domestic sales, Chinese automakers have produced far beyond what the domestic market can bear and, as a result, are exporting at highly competitive prices, which puts further strains on the incumbent players around the world.

The second disruptive component of China's turn toward EVs is technological. China's push into EVs was highly deliberate and assertive. In contrast, international automakers have been far more hesitant. Although EV technology was originally developed in the United States, Europe, and Japan, those automakers have treated EVs (and hybrids) as niche markets, in part because of their own advantages with ICE vehicles and the conventional view of EVs as a pricey ethical choice, not simply an alternative energy and propulsion system. Add to this Chinese automakers' huge investments in connected and intelligent vehicles and autonomy and one can see how China's efforts are having a transformative effect on the sector as a whole. Even more remarkable is that this total transformation of the industry was viewed as entirely unlikely even five years ago.

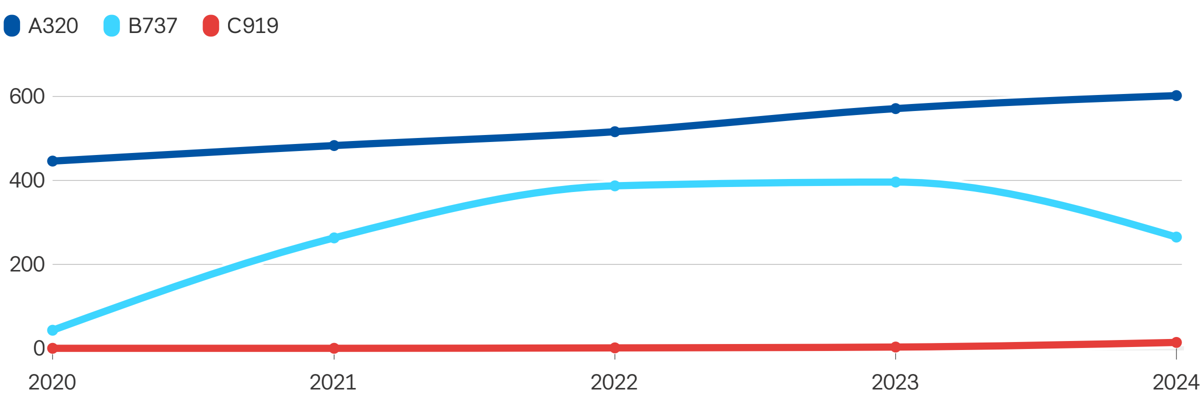
## Conforming Failure: Commercial Aircraft

In stark contrast to the Chinese auto sector, the commercial aircraft industry in China has continued to flounder. This frustrating result is not for lack of attention or effort. China's top leadership has made developing a domestic commercial aircraft a high priority since the 1970s. In the early 1980s, China developed the *yunshi* (Y-10) jet—a four-engine aircraft modeled on Boeing's 707—but due to worries about safety, the project was mothballed; only three Y-10s were ever assembled. In the 1980s and 1990s, Chinese policymakers took an approach similar to the automotive industry and formed a partnership with a leading Western firm, McDonnell-Douglas. The U.S. company sold several planes to China, but efforts to at co-production went nowhere. The partnership was then dissolved when Boeing acquired McDonnell-Douglas in the early 2000s.[130] Soon after, in 2003, China's Ministry of Science and Technology (MOST) developed a new plan for a domestic airliner, and this goal was included in both the 2006 Medium- and Long-term Plan for the Development of Science and Technology and the 11th Five-Year Plan (2006–10). It was on this basis that the Commercial Aircraft Corporation of China (COMAC) was created in 2008, with initial assets of RMB 19 billion ($2.7 billion). The company was given two tasks: (1) Complete the design and production of a regional jet to reduce China's dependence on Embraer and Bombardier; and (2) Develop a single-aisle airliner to reduce dependence on Boeing and Airbus. In the 17 years since its foundation, COMAC has made some progress toward both goals, but far less than originally envisioned.

It is important to note that China has a large aircraft manufacturing sector and an extensive aviation industry. COMAC was born out of the Aviation Industry Corporation of China (AVIC), the country's top aerospace firm, which produces both civilian and military aircraft and equipment.[131] Besides COMAC and AVIC, there are thousands of other aviation manufacturing firms in China, which together generated RMB 121.5 billion ($17.4 billion) in sales in 2023, almost double the value from 2016 of RMB 67.1 billion ($9.6 billion).[132] These companies have large R&D teams, and there is a mass of research organizations associated with the sector. In 2023, companies in this sector submitted 16,564 patent applications, were granted 10,753 patents, and had a total of 60,200 patents in force. In the same year, these organizations generated RMB 135.7 billion ($19.1 billion) through various technology contract arrangements, including technology transfers, IP licensing, consulting, and others.[133] China's commercial aviation market is similarly huge. The government has invested heavily in airports and other transportation infrastructure. In 2024, the country had 730 million air travelers.[134] As of early 2023, China's 10 largest airlines had a combined 2,864 aircraft in their fleets.[135] Forecasts by Boeing and COMAC both indicate that China will account for roughly 20 percent of all new commercial aircraft purchases through 2040.[136]

All of this activity, however, has not added up to much, particularly in comparison to other sectors with greater momentum. As of 2020, it was clear that COMAC was a "minor leaguer" compared to its international rivals.[137] Six years later, this conclusion still holds. COMAC had originally aimed to deliver its regional jet—the ARJ21, later renamed the C909—in 2010 or so, but the first plane was not delivered to an airline until 2015. As of late 2024, COMAC had delivered over 140 of the aircraft to various airlines, almost all within China.[138] The schedule for its single-aisle jetliner, the C919, was similarly delayed by several years, with its first delivery not coming until December 2022.[139] COMAC claims to have received over 1,000 orders for the C919, but as Figure 4.2 shows, its production schedule has ramped up extremely slowly, particularly in comparison to its main competitors. As of the end of 2024, COMAC had delivered a total of only 16 planes, less than what Boeing or Airbus produce in a single month. In 2021, Boeing and Airbus had revenues of $60.0 billion and $50.2 billion, respectively. By contrast, COMAC's sales that year were $1.5 billion.[140]

### Figure 4.2: Deliveries of Narrow-Body Commercial Jetliners, 2020–2024




Source: Press releases from Boeing, Airbus, and COMAC.

More significant than the delays in their delivery is the fact that these planes are almost entirely dependent on foreign technology and global supply chains. Both are modeled on Western versions, and the primary suppliers for both planes are from the United States and Europe.

Using a highly respected third-party platform (Airframer.com), an analysis in 2020 by CSIS's Trustee Chair in Chinese Business and Economics demonstrated that both the regional C909 and the narrow-body C919 depend almost entirely on Western components, including the engine, avionics, landing gear, and other critical systems.[141] A 2025 analysis of the Airframer data by the Rhodium Group found that the C919 continues to depend on foreign suppliers for 100 percent of its raw materials, 90 percent of its components, 83 percent of its power systems, 57 percent of the airframe, and 72 percent of the avionics.[142]

## *China's aviation industry has missed every single deadline it has ever set.*

Chinese companies have tried unsuccessfully to steal gas and steam turbine technology from General Electric.[143] Since 2015, they have also expanded efforts to create their own engines. For example, the Aero Engine Corporation of China (AECC), founded in 2016, has made some technical progress on its CJ-1000 turbo-fan engine, but it is still in development and far from being able to replace the Leap-1C produced by CFM International, a joint venture of the U.S.-based GE Aerospace and France-based Safran Aircraft Engines.[144] News reports suggest that China is aiming for the CJ-1000 to be certified by 2027 and available for commercial use by 2030, but China's aviation industry has missed every single deadline it has ever set. Observers are not holding their breath.

Despite the foreign technology they contain, according to my interviews, the C909 and C919 are less capable than their global counterparts. Sources report that the C909, in particular, is poorly designed, and the rear of the craft is known to get warm during flights. As a result, the maintenance hours for the plane have been high by international standards. Finally, the C919 is less fuel efficient than the Boeing 737 MAX or the Airbus A320neo. As a result, according to interview sources, despite placing orders for the C919, Chinese airlines are not genuinely interested in buying the plane. They would prefer to have fleets entirely composed of Boeing and Airbus planes. The domestic alternatives are less efficient and less reliable, and having planes from three producers complicates fleet maintenance, training, and crew scheduling.

Given these problems, it is no wonder that China's plans for its own wide-body jetliner, the CR929, are far from reaching fruition. In May 2014, Xi Jinping and Vladimir Putin oversaw the signing of a joint venture that would focus on the co-production of this plane—hence the "C" for China and the "R" for Russia—but their collaboration never went beyond the drawing board; the joint venture was officially dissolved in the early 2020s.[145] COMAC has said that it is moving ahead on its own, but as China's relations with the West worsen, the company is encountering difficulty attracting Western suppliers, which would still be essential if the plane were to ever be produced.

Why have China's aircraft dreams not been realized?[146] Most importantly, the technology is incredibly complex, both for individual components as well as for systems integration, the latter of which requires millions of parts working together seamlessly. The single most difficult challenge lies in the engine, which itself is based on thousands of patents as well as tacit knowledge gained by engineering teams over decades. Understanding how the metallurgy of engine blades is affected by operating at high temperatures in high-altitude conditions, for example, is only captured through thousands of hours of experimentation, testing, and flight time—data and experience the CJ-1000, for example, does not have.

Second, unlike both ICE and EV automobiles, where 40 to 50 million vehicles are produced, sold, and, most significantly, used annually, the global market for planes and their components is counted annually in the low thousands. This means that development through a method of incremental progress gained via constant feedback loops during production and use is not possible for the commercial aircraft sector. In fact, due to the high risks of air travel, incremental improvements are unfortunately often acquired through the learning process following crashes. This kind of learning process is viable for China in the context of social media apps or even EVs, but a serious accident would be fatal to its dreams of building a competitive airliner.

Third, unlike in pharmaceuticals and EVs, and most other successful industries, China's aircraft manufacturing industry is dominated by large SOEs. AVIC emerged out of the People's Liberation Army Air Force and is deeply embedded in the military production system. COMAC and AECC are also part of this system. SOEs, including those with military industry ties, are highly bureaucratic and have low internal transparency. Moreover, their interaction with foreign companies and experts is quite rigid.[147] According to interview sources, COMAC has hired several hundred aviation and aerospace experts from other countries, including the United States, in order to help the company catch up. But these foreign employees are given very little decisionmaking authority and are even segregated from their Chinese colleagues. Though foreign-born executives rarely rise to the top of Chinese companies in general, COMAC and other companies in aviation manufacturing are extreme in their control of foreign employees.

Fourth, and relatedly, the level of technology sharing between Western and Chinese aviation firms has been much less than in other industries. Western leaders have fiercely protected their technology, and as noted above, Chinese airlines have preferred to buy planes from the incumbent leaders and have not been enthusiastic about switching to domestic alternatives. Beyond the commercial disincentives for sharing, the U.S. government placed AECC on the U.S. Commerce Department's Bureau of Industry and Security (BIS) Entity List in 2020, which makes future legal technological collaboration even less likely.[148]

Finally, the United States and the European Union have an outsized role in regulating the global aviation industry. Unlike with trade and other areas where multilateral institutions set and enforce the rules, the U.S. Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA) remain the aviation sector's chief regulators. They are the gold standard for the certification of aircraft and their major components. Interviews suggest that the FAA and EASA are skeptical of China's commercial aircraft quality and safety; if the FAA or EASA do not certify the C909 and C919 (or recognize the Chinese aviation regulator's certification), then it would be difficult for COMAC to sell its planes abroad.[149] It appears that, to date, the FAA's and EASA's positions are based purely on questions of safety and reliability and are not instruments of protectionist governments seeking to block COMAC's products from markets outside China, but this regulatory hurdle will still be hard for COMAC to meet in the coming years.

The above discussion demonstrates that China's efforts in aviation manufacturing have yet to pay off and, moreover, that the chances of changing this outcome any time soon are quite low. At the same time, China's frustrations are not hurting the global industry. China has continued to promote cooperation between COMAC and its foreign suppliers. For example, though it has paused receipt of Boeing planes as a result of recent crashes and the ongoing trade dispute with the United States, it has increased its orders of planes from Airbus. Industry sources also expect China to eventually renew purchases of Boeing aircraft because of continuing market needs and the fact that China does not want to be dependent on a single supplier. There is no chance that domestic Chinese suppliers will be able to meet Chinese demand for aircraft in the foreseeable future, which is why this report categorizes this sector as a "conforming failure."

There are several ways this outcome could potentially change, but none of them are likely. Chinese authorities could provide more subsidies to COMAC and others in the supply chain in the hope of achieving new breakthroughs, but this would likely yield continued slow, plodding progress. If Chinese authorities were to suddenly open the industry up to private players and invite the likes of Huawei, Alibaba, or others to become plane manufacturers, they would theoretically be more attuned to markets and quality. However, planes are a world away from e-commerce, mobile phones, telecom equipment, and even EVs. The incremental learning model these firms are familiar with in their own industries would not necessarily translate easily into commercial aviation.

Alternatively, China could ramp up protectionism even further, blocking both Boeing and Airbus from its market. But it cannot replace something with nothing, and COMAC is still very far from being able to ramp up production. Moreover, if China took such a protectionist step, one would expect U.S. and EU authorities to restrict sales of major components for the C919, including the engine and avionics. This would immediately lead to a halt of the plane's production and operations.

*Given the problems facing China's aviation innovation ecosystem and the structure of the global industry, the status of China's aviation sector as a "conforming failure" is likely to endure.*

The final source of change would be a disruptive technological breakthrough, such as occurred with electrification in autos. There are efforts around the world, including in China, to move toward batteries and electric motors for small jets, but the physics of flying make this solution impractical to apply to larger commercial aircraft. There are also efforts related to "flying taxis" and the "low-altitude economy" in China and elsewhere. However, while initiatives have shown some technical progress, they are still many years away from commercialization, and even then, they would not be an option for long-distance travel. Given the problems facing China's aviation innovation ecosystem and the structure of the global industry, the status of China's aviation sector as a "conforming failure" is likely to endure.

## Disruptive Failure: Advanced Semiconductors

The center of China's high-tech drive is most certainly the semiconductor industry. This industry's development is foundational for almost every other sector, from autos to medical devices to AI. In its early years, the semiconductor industry was primarily centered around fully integrated companies that both designed and manufactured their own chips. But since the 1990s, the sector has been radically restructured through fragmentation and specialization. At the heart of this shift has been the emergence of "pure-play foundries" or "fabs," companies that provide contract manufacturing services for firms that design chips. Upstream in the production chain, there are firms that specialize in making the equipment and software tools that fabs then use, and downstream there are testing and packaging firms that assemble the final chipsets together for shipment to end users for mobile phones, autos, home appliances, and many other industries. The result of this transformation is that the semiconductor industry has become geographically dispersed and that cross-country collaboration has become integral to the industry's operations and identity. No country or company is an island unto itself.[150]

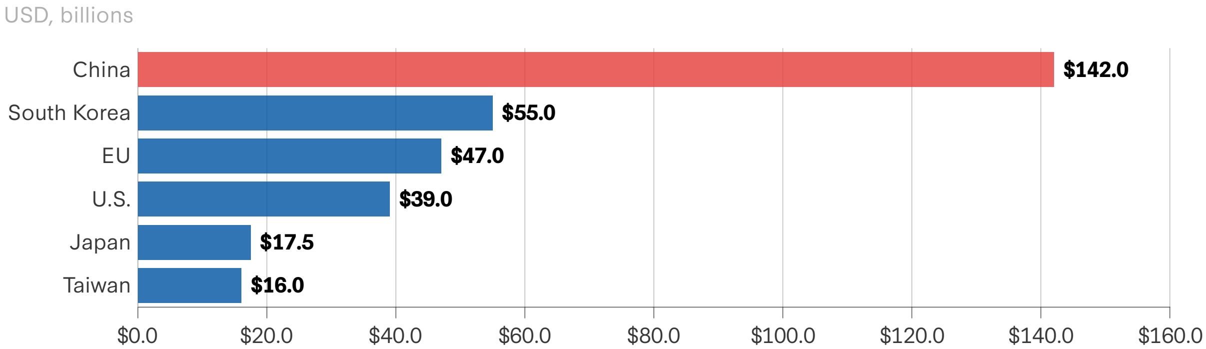
It is in this more globalized sector that China, for both economic and national security reasons, has tried to become more influential. Although China has invested more resources and policy support for advanced-node semiconductors than just about any other sector, and has made substantial progress over the last decade, this report characterizes the outcome as a "disruptive failure." In absolute terms, China has made gains, but it is still far behind the United States and others in the most important areas of the industry. Moreover, China's activities have been quite disruptive, both due to its extensive industrial policy support and because of actions taken by the United States, China, and others aimed at protecting their own economic security.[151]

China issued its first industrial policy on semiconductors in 1994. Adopting the same strategy that it had used for automobiles and commercial aircraft, it created several large SOEs—such as the Semiconductor Manufacturing International Corporation (SMIC)—to act as national champions for this strategic sector. The country invited leading firms from around the world to open fabs in China, including SK Hynix (2006), the Taiwan Semiconductor Manufacturing Company (TSMC) (2007), Intel (2010), and Samsung (2019). China also encouraged collaboration between the Chinese SOEs and foreign leaders through joint ventures and other arrangements. But all of these efforts have generated little in the way of success. The joint ventures, for example, entrenched the dependence of Chinese partners on foreign companies and resulted in minimal technology transfer or upgrading. Moreover, the SOEs made limited progress on their own. Analyses conducted in the 2010s found very little positive results from China's efforts.[152]

China shifted gears dramatically in 2014 when it launched a National Integrated Circuit Industry Investment Fund, or "Big Fund," which over the subsequent decade invested over $140 billion in promoting the development of stand-alone domestic firms and capacity in every segment of the semiconductor value chain (see Figure 4.3). Intensive support has gone to talent recruitment, R&D, design, equipment and tools, manufacturing, and downstream applications of semiconductors.[153]

In mid-2024, the Chinese government announced a third round of funding totaling $47.5 billion, which was supposed to focus on addressing some of the largest weaknesses of the country's semiconductor industry, including in manufacturing tools, equipment, and graphics processing unit (GPU) chips used in AI. One component of this approach has been to encourage mergers and acquisitions in order to consolidate capabilities in the most effective organizations.[154]

## Figure 4.3: Semiconductor Industrial Policy Spending, 2014–2023 (USD, billions)




Source: Raj Varadarajan et al., *Emerging Resilience in the Semiconductor Supply Chain* (Boston: Boston Consulting Group and Semiconductor Industry Association, May 2024), https://www.semiconductors.org/wp-content/uploads/2024/05/Report_Emerging-Resilience-in-the-Semiconductor-Supply-Chain.pdf.

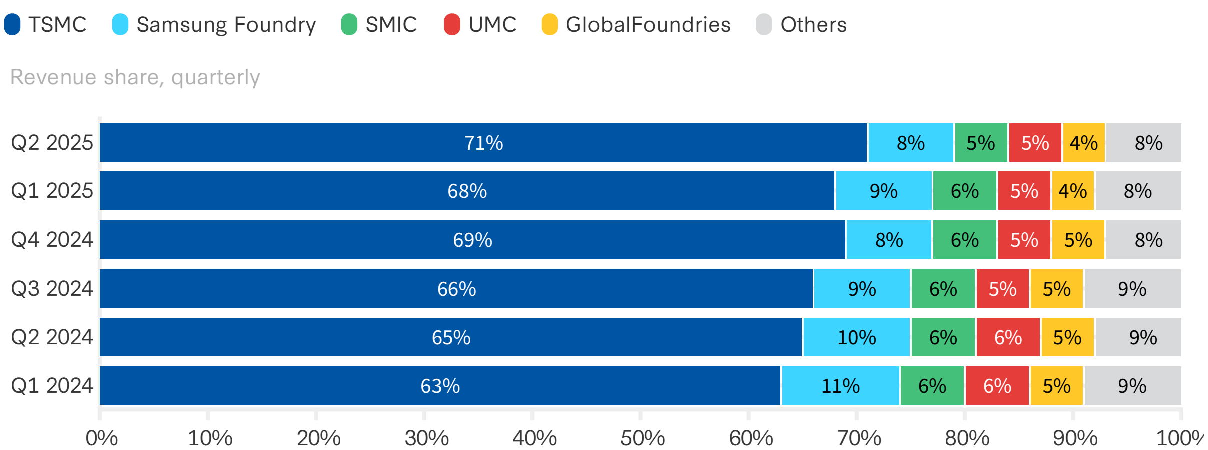
A critical context to understanding the Chinese semiconductor sector is the dramatic expansion of export controls over this same period, led by the United States but also incorporating restrictions from elsewhere, most importantly, the Netherlands and Japan. As China has ramped up efforts to achieve greater domestic capabilities and to reduce its reliance on suppliers from the United States and others, the United States has simultaneously expanded restrictions on technology sharing. It originally targeted a small number of companies, placing them on the BIS Entity List or imposing other restrictions, but in October 2022, U.S. efforts shifted dramatically, imposing restrictions on providing the most advanced semiconductors and manufacturing equipment used to make such chips. The United States asserted extraterritorial jurisdiction by simultaneously requiring companies in other countries that use U.S. technologies in their own products, most importantly semiconductor equipment manufacturers in the Netherlands (ASML) and Japan (Tokyo Electron), to similarly desist in sharing their most advanced semiconductor technology with China. The rules were augmented by closing some gaps in coverage and adding some new elements in late 2023 and late 2024. These restrictions have not been absolutely comprehensive and airtight, but they have created much higher hurdles for China to make progress in the sector than would have otherwise been present.[155]

*The full balance sheet of China's trajectory in the semiconductor sector is not simple, with successes, setbacks, and outright failures.*

The full balance sheet of China's trajectory in the semiconductor sector is not simple, with successes, setbacks, and outright failures. Those who emphasize progress focus on absolute improvements in Chinese capabilities, even in the face of significant restrictions.[156] However, this report sides with those who highlight ongoing struggles within the industry and on the continuing gap between China and other major players across many elements of the industry, particularly at the leading edge.

There have been improvements within the sector. For example, in the case of manufacturing, SMIC has raised its capabilities significantly. As of mid-2025, it accounted for 6 percent of all fab production, putting it third globally behind TSMC and Samsung (see Figure 4.4). However, SMIC is still at least two to three generations behind TSMC, according to analysts. Moreover, SMIC's yield rate–the proportion of chips produced on a wafer that are functional–is reportedly 20 to 40 percent, whereas the rate for TSMC is 90 percent, a massive gap. SMIC's inability to access the most advanced lithography machines means that it will not be able to manufacture chips smaller than 7 nanometers (nm), indicating that the distance between it and the world's leaders may in fact expand in the coming years. SMIC and another Chinese fab, Huahong, are more competitive in less

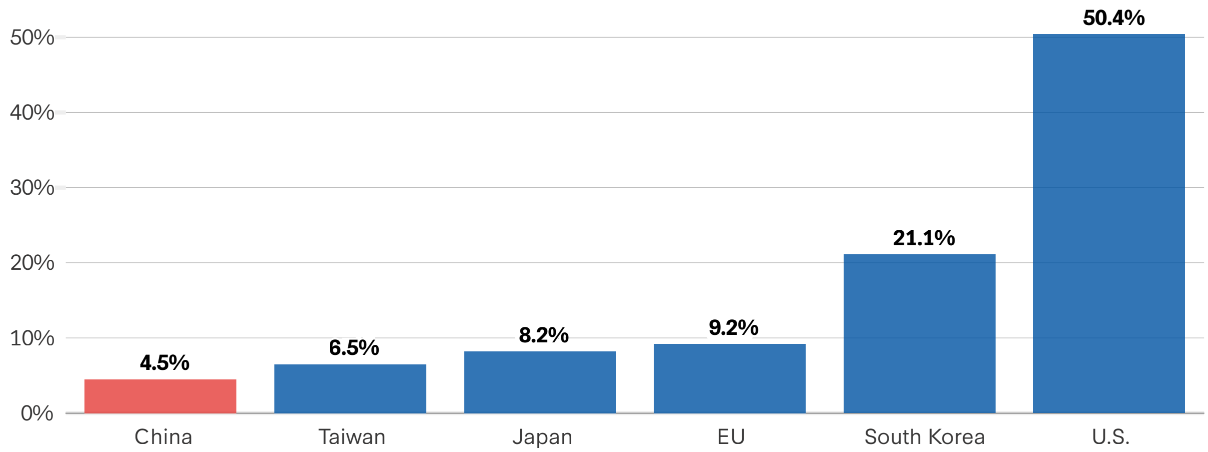
## Figure 4.4 Global Foundry Market Shares




Source: "Global Pure Foundry Market Share: Quarterly," Counterpoint, October 25, 2025, https://counterpointresearch.com/en/insights/global-semiconductor-foundry-market-share.

advanced "legacy" chips–28 nm and higher–where their market share has risen substantially.[157] While legacy chips occupy a large share of the overall semiconductor industry, a lead there still leaves Chinese companies behind their foreign counterparts and industry leaders.

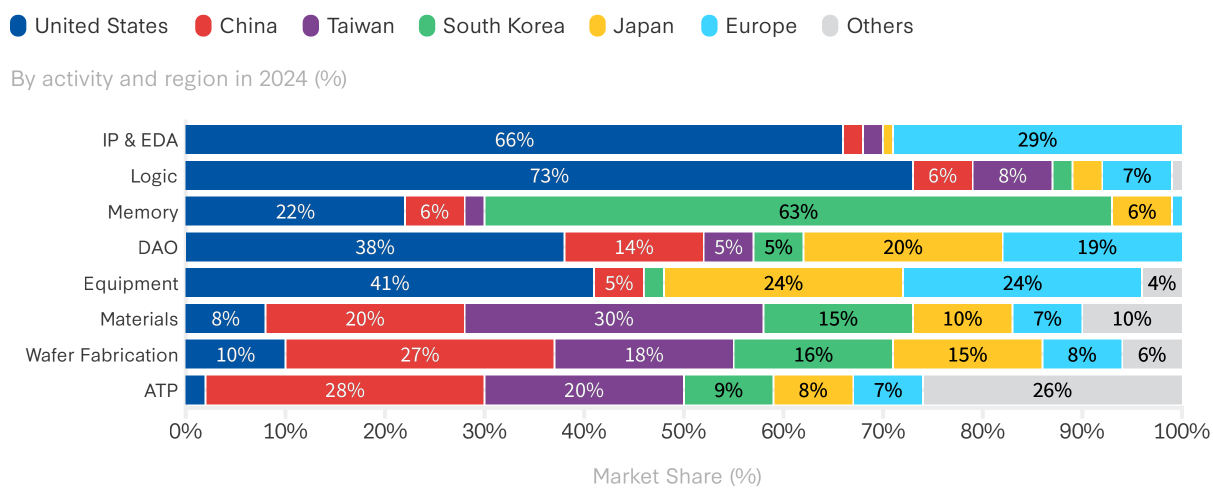
### Figure 4.5: Regional Share of Semiconductor Shipments by Company HQ




Source: Sarah Ravi, *2025 SIA Factbook* (Washington, DC: SIA, May 27, 2025), https://www.semiconductors.org/resources/2025-sia-factbook/.

Equally telling as to the state of the Chinese semiconductor sector is data that breaks down the market share of semiconductor design firms and their global shipments. As Figure 4.5 shows, U.S.-headquartered companies still account for over 50 percent of all chips produced globally. China trails dramatically, with only a 4.5 percent market share.[158]

### Figure 4.6: Semiconductor Industry Value Added, 2024




Note: EDA stands for electronic design automation, DAO stands for design automation optimization, and ATP stands for assembly, testing, and packaging.

Source: SIA, *2025 State of the U.S. Semiconductor Industry* (Washington, DC: SIA, July 2025), https://www.semiconductors.org/wp-content/uploads/2025/07/SIA-State-of-the-Industry-Report-2025.pdf.

The imbalance in advantage is brought home even more clearly when one delineates the origins of value added across each of the various segments of the semiconductor industry. As Figure 4.6 demonstrates, China has made significant inroads in materials, fabrication (at least in legacy chips), and assembly, packaging, and testing.[159] However, in the most advanced and valuable parts of the industry, China is still substantially behind the United States and others.

A brief look at two segments—memory and GPUs—illustrates how Chinese firms are making progress but still trailing industry leaders in important ways.

China launched three major memory chip firms in 2016: Fujian Jinhua Integrated Circuit Corp (JHICC), based in Jinjiang, Fujian Province; Yangtze Memory (YMTC), based in Wuhan, Hubei Province; and ChangXin Memory Technologies (CMXT), based in Hefei, Anhui Province. The country's goal was to peel away market share from the world's leaders, most notably Samsung, SK Hynix, and Micron.[160] YMTC has focused its efforts on NAND flash memory, and it has gradually raised its capabilities such that it can produce "3D NAND," with over 232 active layers, which brings it somewhat closer to both Samsung and SK Hynix. YMTC is also known to have innovated with "hybrid bonding," connecting the flash memory with the logic chips in a device.[161] CMXT has made similar kinds of progress in DRAM memory.[162] Both companies have made these advances in the context of expanded export controls in the United States, which have limited their access to the most advanced equipment (and technical support) as well as to overseas markets.

In the case of GPUs, China's progress has been more halting. A number of startups have appeared in this segment, but none have been able to present a significant challenge to the world's clear leader, U.S.-based Nvidia, which holds over 90 percent of the global market.[163] The most serious recent entrant into this space is Huawei, whose Ascend series of chips are, in principle, closer in capability to Nvidia's chips. However, Huawei is still behind Nvidia in terms of computing power.[164] Alibaba's semiconductor subsidiary T-Head is also a credible market entrant, producing 100,000 chips in 2025, though again, at lower computing power relative to Nvidia.[165] Other notable entrants include Cambricon and Moore Threads. The former, which reportedly has received substantial investment from the Chinese Academy of Sciences and the second round of China's national semiconductor fund, has developed a chip useful for inference but not for training.[166] Moore Threads, which was founded by a former Nvidia employee, received fast-track approval for listing on Shanghai's Star Market in December 2025.[167] A clear bottleneck for each one of these AI chip designers is production capacity and quality limits from SMIC and any other domestic fab that might be a suitable producer. Given their inability to access TSMC, Chinese companies will likely be in a zero-sum fight for a finite amount of production capacity well into the future.

One could look at China's extensive efforts and these cases to tell a positive story of progress. This is the posture a Chinese industry source provided in an interview for this project. He framed it this way: "In the past, one could not even compare the U.S. and Chinese semiconductor industries. And now they are comparable. China is x years or x months behind." And this progress, in my view, is a direct result of U.S. pressure since 2018, which has forced China to accelerate and expand its efforts to become more self-sufficient.

While understandable, an equally good case can be made on the other side. Although China is advancing in absolute terms, as another analyst notes, "it is still dramatically behind the U.S."[168] This is not only a product of China's difficulties, but also a function of the United States' and others' continued innovation and forward progress. Although China has expanded R&D in the industry, U.S. firms on average allocate the equivalent of 17.7 percent of their sales to R&D, compared to only 9.2 percent for Chinese firms.[169] In the case of AI chips, as China's firms make progress on computing power and scale, so will Nvidia, and likely at a faster clip, perhaps leading to a widening gap between China and the cutting edge. As a result, this report agrees with the conclusion offered by another long-time analyst of the industry, Jimmy Goodrich, who concludes: "For the foreseeable future China will likely be a 'fast-follower,' perennially challenged in keeping pace with global leaders."[170]

Beyond this relatively negative outlook, it is clear that China's efforts have been highly disruptive, not because of new technological breakthroughs but rather due to two other reasons. The first comprises the national security concerns that underly the arms race in investments and restrictions by the United States, China, and other countries. These steps have fundamentally shaped the semiconductor industry's development, which is leading to major shifts in supply chains, investment, talent flows, and types of collaboration. The second cause of disruption centers on China's expansion of its efforts in materials, legacy chips, and certain product segments, including memory. As a part of this effort, China has tried to gain market share by selling at prices lower than foreign competitors.[171] The country is also in the process of expanding fab capacity in legacy chips to such an extent that the kind of excess capacity problems witnessed in solar panels and EVs could occur in semiconductors.[172] Occasional bouts of overcapacity are not unusual in semiconductor production, but China's investments could exacerbate this problem and make the ultimate process toward consolidation more difficult.

## Conclusion

This analysis demonstrates that although China has made enormous strides toward greater technological leadership, there is substantial variation within and across industries. This mixed picture is not just the result of timing, with the country inevitably making up ground in areas in which it has long trailed competitors. Instead, these differences are likely to persist because of the features of China's domestic innovation ecosystem and the distinctive dynamics of the various industries in which China aims to compete.

*Although China has made enormous strides toward greater technological leadership, there is substantial variation within and across industries.*

China has been more successful in industries with medium-level technological barriers, where incremental learning is possible and where there are large economies of scale, which allow it to take advantage of its substantial manufacturing prowess and huge domestic market. These markets are typified by EVs, as discussed above. By contrast, highly advanced sectors with low economies of scale, such as commercial aircraft, have been more difficult in which for China to make headway.

The international context has also been critical. When the global industry is cooperative, technology sharing has been much more common and has facilitated China's advancement. This is certainly the case in pharmaceuticals. In addition, there are some occasions where overseas leaders have developed new technologies but have not put sufficient resources behind their diffusion. Such circumstances present an opportunity for China to step in and fill the vacuum. This appears to have been the case with EVs, where China's adoption of a leapfrog approach to technological advancement has presented a massive challenge to the global automobile industry. By contrast, in industries where the incumbents are highly focused on maintaining their advantages for commercial and security reasons—such as with semiconductors—the obstacles for China have been more daunting. In others, such as with commercial aircraft and jet engines, the sector-specific advantages of the incumbent Western firms mean Chinese producers have no clear path to global competitiveness.

This discussion is important for understanding the mixed trajectory of Chinese industry. It raises the question of what China's record of innovation means for its international power, including its military capabilities and diplomatic influence. This report turns to these issues in the next two chapters.

# Chapter 5

## *Progress in Military-Civil Fusion*

Although the ins and outs of China's commercial economy, including macroeconomic trends and global business footprint, are rarely discussed in tandem with analyses of its military, a key component of China's international power lies in the close relationship between the two. Since the mid-2010s, China has increasingly emphasized the need to apply achievements in commercial technology in support of the country's military preparedness. Most commonly known as "military-civil fusion" (MCF), this initiative appears to have been embedded within the broader–and more ambiguous–initiative "integrated national strategic systems and capabilities" (*yitihua guojiazhanlue tixi he nengli*, 一体化国家战略体系和能力), simplified by Chinese military industry expert Tai Ming Cheung as "national strategic integration."[173]

A high priority under Xi Jinping's leadership, MCF permeates Chinese policy and official texts and publications, including appearing in the 2017 constitution of the Chinese Communist Party (CCP). In addition, it has been the focus of a series of military development documents and has been featured in China's five-year plans. In fact, MCF has become a part of the regular policy lexicon in China.[174]

Since the rise of Xi Jinping, the MCF initiative has drawn enormous international attention, particularly from Western governments, businesses, policy analysts, and the media.[175] The U.S. Department of Defense's annual review of China's military has included an extended discussion of MCF in its most recent iterations. Moreover, the U.S. government has added a growing number of companies to the U.S. Commerce Department's traditional Bureau of Industry and Security (BIS) Entity List.[176] In 2021, other parts of the U.S. government went further, creating two additional blacklists: the Pentagon's list of "China Military Companies" with business in the United States (the "1260H" list), and the Treasury Department's "Non-SDN Chinese-Military Industrial Complex Companies List."[177] Companies on the 1260H list presently face few substantive restrictions, whereas American investors cannot buy publicly traded securities of those on the latter list. There is also a distinct possibility that further restrictions will be placed on interactions with companies on both lists in the coming years.

Building on this report's analysis of China's technological trajectory in general, enhanced with the discussions on specific sectors, this chapter reviews the origins of MCF and explores the creation of the MCF policy framework under Xi Jinping. The chapter then offers an analysis of MCF's effectiveness, focusing in particular on MCF's role in shaping how China's civilian economy supports the country's military preparedness. The discussion concludes with an assessment of the broad policy challenges this poses for the United States and others.

## MCF's Origins, Inspiration, and Obstacles

Although in many ways the logic behind the MCF initiative is clear, there are several surprising elements given conventional views about China's political system. First, in view of China's massive, sprawling defense industry, one may wonder if such a program is truly necessary. The largest of China's traditional defense firms are all state-owned enterprises (SOEs)—among them the China Northern Industries Group Corporation (Norinco), the China Electronics Technology Group (CETC), the China State Shipbuilding Corporation (CSSC), the Aviation Industry Corporation of China (AVIC), the China Aerospace Science and Technology Corporation (CASC), and the China Aerospace Science and Industry Corporation (CASIC).[178] These companies service much of China's military needs: Norinco is the country's largest weapons manufacturer; CETC makes radar systems and communications equipment; CSSC builds ships for the PLA Navy; AVIC and its subsidiaries are the primary designers and manufacturers of China's military aircraft; and CASC and CASIC, while primarily responsible for the country's space program, also manufacture ballistic and cruise missiles.[179]

In addition, the top executives of defense enterprises are all highly ranked within China's political system, while the businesses themselves receive an enormous amount of funding from the government. Finally, these firms, like other SOEs, are supervised by the State-Owned Assets Supervision and Administration Commission (SASAC) and the CCP's Central Discipline and Inspection Commission, but they operate without any external checks from China's media, legislature, or other sources. Conventional wisdom might question what substantial role, if any, commercially focused companies could play in this space.

MCF, however, is not about these firms. Instead, it focuses on the products, services, capabilities, and skills of Chinese companies and research organizations that typically focus on the civilian economy, as they may be able to supplement the traditional defense sector in support of the CCP's goals. China's traditional defense enterprises concentrate on the country's core combat-related weapons systems and supporting logistical technologies, the first of China's three-category military acquisition system. On the other hand, MCF—including the participating enterprises and organizations—is primarily focused on the second and third categories: (1) dual-use equipment, or items that have both commercial and potential military applications, and (2) standard civilian products that the military needs for general operations, such as food, clothing, and other supplies.[180]

Another surprising element to MCF is that China's push to more effectively utilize its civilian technology ecosystem for military purposes, particularly in its early years, grew out of a certain admiration for the United States' technological capabilities, the strength of the U.S. defense industrial base, and the U.S. military's ability to effectively absorb and apply commercial developments.[181] Representative of early admiration is a 2014 *People's Daily* article that emphasizes how MCF was viewed as a natural extension of market reforms during this period. The article notes that "integrating military and civilian sectors and promoting military-civil integration are common practices in market economy countries."[182] This appreciation was not just about generalities but also touched on specific aspects of the United States' defense industrial system. In fact, MCF's most direct inspiration is the U.S. concept of civil-military integration, an idea often cited by Chinese sources in the context of MCF. For example, many Chinese experts cite a 1994 report from the former U.S. Office of Technology Assessment, *Assessing the Potential for Civil-Military Integration*, to bolster their own view on the benefit of China having a similar program.[183] Furthermore, the 2007 edition of China's *Technology Foundations of National Defense* discusses the U.S. model of civil-military integration in depth and then evaluates U.S. programs and agencies such as the Tactical Response Plan, the Defense Advanced Research Projects Agency, the National Aeronautics and Space Administration (NASA), the Dual Use Science & Technology Plan, and the Small Business Innovation Research program, as well as their impact on U.S. military capabilities.[184] More recently, the State Council's Development Research Center published a document in 2018 outlining the role of legislation such as the United States' Federal Technology Transfer Act of 1986 and the 1996 Federal Acquisition Reform Act in the development of dual-use industries in the United States.[185]

China's strong interest in the U.S. approach exists despite massive differences in the countries' political systems and contrasting approaches to government-business relations. On one hand, with a very clear boundary between the private sector and government, the United States has a detailed regulatory and legal system to manage these complex relationships. For example, there are clear rules restricting the appropriation of intellectual property (IP), including the Federal Acquisition Regulation and the Defense Federal Acquisition Regulation Supplement, both of which are periodically updated.[186] In addition, in certain circumstances, the United States can compel industry support, such as with the Defense Production Act (1950), though in general the private sector and citizens have significant legal protections. Moreover, there are detailed procedures to manage the actual engagement that protects both sides, including a system of security clearances and firewalls within U.S. firms that separate their commercial and military-related activities.

In China, on the other hand, although there are some legal protections for the private sector, enterprises lack fundamental political and regulatory protections. Beyond the CCP's role in the appointment of personnel and investment decisions in SOEs, the country's Defense Mobilization Law (2010), National Security Law (2015), National Intelligence Law (2017), and various other regulations weaken the autonomy of companies by placing national security interests, which can be very broadly defined, above the interests of companies and the privacy and rights of their customers.[187] Despite this environment, the PLA has been hesitant to work with commercial firms because of the opposite perception—being unconvinced that private firms are trustworthy enough to handle sensitive information about China's military system and its technology needs.

Chinese admiration of the United States is even more surprising given the extensive, and expanding, domestic criticism of the United States' insufficient military capabilities, outdated military procurement system, and an overall sense of growing problems with defense firms. Some analyses of the United States current defense industry go so far as to suggest that it may be the United States, not China, that needs substantial reforms to its military industrial base.[188]

Despite the power of the Chinese state and the existence of a regulatory environment which appears to compel cooperation in certain circumstances, the Chinese state—particularly the military—has found it surprisingly difficult to utilize the technologies and services made available through the country's civilian economy. This is because the PLA and the traditional defense industry are deeply intertwined and have long been isolated from the rest of society, including from private enterprises and research organizations. Moreover, compelling the private sector to provide help during a war or in emergencies is fundamentally different to facilitating long-term peacetime collaboration and mutually beneficial relationships that support the nurturing of an entire ecosystem.[189] As a result, achieving MCF has required building regulatory infrastructure and mechanisms of interaction which previously did not exist.

## MCF's Policy Framework

The goals embodied in MCF, specifically around drawing on the civilian economy for the military's benefit, are of long standing, albeit under a variety of names and with changing foci due to various failures and a general inability of private firms to break into China's largely self-contained—and often graft- and corruption-ridden—defense ecosystem.[190] Though the term "military-civil fusion" was first used at the 17th Party Congress (2007) by then General Secretary Hu Jintao, earlier texts provide evidence for a similar conceptualization. For example, policy documents during the administrations of Jiang Zemin (1989-2003) and Hu Jintao (2002-12) regularly mention "civil-military integration" (*junmin jiehe*, 军民结合) and the concept of "embedding defense within the people" (*yujunyumin*, 寓军于民).[191]

*It has really been under Xi Jinping that China has pushed more fully to institutionalize the goals associated with MCF and to formalize the concept into a major strategic component of China's military modernization.*

But it has really been under Xi Jinping that China has pushed more fully to institutionalize the goals associated with MCF and to formalize the concept into a major strategic component of China's military modernization.[192] Much of the policy framework—the policy designs, institutions and organizations, and initial funding—was put in place from 2013 to 2017. Since then, the primary focus has been on implementation. This chapter will cover both in turn.

The report of the 3rd Plenum of the 18th Party Congress in November 2013 was the first to highlight Xi's new MCF formulation, and major policy documents were rolled out over the next three years elaborating the goals of MCF, as well as the institutions and funding supporting it.[193] China's 2015 defense white paper offers a more fleshed-out purpose and strategy for MCF: "With stronger policy support, China will work to establish uniform military and civilian standards for infrastructure, key technological areas and major industries." Moreover, the paper highlights areas where the military can leverage civilian capabilities, such as through "outsourcing logistics support to civilian support systems" and the "joint building and utilization of military and civilian infrastructure."[194] In a 2017 speech, Xi noted that

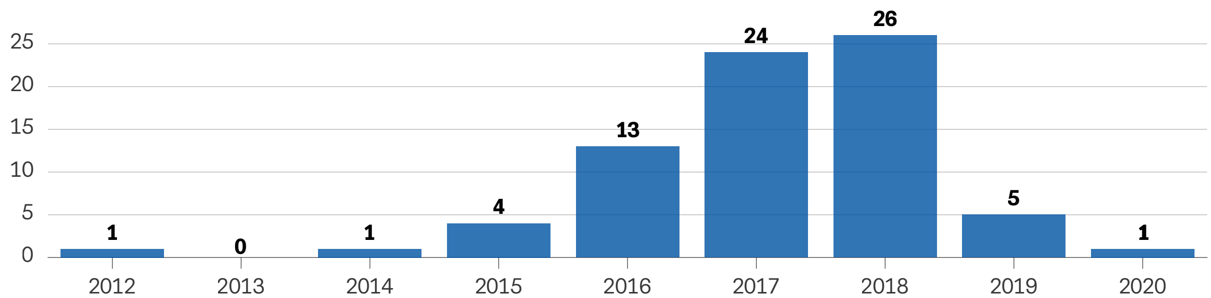
> . . . after a long period of development, our country's economic and technological power has increased greatly to the point that in several technological areas our country now leads the world. This provides a solid foundation for strengthening the military through science and technology, and we are fully capable of doing a better and faster job in integrating military and civilian technologies.[195]

Based on this policy, China has built a large organizational structure to support MCF. In 2016, the Central Military Commission—chaired by Xi Jinping—created the National Defense Mobilization Department. Then, in January 2017, Xi created—and made himself head of—the Central Military-Civil Fusion Development Commission (CMCFDC). Staffed with top officials from across every part of the relevant bureaucracy, the CMCFDC reports to the Politburo Standing Committee, also headed, of course, by Xi Jinping, and not to the State Council. The CMCFDC has leading groups (essentially small committees) which focus on specific areas of work and subsidiary offices in every province around the country. Other key agencies supporting the implementation of Xi's policy of MCF comprise the Military-Civil Integration Promotion Department under the Ministry of Industry and Information Technology (MIIT) and the Economic and Defense Coordination Department within the National Development and Reform Commission (NDRC).

These core organizations have overseen the creation of specific systems to facilitate cooperation among the military, traditional defense enterprises, private companies, and civilian research organizations unrelated to the PLA. Extensive efforts have focused on supporting both collaborative research and development (R&D) as well as procurement. For example, the MCF agencies created certification systems for both R&D and acquisition to which all firms can apply. These systems are supported by online platforms where firms can see procurement tenders and submit their bids.[196]

The final piece of the policy framework is funding. In the latter half of the 2010s, Chinese policymakers oversaw the creation of both a national MCF fund and various provincial funds, much of which went to support the creation of industrial parks. As Figure 5.1 shows, the establishment of MCF funds ramped up dramatically starting in 2017, coinciding with the establishment of the CMCFDC and the release of a policy calling for greater public investment to help promote MCF by the State Council.[197]

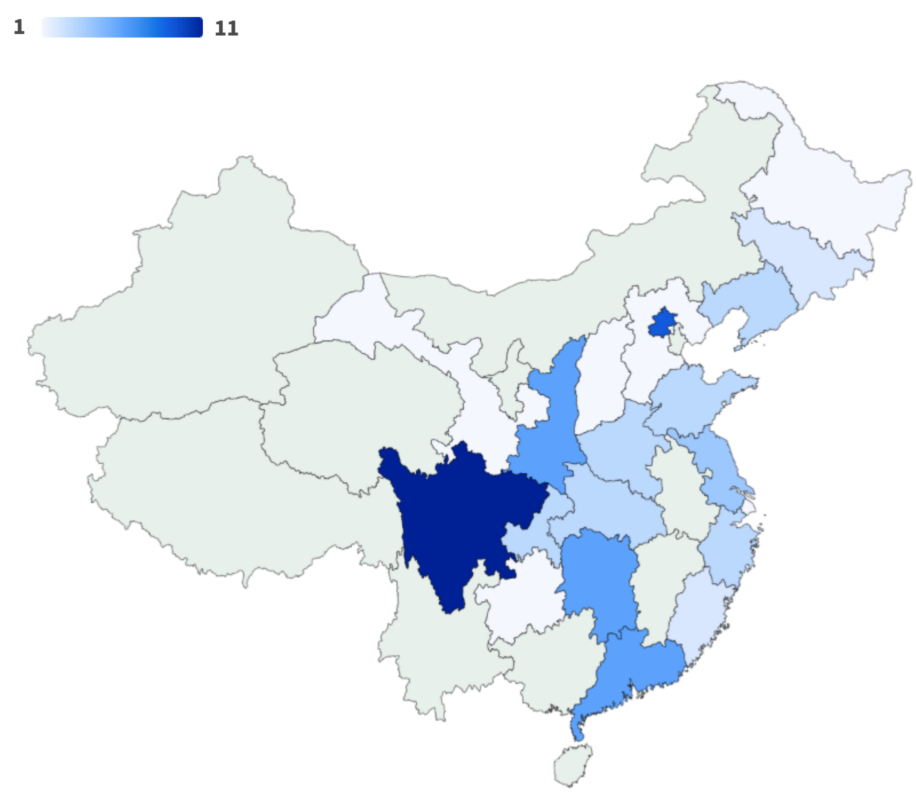
## Figure 5.1: Number of Newly Established Military-Civil Fusion Funds by Year




Source: Scott Kennedy and Audrey Fritz, "China's Military–Civil Fusion Funds: Big but Not Necessarily Effective," *Trustee China Hand* (blog), CSIS, October 4, 2019, https://www.csis.org/blogs/trustee-china-hand/chinas-military-civil-fusion-funds-big-not-necessarily-effective; Elsa B. Kania and Lorand Laskai, *Myths and Realities of China's Military-Civil Fusion Strategy* (Washington, DC: Center for a New American Security (CNAS), January 2021), https://www.cnas.org/publications/reports/myths-and-realities-of-chinas-military-civil-fusion-strategy; and Tai Ming Cheung and Eric Hagt, "China's Efforts in Civil-Military Integration, Its Impact on the Development of China's Acquisition System, and Implications for the United States," in *Proceedings of the Sixteenth Annual Acquisition Research Symposium*, Wednesday Sessions vol. 1, April 30, 2019, https://dair.nps.edu/handle/123456789/1725.

As Figure 5.2 reveals, the funds were far from evenly distributed geographically, with the largest number being created in Sichuan Province (11), followed by Beijing (9), Guangdong (6), Hunan (6), and Shaanxi (6).

## Figure 5.2: MCF Fund Distribution by Province




Source: Kennedy and Fritz, "China's Military–Civil Fusion Funds"; Kania and Laskai, *Myths and Realities*; and Cheung and Hagt, "China's Efforts in Civil-Military Integration."

Basic policy formation was thus completed by 2018-19. Since 2020, as noted above, the term MCF has appeared less often in official documents and Chinese state media. This may be because, as with the Made in China 2025 initiative, the term MCF drew extensive negative external attention. Another explanation is that "military-civil fusion," as originally conceived, no longer adequately captures every aspect of what China's leadership hopes to achieve. In either case, the broader phrase of "national strategic system and capabilities" has become the most common official verbiage to describe this area.[198]

## Implementation

With the policy framework in place, the focus of MCF since 2020 has been on implementation. However, given the short duration of the policy and the high degree of opacity of China's policy process—and of the defense realm in particular—any evaluation of MCF's performance record must necessarily be tentative and cautious.

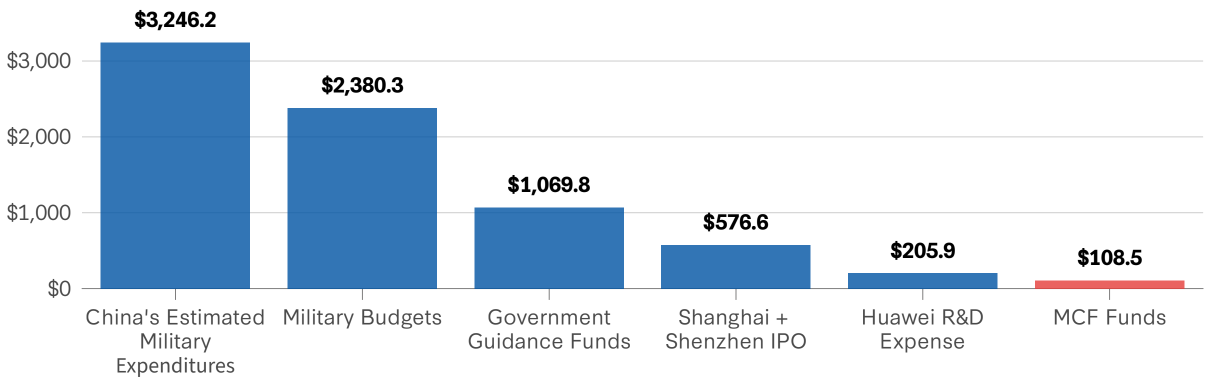
Using the broad metrics publicly available, it is difficult to conclude whether MCF has been a resounding success, or even if it has made a major difference in China's military capabilities. Chinese authorities themselves have not publicly provided a clear evaluation of MCF. China's own experts have used terms such as "MCF level" (*junmin ronghe chengdu*, 军民融合程度) and "MCF depth" (*junmin ronghe shendu*, 军民融合深度) as yardsticks to measure the level of progress in integrating the civilian and defense economies in various spheres, but neither a clear explanation of the strategy's components nor any systematic data on its implementation have ever been offered.[199] Moreover, a higher fusion level would not necessarily translate into greater defense capabilities. Hence, "MCF level" and "MCF depth" are even less meaningful than the ambiguous "science and technology contribution rate" discussed in Chapter 3, which is meant to measure technology's effect on the country's economic growth.

Chinese officials occasionally point to the establishment of MCF-related funds and programs as evidence for the initiative's development, but rarely if ever do they discuss any concrete outcomes. Equally important, collectively, MCF-related funds do not add up to very much compared to other government spending priorities. As Figure 5.3 illustrates, the total size of MCF-related funds between 2010 and 2024—$105.8 billion—comprises a tiny fraction of China's military spending (whether unofficial estimates or the official figure, $3.2 trillion and $2.4 trillion, respectively), the more conventional government guidance funds ($1.1 trillion), or even the market cap of the country's stock markets ($576.6 billion). Even a single company, Huawei—one of China's largest tech companies—expended far more in R&D ($205.9 billion) over the period than all MCF-related funds combined.

Another important point to consider when examining MCF's implementation is that the policy appears primarily focused on the second and third categories of China's three-pronged military acquisition system: (1) developing the potential military applications of dual-use technologies originally designed for civilian use, and (2) making standard commercial products available to military customers. MCF-related activities do not appear to target the first prong, China's core military equipment—by far the largest category of military acquisition category. According to analyses by the U.S. government and independent scholars, China's military capabilities have improved dramatically over the past two decades.[200] The vast majority of this progress within the most consequential parts of China's military likely originates "in-house," that is, out of work by China's traditional defense enterprises and not from MCF-related funding or activities.

### Figure 5.3: China's Minimal MCF-Related Funding

USD, billions




Source: Aggregated from various public, private, and think tank estimates.

## Sector-Specific Contributions

Although MCF's effect on China's overall defense modernization drive has likely been supplemental, it is possible to identify specific areas where collaboration among the military, defense enterprises, research organizations, and commercial companies has generated meaningful results, including strengthening specific elements of China's capabilities which could be valuable in combat, espionage, logistics, and other spheres. As noted previously, the discontinued use of "MCF" in official lexicon means that it is challenging to identify MCF-related activities. As a result, the below examples are highlighted because they appear to reflect the broader trend toward the collaboration that MCF is seeking to foster. Whether these instances are officially recognized as part of the wider MCF initiative seems less significant than their value in facilitating an understanding of the larger policy.

### RESEARCH

China has several hundred national "state key" labs throughout the country. They work on every imaginable area of science and technology and have enormous resources at their disposal. Much of the labs' work is for civilian purposes, but certain research areas have high potential for military applications, including the life sciences, chemistry, physics, quantum, and AI. In many instances, state key labs collaborate with nearby universities and civilian companies.[201]

In addition to the state key lab system, a new class of labs involved in research that supports MCF's goals is also emerging. The Shenzhen-based Peng Cheng Lab (PCL) is one example. Co-founded in 2018 by the Shenzhen and Guangdong governments, PCL primarily focuses on AI and cybersecurity, both of which have extensive potential military applications.[202] When the organization was placed on the BIS Entity List in January 2025, the notice said that PCL was included among a group of organizations that likely assisted China in developing hypersonic weapons and flight.[203]

According to public records, PCL has had a wide variety of research partners, including many participants in China's military defense sector as well as numerous private companies. PCL's AI compute cluster "Cloud Brain II," for example, is reportedly powered by Huawei chips and has trained large language models (LLMs) for Huawei and other private Chinese technology firms, including Zhiyuan, Baidu, and Deepseek.[204] PCL's research subdivisions also include the Control and Network Basic Research Laboratory, which studies defense and resilience for satellite constellations in "uncertain environments" caused by "interference" or "attack."[205] Additionally, PCL's other strategic partners have included organizations with explicit ties to China's defense industrial base, such as the National University of Defense Technology, the Key Laboratories of Science and Technology on National Defense, and the State Key Laboratory of Information Security (which is under the Chinese Academy of Sciences Institute of Information Engineering). More concretely, PCL hosts "cyber ranges," which provide virtual simulations, among other uses, for cybersecurity training, potentially including offensive cyberattacks.[206]

### AI APPLICATIONS

As noted above, one element of the MCF initiative has been creating mechanisms to facilitate companies' bids for contracts with the PLA and related organizations. The PLA uses platforms such as PLA Procurement Net (*jundui caigouwang*, 军队采购网) to issue bids and announce results. It likely was from such a platform that researchers at Georgetown University's Center for Security and Emerging Technology (CSET) created a database of almost 3,000 AI-related contracts awarded by the PLA in 2023 and 2024.[207] The CSET team found that 11 of the top 15 successful bidders were SOEs and other organizations who regularly engage with the PLA, such as CETC and Norinco. However, they also found that over 70 percent of companies that won two or more AI-related contacts were typical commercial AI companies, with top firms being iFlyTek Digital (20 contracts), PIESAT (18), NovaSky (15), JOUAV (12), and Nanjing Huage Information Technology (11). The commercial contracts comprised AI model assessment, surveillance, drone simulations, drone control, and many other applications.

### SPACE

Most of the technologies China uses in space were developed by the Chinese defense industry, one of the most prominent being the Beidou Navigation System (BDS), a global satellite network used for positioning, navigation, and timing services. Jointly created by the China National Space Administration and the Chinese Academy of Space Technology, BDS was meant to serve as an alternative to the U.S. Global Positioning System (GPS) in the wake of the First Iraq War.[208] BDS, which has over 50 satellites within its network, has both civil and military applications.[209]

Some space-related technologies in China are emerging from the private sector. In particular, following the 2020 Russian invasion of Ukraine and the subsequent rapid deployment of SpaceX's Starlink satellites in 2023 and 2024, several Chinese organizations have begun launching large constellations of low Earth orbit (LEO) satellites to compete with the Starlink system. The Xingwang system is being developed specifically for military uses by China SatNet, while several private companies, Qianfan and Landspace, are developing commercial versions with at least 10,000 satellites in each constellation. Overall, Chinese firms aim to launch nearly 40,000 satellites into LEO as part of three mega-constellations.[210] Though these efforts are encountering a variety of obstacles (including space debris left from failed missions), they may eventually succeed, and if they do, these systems could very well have dual-use capabilities and be available to China's military.[211]

Chinese companies have also recently started to develop reusable rockets. Landspace, iSpace, CAS Space, and Deep Blue Aerospace are following in the footsteps of private Western companies in this field, such as SpaceX, Blue Origin, Rocket Lab, Relativity Space, Stoke Space, and Virgin Galactic.[212] In December 2025, Landspace launched the Zhuque-3, which achieved some milestones during a notable trial before then exploding.[213] These private Chinese firms could eventually provide services to the PLA as SpaceX is doing for NASA.[214]

*Chinese institutions with strong ties to the PLA are carrying out research on AI use cases in space, including big data–driven decisionmaking, cybersecurity, and satellite resilience.*

China's private sector supports military space applications in other ways as well. For example, Chinese institutions with strong ties to the PLA are carrying out research on AI use cases in space, including big data–driven decisionmaking, cybersecurity, and satellite resilience.[215] Zhijiang Lab (ZJL), for instance, has played host to interactions between the Chinese big tech firm Alibaba and the MCF-involved space firm ADA Space. ZJL is jointly funded by the Zhejiang provincial government, Zhejiang University, and the Alibaba Group, and its director was the cofounder of Alibaba Cloud and the former chief technology officer of Alibaba.[216] In 2018, ADA Space was founded via explicit MCF support under the Sichuan Military-Civil Integration Satellite and Application Industry Innovation Project, and in the same year launched the Tian Fu Military Integration-1 satellite.[217] In May 2025, ZJL and ADA Space launched 12 satellites as part of the latter's "Star-Compute Plan" using rockets constructed by CASC; each satellite carried AI compute and remote sensing payloads.[218] Other non-state tech companies have signed cooperation agreements with ADA Space, including Huawei, iSoftStone, and Ucap.[219]

### NUCLEAR FUSION

China's nuclear fusion program is characterized by a centralized group of state-aligned firms and research labs working alongside a dynamic private industry which also receives significant government support. Housed at the Hefei Institute of Physical Sciences in the capital of Anhui Province, the government-funded Institute of Plasma Physics (ASIPP) developed the Experimental Advanced Superconducting Tokamak in 2006, the first fully superconducting tokamak worldwide. (A tokamak is used to create nuclear fusion using a combination of magnetic fields.) In November 2025, ASIPP officially revealed its plan to develop a next-generation fusion facility, the Burning Plasma Experimental Superconducting Tokamak.[220]

China's Academy of Engineering Physics—the main institution responsible for the research, development, and testing of nuclear weapons—has taken a leading role in nuclear fusion research as well, focusing on other pathways to fusion, such as laser and pulsed-power Z-pinch inertial confinement.[221] The academy is also collaborating with institutions such as ASIPP and the Southwestern Institute of Physics on their fusion research.[222] Such collaboration is not necessarily surprising given that fusion reactions are applicable for both civilian and military use cases.[223]

Private fusion-focused companies such as Xi'an Startorus Fusion and Neo Fusion have received direct state support; Xi'an Startorus received support from the Shaanxi provincial and Xi'an municipal governments, and Neo Fusion received support from the Anhui provincial and Hefei municipal governments.[224] China reportedly led equity investments in fusion worldwide in 2023, with much of the funding going to private firms.[225] This kind of dual-track approach to technology—state-backed SOEs and research institutions working alongside private firms focused on eventual commercialization—is an outgrowth of MCF. Once commercialized, nuclear fusion has the potential to confer enormous commercial value, improve China's economic security posture by reducing the country's dependence on imported energy, and even potentially yield further direct military benefits, such as with nuclear weapons development.

## Conclusion

Military-civil fusion is highly emblematic of China's current direction, in which technological progress is being harnessed for both economic benefits and national security advantages. Furthermore, MCF has the imprimatur of China's top political leadership and is supported by a complex institutional infrastructure. Although direct state funding has been limited, the policy has been more about matchmaking than financing. This initiative would not have made sense in 1985, or even in 2000, but it makes sense in 2026, in an era when Chinese companies and research organizations are making rapid technological progress.

The vast majority of the credit for China's impressive military modernization should go to the country's traditional defense industry, but the cases discussed above reveal that MCF is making a difference in a range of areas, including AI, space, drones, and energy. At the same time, despite a tradition of deep intervention by the state in China's economy, the MCF initiative has yet to solve the problem of limited trust between the PLA and normal commercial firms, which continues to be an impediment to greater contributions.

If those obstacles can be overcome, there are many other industries where MCF could make a more sizeable impact in the future. For example, China's civilian shipbuilding industry is already closely connected, both physically and through various relationships, with military shipbuilders.[226] China's military drones are produced by traditional defense enterprises, such as AVIC, CASIC, and Norinco.[227] Yet commercial drones could have potential military benefits, ranging from surveillance to carrying weapons. Shenzhen-based DJI, the world's dominant commercial drone producer, has vehemently denied allegations that it supports its devices being used for military purposes.[228] In 2025, the company sued the U.S. government (and lost) for being designated as a PLA-related firm.[229] Yet even without the company's active cooperation, militaries worldwide have been able to modify DJI drones for military purposes.[230]

EVs also have potential military value because of their quiet motors and because using batteries for energy storage could minimize refueling logistics in certain situations.[231] In January 2025, the Pentagon added the world's largest EV battery maker, CATL, along with several other companies, to its list of 1260H PLA-related firms, and as of early 2026, it reportedly was poised to add leading EV producer BYD and others (among them Alibaba).[232] There does not appear to be much publicly available information definitively showing such collaboration or any substantial results which may have come from it, but it would not be surprising for this to become an area of MCF focus.[233]

The qualified success of the MCF initiative presents the United States and other Western governments with three policy challenges. The first is to develop a clear and consistent rationale for why companies that do business with the PLA should face restrictions by the United States, what these restrictions should be, and how they should be managed internally within the U.S. government and in relation to like-minded countries. Should the bar be set at firms that provide weapons systems or dual-use technologies, or should the scope be even broader? Currently, the United States has three separate lists managed by the Commerce, Defense, and Treasury Departments, with different foci, standards, and tempos. To what extent should the United States seek to unify these lists or at least expand coordination of their administration?

The second set of questions concerns potential rationales to set limits on expansion of these restrictions or how they are applied to different kinds of companies developing different kinds of technologies. For example, improving China's ability to develop hypersonic missiles is significantly different from facilitating the sale of vaccines which are used to protect the health of military personnel. Relatedly, given that some companies involved in MCF may have multiple business lines, it is worth considering whether a Chinese company's ties with the PLA in one area of business should disqualify the company from having any commercial interactions with the United States in unrelated non-defense business domains. The United States itself expects other countries to differentiate between the defense- and commercial-oriented subsidiaries of American companies. Also, another rationale for maintaining ties with commercial firms that have some PLA ties could be, ironically, to reduce the PLA's confidence in the trustworthiness of these companies for further collaboration.

The last policy issue is the extent to which U.S. policymakers, impressed by China's rapid technological progress and by the supposedly close ties between Chinese industry and the PLA, may want to use the MCF as a model for defense industry reforms at home. Although MCF itself, at least in its early years, was partly inspired by the perception of a successful partnership between U.S. industry and the U.S. military, the question now is whether the learning process should go in the other direction. The United States might consider creating more "patriotic capital" and blurring the lines between firms and the military, but it is worth evaluating the potential benefits and risks. This is particularly worth analyzing at a moment when China's political leadership has instituted a widescale purge throughout the PLA, ostensibly for endemic corruption.[234]

The difficulties of determining how to most appropriately impose restrictions on China, under what circumstances one might loosen such restrictions, and how to facilitate the United States' own advancement are questions that are also relevant to the world of technology standards. However, the starting point of that policy space (international cooperation) makes it a valuable contrast to the discussion of MCF offered here. It is to the discussion of technological standards that this report next turns.

# Chapter 6

## *The Power of Standards*

### Why Focus on Technical Standards?

There are a range of economic diplomacy issues beyond the realms of military and defense where one could evaluate the extent to which China's growing technology capabilities translate into greater international power and influence. As China makes progress in green technologies, for example, it could have a greater foundation to shape how the world tackles climate change. Similarly, as the country's capabilities grow in infrastructure and healthcare, it gives China a stronger basis to become more involved in international development assistance and public health. These and other areas provide valuable windows into the linkage between capabilities and influence.

As insightful as investigations into the areas of the environment and healthcare would be, this study has chosen to focus on the world of technical standards. Although, as discussed in Chapter 4, China is still highly dependent on foreign suppliers for the most advanced semiconductors and semiconductor manufacturing equipment, the country has made enormous progress in information and communications technologies (ICT) more broadly. Chinese enterprises have gone from assembling electronics and telecommunications products to being original equipment manufacturers, designers, and developers of underlying technologies. This is reflected in the growth of invention patents, licensing royalties, and highly visible breakthroughs in telecommunications equipment, mobile phones, AI applications, and large language models (LLMs).

If technological prowess matters for international power and influence, it should be visible in the world of technology standards. Although quite arcane and often slow-moving, standards are surprisingly important and more controversial than one might expect. As researcher John

Seaman writes, standards "are documents that define requirements, specifications, guidelines or characteristics that can be applied to materials, products, processes and services to ensure that they are fit for purpose."[235] Standards—which normally set requirements for quality, safety, operational design, or interoperability—are typically voluntary and set through processes that are transparent, multistakeholder, and consensus-based. Though standards are intended to be public goods that spur innovation and benefit society as a whole, standards have been highly contested in ICT in particular for two reasons. First, shaping technology standards in ICT can be disproportionately valuable to the contributors when the standard includes their own intellectual property (IP) or aligns with their own products and business plans. And second, widely dispersed digital technologies create potential national security risks, a challenge that has expanded with the advancement of mobile communications, the internet, and the Internet of Things (IoT).[236]

The cooperative benefits, competitive value, and national security risks associated with technology standards have not been lost on Chinese companies or the Chinese government. In fact, both have actively participated in the international standards system for almost three decades, with their attention and efforts growing over time. China's mounting involvement has drawn sustained attention from Western scholars and policymakers. On the one hand, there is substantial concern that China is increasingly dominating standards development organizations (SDOs) and, in the process, undermining SDOs' traditional operating norms, pushing Chinese technology on the world, and promoting rules that support authoritarian views about information and data.[237] On the other hand, some observers, while recognizing growing Chinese activism and efforts to achieve these goals, believe the existing standards system has been sufficiently robust so far to effectively blunt China's more disruptive aims.[238] Not surprisingly, evaluations of China's effectiveness have translated into different opinions about how the United States and others should best respond, with attention paid alternatively to either limiting Chinese involvement or expanding Western activism.

To understand these issues, this chapter begins by tracing China's initial interest in standards, the evolution of its policy framework, and the development of its domestic standards system. The discussion then turns to examining China's involvement in international technical standards setting, with particular attention to its level of participation in important ICT-related SDOs. This provides a basis for determining China's actual level of influence, both materially in terms of proposals adopted and normatively in terms of how SDOs operate and the impact of international rules related to information and data security. The chapter examines broader trends as well as specific controversial cases that shed light on the supposed disruptiveness of Chinese activism and the role of Western policy. The chapter concludes with a brief look to the future, with an eye toward the implications for U.S. policy options.

## The Evolution of Chinese Policy, Institutions, and Practice

China's strong interest in technology standards began in the 1990s. The People's Republic of China (PRC) joined the International Organization for Standardization (ISO) in 1978 and then began the process of aligning its own domestic standards with international ones. However, it was not until the late 1990s, as the country began to court overseas investment and become connected to international supply chains, that it saw standards as a strategic area of activity. China's experience of having to pay high royalties to use second-generation (2G) wireless technologies developed in Europe and the United States and to assemble and sell DVD players, most of the IP for which was owned by Japanese firms, left the impression that standards were not just about facilitating cooperation but also about achieving technological leadership and expanding a country's share of the income from global value chains. In reaction to this experience, Chinese companies tried to develop alternative standards and products to DVDs in the late 1990s and to Wi-Fi in the early 2000s. Failure in both instances generated an internal debate in China not only about standards but also about technology policy more generally. Techno-globalists—from both industry and government—argued that China should pursue a strategy of integration and, at least for the time being, rely on technologies (and standards) from advanced economies. Techno-nationalists, in contrast, concluded that China should invest more in the research and development (R&D) of underlying technologies to give the country a greater chance to successfully shape international standards, which would allow Chinese industry to monetize IP and obtain a higher share of the value chain in ICT products.[239]

Since the early 2000s, and particularly under Xi Jinping's leadership, techno-nationalists have dominated the formal policy debate. Yet the varying capabilities and business interests of different elements of Chinese industry and the differing responsibilities for various parts of the bureaucracy have meant that the issue of how to approach technical standards has never been fully resolved.

*Xi Jinping sees technology standards as an important source of China's international power. He went so far as to state in 2018 that China should lead "the reform of the global governance system."*

Based on his speeches and statements, Xi Jinping sees technology standards as an important source of China's international power.[240] He went so far as to state in 2018 that China should lead "the reform of the global governance system."[241] Former Premier Li Keqiang (2013–23) shared a similar sentiment, stating in 2016 that "standardization is a reflection of a country's core competitiveness and overall strength."[242] The year prior, the State Council launched a plan to reform China's standardization system and strategy, indicating broader agreement as to the importance of standards in policy and government.[243] The initial result was the 2017 issuance of a "Standardization Law," which explained the importance of standards and codified the formulation and implementation processes for standards.[244]

The solidification of China's approach came in 2021, when the country issued a comprehensive national standards strategy that stressed the linkages among technological innovation, standards, and China's international influence. The strategy called for greater attention to updating China's standards system, emphasized the significance of patents, and stressed the varying roles of industry standards groups and consortia. It also called on China to synchronize 85 percent of its domestic national standards to parallel international standards in order for China to avoid being isolated. Known as "Standards 2035," the plan set out its ultimate goal for that year:

> By 2035, a more robust, advanced, and internationally compatible standards system will be in place, and a more comprehensive standardization management system with Chinese characteristics will be established. A standardization work framework driven by the market, guided by the government, led by enterprises, involving society, and characterized by openness and integration will be fully formed.[245]

Although there has been substantial institutional and policy development since the launch of the 2015 standardization reform plan, there has also been a high degree of continuity both in the overall orientation and in the processes for standards development and regulation. This is still a hybrid system in China, with leadership provided by the state but highly dependent on the active participation of industry and technical experts. Sitting at the apex of day-to-day work is the Standardization Administration of China (SAC), which sits under the State Administration of Market Regulation (SAMR). SAC oversees all of China's technical committees and related working groups in coordination with the relevant functional bureaucracies, such as the Ministry of Industry and Information Technology (MIIT). The most authoritative standards are "national standards," which can be mandatory or voluntary. China also allows for the separate creation of voluntary standards developed by local governments, industry associations, and enterprises, with participants coming from government, industry, academia, and research organizations.[246] As Table 6.1 illustrates, China has set a rapid pace for the development of national standards.

### Table 6.1: National Technical Standards in China, Select Years

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Domestic Standards | | | | | | | |
| Total in Effect | 1,320 | 2,860 | 1,931 | 2,252 | 2,815 | 2,266 | 2,902 |
| Formulated | 690 | 2,123 | 1,330 | 2,584 | 1,900 | 1,382 | 1,708 |
| Revised | 630 | 737 | 601 | 668 | 915 | 884 | 1,194 |
| Adopted International Standards | | | | | | | |
| Total | 711 | n/a | 500 | 568 | 876 | 792 | 999 |
| Identical | 417 | n/a | 283 | 245 | 521 | 379 | 543 |
| Modified | 220 | n/a | 171 | 323 | 355 | 413 | 456 |
| Non-equipment | 74 | - | 46 | - | - | - | - |

Source: National Bureau of Statistics, *China Statistical Yearbook on Science and Technology 2024* (Beijing: China Statistics Press, November 2024), 216, https://www.stats.gov.cn/sj/ndsj/2024/indexeh.htm.

The mirroring of China's standards system with that of the international system is intentional. Many domestic technical committees have purposefully adopted an equivalent substantive focus to their international counterparts at the ISO and other international standards bodies, such as the International Telecommunication Union (ITU). This provides the basis for China's ability to determine how aligned its domestic standards are with international ones. The reported data in Table 6.1 indicate, however, that China was still far short of its goal of having 85 percent of its standards aligned with international equivalents as of 2024.

## Chinese Participation in International Technical Standards Bodies

Since the late 1990s, Chinese participation in international technical standards development has risen substantially. This applies to: (1) treaty-based organizations, such as the ITU; (2) non-state organizations whose participants are "national bodies" of the country members, such as the ISO and International Electrotechnical Commission (IEC); and (3) other private organizations, such as industry consortia and other non-profit groups, whose members are private organizations or individuals. Experts from industry and research organizations participate in all three kinds of SDOs, but they clearly have a greater say in groups like the ISO and industry consortia. Some sources interviewed for this project held that the governance norms for treaty-based organizations, such as the ITU, were weaker and more vulnerable to the influence of powerful members. These sources believe that the UN system allows its largest members, such as China, to have more influence than other participants, whereas the other organizations are more independent and have more robust governance norms less subject to the preferences of individual members.

Broadly speaking, several things are striking about Chinese participation. First, some developments clearly fit the general narrative of a concerted and well-organized increase in Chinese participation in the development of international standards. The number of Chinese participants has increased substantially in many international SDOs. In fact, representatives of Chinese organizations comprise the largest share of members and meeting participants in some SDOs. In addition, representatives of Chinese institutions are increasingly occupying positions of leadership within standards-setting bodies, originally at the working level and now more recently in top leadership positions at SDOs. Moreover, there is clear evidence, provided by interview sources and reported by others, that Chinese participants from different organizations coordinate their positions, commonly in the case of leadership selection but also occasionally with respect to substantive issues as well.

At the same time, several unexpected trends in Chinese participation complicate the picture of a unified, top-down approach. Perhaps the most visible of these shifts concerns the types of individuals representing Chinese organizations. Originally, the most highly ranked officials and engineers from China attended as a reflection of their seniority. However, because of their weak language skills, and because all international standards organizations operate in English, these older individuals were typically unable to contribute significantly and were able to influence even less. Increasingly, younger engineers, with better English and more overseas experience, have been tapped to participate. In addition, Chinese companies have increasingly hired away senior standards experts from Western technology companies to lead their international activities. As a result, it has become impossible to use ethnicity to identify who works for Chinese companies.

In addition, China's national standards bodies are composed not only of Chinese citizens who work for the government and domestic enterprises, but also often Chinese citizens who work for multinational companies. This third group gains membership in SDOs based on their technical knowledge, and it is understood that they are likely to promote ideas aligned with their companies' interests, not just with China's. Although this mixed composition of membership is common throughout the world, it is somewhat surprising to find it occurring in China.

Finally, there is an increasingly wide diversity of Chinese companies that participate in international standards activities. In the 2000s, at least in the ICT space, most participating companies were either Huawei or state-owned enterprises (SOEs), such as China Mobile and ZTE. More recently, it has become common to see representatives from privately owned companies such as Alibaba, Tencent, Xiaomi, Oppo, Vivo, and others. This shift signals the existence of a deeper pool of companies engaging in extensive R&D and thus being capable of substantive contributions to international standards. Moreover, the list of specific Chinese companies becoming involved in SDOs in the area of ICT reveals that there are growing numbers of Chinese device makers whose interests tilt toward having global standards for products that can be sold around the world and whose business strategies are based on inexpensive licensing schemes, a posture different from those of Chinese companies trying to maximize their revenue through standardization.

These trends are visible across both state-based and non-state-based international standards institutions.

The most important place to start is ISO, the largest international standards organization. As Table 6.2 shows, Chinese participation in ISO technical committees (TCs), where the daily work of standards setting occurs, has grown from 695 TCs in 2008 to 780 in 2025. During the same period, German participation barely changed (724 in 2008 to 725 as of 2025), while U.S. involvement has dropped over the same period (620 to 566). The trend is the same for hosting the secretariats of these ISO TCs. Germany still hosts the most (134 in 2025), but China and the United States now host the same number (91), representing growth for China (up from 23 in 2008) and decline for the United States (down from 127 in 2008). The one area within the ISO system where little has changed is with secretariats for TCs in the ICT sector (JTC-1), where China has managed to host only one of several dozen secretariats.[247]

Trends in overall participation at the ITU show an even larger transition (see Figure 6.1). The number of Chinese members involved in various working groups rose from 14 in 2008 to 139 in 2025. During the same period, German participation rose slightly, from 26 to 35, while U.S. participation fell from 148 to 119.

Chinese leadership within the ITU has also grown. Houlin Zhao, a former Chinese official, served as the ITU's deputy secretary-general from 2007 to 2015 and as its secretary-general between 2015 and 2022. He has held the highest rank of any Chinese national in an international standards-related organization.[248] Multiple interview and written sources report that although he did not explicitly tilt the scales in the direction of Chinese participants with regard to any specific standards, Zhao was highly encouraging of Chinese involvement, including for Huawei.[249]

### Table 6.2: Participation in the International Organization for Standardization (ISO), Selected Years

**China**

| Year | ISO Technical Committees | ISO Secretariats | JTC-1 Secretariats |
|---|---|---|---|
| 2008 | 695 | 23 | 0 |
| 2021 | 741 | 66 | 0 |
| 2022 | 733 | 73 | 0 |
| 2023 | 748 | 79 | 1 |
| 2024 | 769 | 86 | 1 |
| 2025 | 780 | 91 | 1 |

**Germany**

| Year | ISO Technical Committees | ISO Secretariats | JTC-1 Secretariats |
|---|---|---|---|
| 2008 | 724 | 136 | 2 |
| 2021 | 741 | 132 | 2 |
| 2022 | 703 | 132 | 2 |
| 2023 | 706 | 130 | 2 |
| 2024 | 719 | 136 | 2 |
| 2025 | 725 | 134 | 2 |

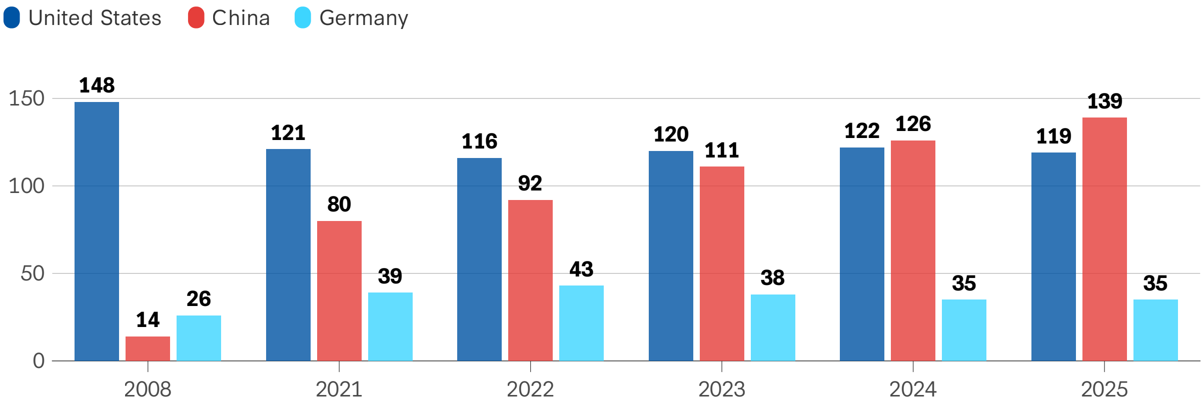
**United States**

| Year | ISO Technical Committees | ISO Secretariats | JTC-1 Secretariats |
|---|---|---|---|
| 2008 | 620 | 127 | 6 |
| 2021 | 570 | 100 | 8 |
| 2022 | 555 | 94 | 8 |
| 2023 | 554 | 92 | 8 |
| 2024 | 562 | 93 | 8 |
| 2025 | 566 | 91 | 7 |

Source: “Members,” International Organization for Standardization, www.iso.org/about/members.

Within the ITU, Chinese representatives have increased their positions of leadership within ITU-T, the part of the organization responsible for telecommunications standards. As of 2024, according to data from ITU’s website, Chinese representatives occupied 14 of 54 seats as chair and co-chair (25.9 percent) and 21 of 158 vice-chair positions of ITU-T study groups (13.3 percent). By contrast, though China has increased its hold on leadership positions within ITU-R, the section of the ITU responsible for radio communications, the gain is much smaller. In 2024, Chinese representatives held 2 of 28 chair positions (7.1 percent) of ITU-R study groups and only 11 of its 131 vice-chair positions (8.4 percent).[250]

## Figure 6.1: Membership in the International Telecommunication Union




Source: "Membership," International Telecommunication Union, https://www.itu.int/hub/membership/.

Arguably the most important international standards development organization for telecommunications is not the ITU but rather 3GPP. Created in 1998 as the Third Generation Partnership Project, 3GPP's initial goal was to avoid the fragmented mobile telecom world of the second-generation (2G) era, reflected in two different, incompatible standards, GSM (developed in Europe) and CDMA (developed in the United States). As of 2025, 3GPP is jointly run by seven telecom industry groups from multiple regions worldwide, and its stated purpose is to draft the technical specifications for global mobile broadband networks.[251] It recently completed work on various aspects of 5G and is in the early stages of developing standards for a 6G wireless world, a central focus being the implications for AI.

As of late 2025, according to one interview source, there were roughly 550 member companies and organizations participating in 3GPP, including just about every major firm related to the telecom sector.[252] The group's plenary gatherings draw well over 1,000 attendees; multiple interview sources said that Huawei often sends the largest delegations to these meetings and that the Chinese giant is likely one of the most important participants in the body. That said, each member organization has only one vote regardless of its number of attendees at any single meeting.

Another measure of China's participation is the number of leadership positions Chinese representatives hold within working groups across 3GPP's three primary work streams: core networks and terminals, radio access networks, and system and system aspects. As Table 6.3 demonstrates, 19 Chinese organizations hold leadership posts in 3GPP's 17 active operational-level groups (3 plenary bodies and 14 working groups), compared to 13 European companies in 11 groups and 12 U.S. firms in 9 groups.

China's ranks have swelled within the Institute of Electrical and Electronics Engineers (IEEE) as well. A global scholarly society for engineers, the IEEE is also a publisher and an SDO, with eight technical councils, a portfolio of over 1,000 standards, and almost 1,100 projects underway as of late 2025. The IEEE is best known for being the developer of generations of the Wi-Fi standard—also known by the relevant technical committee number of 802.11—for wireless local area networks, done in partnership with the industry consortium Wi-Fi Alliance. The engineering society was also the co-developer of Bluetooth (in its 802.15 working group) together with the Bluetooth Special Interest Group (BSIG).

Table 6.3: Leadership of 3GPP's Working Groups

| Working Groups | Core Networks and Terminals | Radio Access Network | Systems and System Aspects |
|---|---|---|---|
| Plenary | C: **Huawei**<br>VC: Airbus, NTT Docomo, **China Telecom** | C: Samsung<br>VC: **Vivo**, T-Mobile, Telecom Italia | C: Intel<br>VC: **China Mobile**, LG, Deutsche Telekom |
| WG1 | C: Qualcomm<br>VC: Nokia, Apple | C: **China Mobile**<br>VC: NTT, Ericsson | C: Deutsche Telecom<br>VC: **China Unicom**, Nokia |
| WG2 | — | C: InterDigital<br>VC: Samsung, **CATT** | C: Samsung<br>VC: Qualcomm, **Huawei** |
| WG3 | C: Ericsson<br>VC: **China Telecom**, Nokia | C: Nokia<br>VC: **Huawei**, Samsung | C: Samsung<br>VC: NTT, **Oppo** |
| WG4 | C: **China Mobile**<br>VC: **ZTE**, Cisco | C: Apple<br>VC: Qualcomm, **China Telecom** | C: **Tencent**<br>VC: Ericsson, **Xiaomi** |
| WG5 | — | C: Motorola Mobility<br>VC: Qualcomm, **CATT** | C: **Huawei**<br>VC: Ericsson, **China Unicom** |
| WG6 | — | — | C: InterDigital<br>VC: Airbus, Samsung |

Note: Chair (C) and vice chair (VC). Chinese companies are in bold.

Source: "3GPP Groups," 3GPP, https://www.3gpp.org/3gpp-groups.

Whereas voting at the ITU is by country member and at the ISO is done by "national body," voting in 3GPP is by company and in the IEEE is by individual person. As Table 6.4 shows, Huawei has far more individual members in the IEEE's working group for Wi-Fi than anyone else, giving it disproportionate weight in the working group's operations. In addition, ZTE and Lenovo have significant numbers, with a few other Chinese companies also having representation.

Table 6.4: Number of Participants from Leading Companies in the IEEE's 802.11 Wi-Fi Working Group

| Top 10 | Other Notable Chinese Companies |
|---|---|
| Huawei (79) | Oppo (17) |
| Apple (42) | TCL (8) |
| Qualcomm (41) | Xiaomi (7) |
| MediaTek (41) | China Mobile (3) |
| Samsung (41) | Hikvision (2) |
| Broadcom (36) | |
| Cisco (33) | |
| NXP Semiconductor (31) | |
| ZTE (28) | |
| Lenovo (27) | |

Source: "Working Group Members," IEEE 802.11, https://www.ieee802.org/11/members.html.

## Growing Chinese Influence

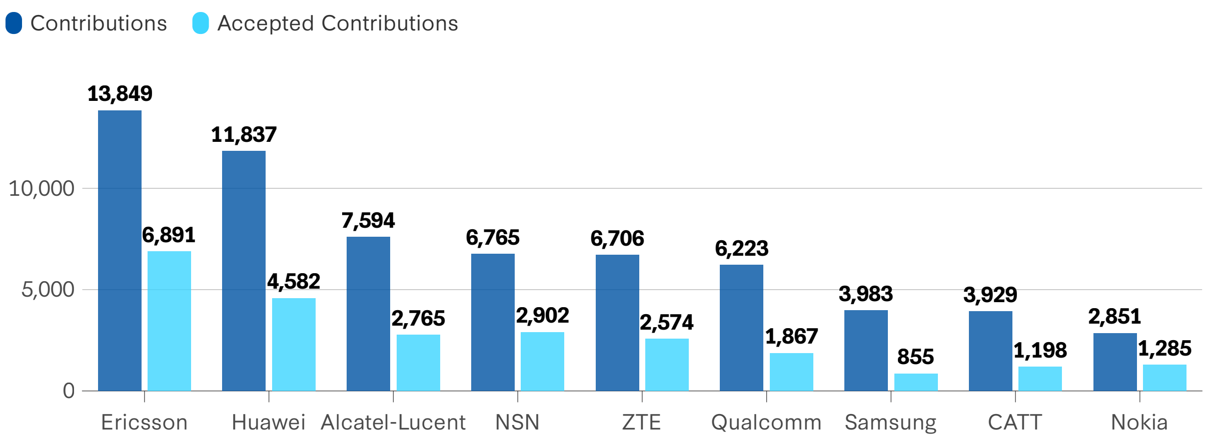
China's substantial participation in standards organizations, representation at standards-setting meetings, and holding of SDO leadership positions reflect the country's growing interest and technical expertise. However, they do not necessarily demonstrate Chinese influence in international SDOs, nor do they indicate the extent to which the actions of Chinese participants align or conflict with those of other countries. Data and information on actual influence is difficult to come by because standards committees are collaborative, and it is often difficult to trace the origins of specific proposals, why one proposal was adopted over another, or how important one idea is relative to others. This is likely why standards organizations rarely if ever provide data on the relative contribution of members to specific technical standards.

*On the basis of 5G standards, which China actively contributed to developing, China rolled out a national 5G network faster than any other country.*

One area where there has been sustained attention in tracking influence is with the development of wireless broadband standards over several generations. As noted above, China was simply a user of 2G standards: GSM and CDMA. When the world moved to 3G in the early 2000s, 3GPP and the ITU approved several versions of the foundational standard, including the Chinese version, TD-SCDMA, along with WCMDA and CDMA2000, developed in Europe and the United States, respectively. Although a breakthrough, TD-SCDMA-based networks only operated within China. When the world moved to 4G in the late 2000s and early 2010s, Chinese proposals were incorporated into a global standard, LTE; however, there were still two variants, TD-LTE (developed primarily by China) and FDD-LTE (developed mainly by others). That said, China did contribute to standards allowing for seamless interoperability (and global roaming) for all 4G-compliant networks and devices.[253] The development of 5G, the initial base standards for which were set in 2017 and 2018 and have been elaborated on in the years since, reflects a further move toward a unified set of international standards, with Chinese contributions to the process expanding further.[254] On the basis of 5G standards, which China actively contributed to developing, China rolled out a national 5G network faster than any other country.[255]

The quantitative data that does exist, as analyzed by third-party industry groups, shows growing Chinese influence on wireless broadband standards. Assembling this data is no easy task, as there are roughly 80,000 technical contributions to 3GPP each year.[256] During the high point of 4G standards development (2009–12), Huawei, ZTE, and the Chinese Academy of Telecommunications Technology (CATT) were among the top 10 contributors in terms of both overall proposals and the number of proposals accepted.[257] As Figure 6.2 shows, Huawei was the stand-out Chinese contributor, offering nearly double the number of contributions compared to ZTE and three times those of CATT and ranking second overall just behind the Swedish telecom firm Ericsson.

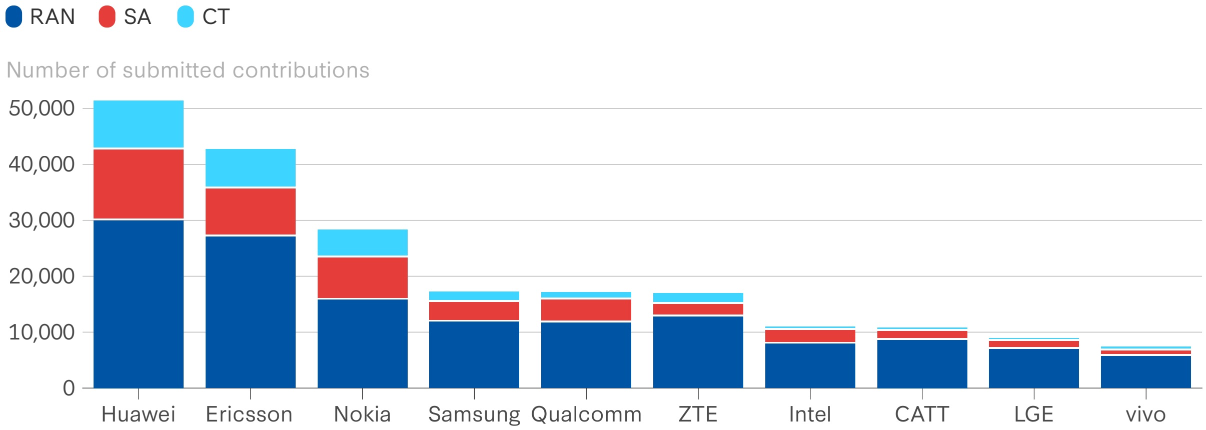
### Figure 6.2: Standards Contribution to 3GPP, Selected Companies, 2009–12




Source: "Standards Leadership within the 3GPP," ABI Research, July 3, 2013.

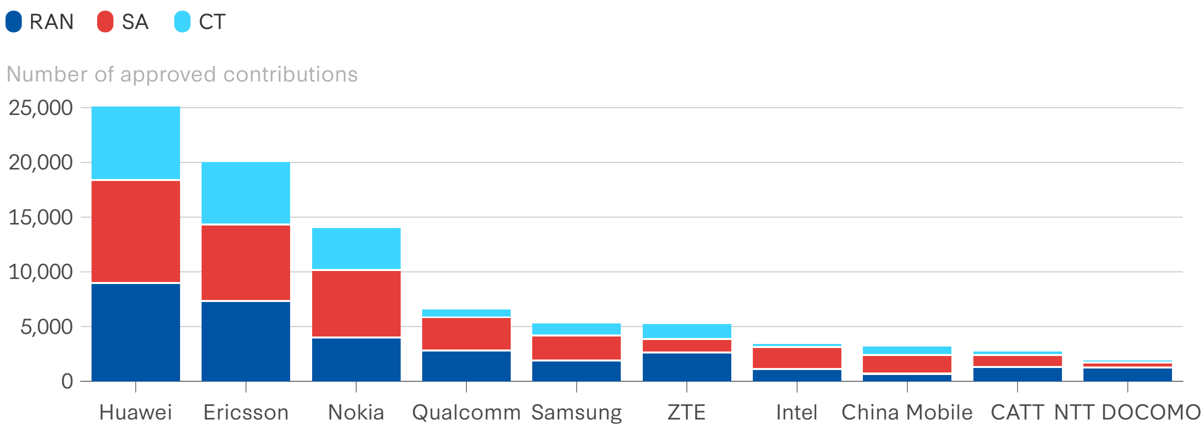
During the 5G era, Chinese companies have become even more prominent. Huawei has moved to the top in terms of numbers of both proposals and accepted contributions (see Figures 6.3 and 6.4). In addition to ZTE and CATT, private Chinese mobile phone maker Vivo (originally a subsidiary of BBK Electronics) has become a substantial participant in SDOs, with a growing number of contributions.[258]

Figure 6.3: Submitted 5G Contributions per Vendor/Operator per 3GPP TSG, 2015–2022 (H1)




Source: Omdia, *3GPP Contributions Analysis – 2022 Update* (London: Omdia, October 2022), https://omdia.tech.informa.com/-/media/tech/omdia/marketing/commissioned-research/pdfs/3gpp-contributions-analysis---2022-update.pdf.

Figure 6.4: Approved 5 G Contributions per Vendor/Operator per 3GPP TSG, 2015–2022 (H1)




Source: Omdia, *3GPP Contributions Analysis – 2022 Update.*

The number of standard-essential patents (SEPs) associated with a standard and related products are further quantitative measures of influence. SEPs are self-declared, typically early on in the standards process, and they form the initial basis for how IP rights are handled between the various contributors and users, either individually, through patent pools, or via some other mechanism. This data is controversial, as different analysts come up with different results based on alternative methodologies. A 2018 report about 5G SEPs listed Huawei fourth in the raw count of both SEPs and patent families (multiple patents that derive from a common invention), behind Samsung, Ericsson, and Qualcomm. When the analysts took into consideration multiple factors, including level of citation by others of one's patents and participation in meetings, Huawei jumped to second, just behind Qualcomm.[259] A more recent study, which accounts for contributions to 3GPP and declarations of SEPs and patent families through September 2024, reaches a similar conclusion, with Huawei and Qualcomm ranked first and second, respectively, substantially ahead of the rest of the field. Other notable Chinese SEP holders include ZTE, the China Information Communication Technologies Group (CICT) (which now includes CATT), Oppo, Vivo, Xiaomi, and Lenovo.[260]

A combination of factors likely explains China's growing influence in the field of 5G standards. Most important is the growing technical expertise of Chinese companies and research organizations. In 2024, Huawei alone spent $25 billion on R&D. China Mobile kicked in another $4.7 billion.[261] China's growing experience in international standards is also central; Chinese companies have complemented local staff with hiring of experienced talent from overseas. According to one interview source, Huawei may have a standards team of up to 1,000 people, a quarter or a third of whom are non-Chinese citizens who previously worked at Western firms. As a result of their growing experience and skills, according to another standards expert interviewed for this project, Chinese firms "use the rules to their maximum advantage." Direction provided by the government's SAC and other Chinese agencies allows Chinese participants to be relatively well organized in certain circumstances, enabling further Chinese influence. A final factor in China's growing reach is the sheer gravitational weight of the country, both due to the size and significance of its market and to the influence of the Chinese state. Being from China may give Chinese participants structural negotiating leverage that those from smaller countries lack.

## Limits on Chinese Influence

Despite the stark reality of China's mounting influence, it is important not to overstate things. In fact, China does not dominate the global world of standards by any means, and the global standards system has displayed an unexpected level of robustness despite being a theater for potential geopolitical competition.

*China does not dominate the global world of standards by any means, and the global standards system has displayed an unexpected level of robustness despite being a theater for potential geopolitical competition.*

First, it is important to highlight that worries that China would adopt a domestic standard and force it on the international system have not been realized. As of late 2025, there has not been a single case of China successfully dominating an entire international standard to the detriment of companies from the United States and its allies or Western norms. Even as Chinese contributions to mobile broadband have risen, the adopted norms are far from "Chinese" standards.

Second, the quantitative approach to counting relative contributions to standards likely overstates China's role. This may simply be because not all contributions are equal. Some Western participants believe that their own contributions, though perhaps somewhat modest numerically, are more central to the core technological elements of standards than those from Chinese participants. In the case of mobile broadband, for example, Qualcomm points to its foundational contributions to network access, antennae architecture, waveform, data encoding, power control, and data utilization. The company argues that many others, including Chinese participants, have only contributed to less central elements of mobile standards, such as improvements, optimizations, corner cases, and targeted applications (for example, IoT, connected vehicles, satellite communications, and smart factories), not to the core elements. The ultimate proof of the centrality of their own contributions, Qualcomm argues, is that it has signed far more licensing agreements for 5G than any other standards contributor.[262]

Third, to the extent that some of the increase in Chinese influence is due to acting in ways inconsistent with the common norms of SDOs, the world of standards has shown remarkable resilience and effectively resisted such challenges. This applies to day-to-day issues as well as larger challenges. Chinese participants submit a massive number of proposals, which on occasion may clearly not be of much value, or they will divide a single proposal into multiple ones to appear to be making more proposals. One interviewed standards expert reported that they have seen Chinese participants use an LLM to draft proposals, which then have hallucinations in them (citations to non-existent publications); when others have pointed this out, the Chinese participants again used an LLM to respond to the critique. There also was a case at the IEEE of Huawei trying to make a company manager a voting member despite the individual not having the technical wherewithal to understand the issues.[263] In all these instances, the other participants have patiently, yet directly and effectively, pushed back. Junk proposals are routinely dismissed, and unqualified staffers, including in the IEEE case, have been kept out of groups.

Other participants have also been able to successfully fend off as what they see as more serious challenges to the governance norms of SDOs. As noted above, Chinese participants have substantially increased their presence and role at the ITU, particularly within ITU-T. In interviews, Western industry observers have pointed to a growing flood of contributions from Chinese participants and the weak governance norms of the institution that have reduced its legitimacy in the eyes of some. In frustration, several important Western corporate participants withdrew from the ITU in 2020–21 and stopped contributing to their standards or referencing them in products. Instead, the Western corporations placed more attention and value on other international SDOs that they characterized as having stronger governance norms, particularly the standards committees under the ISO-IEC's Joint Technical Committee-1 (JTC1). This has not meant participating only where Chinese representatives are absent, but rather focusing on environments where the rules and norms are vigorously implemented to ensure fairness. Western companies argue that chairs must be agnostic and unbiased, that the process must be open and expert-driven, and that there must be an appeals process which participants can (and do) use to complain.

Interview sources cite the ISO-IEC JTC-1 standards committee on AI (SC42) as a positive example for SDO resiliency. SC42, whose secretariat is hosted by the American National Standards Institute (ANSI) in Washington, D.C., sets general AI governance standards for enterprises, for example, on risk management, bias, transparency, the general characteristics of AI, and interoperability. Created in 2017, the committee runs well even though its chair, Wael William Diab, works for Futurewei, an arm of Huawei that operates in North America.[264] All of that is to say that the norms of SDOs and the existence of a large ecosystem of such groups makes it extremely difficult, if not impossible, for any single participant, including China, to manipulate them to the detriment of everyone else. When such behavior is found, others have been able to successfully adapt.[265]

Fourth, to ensure that there are no standards that would undermine the national security of the United States and other Western governments, there often are experts from Western intelligence agencies who attend international standards meetings, including officials from the intelligence community, national security agencies, and economic policy offices. This includes 3GPP and ISO-IEC JTC-1 working groups. These experts typically do not make proposals, but they are able to spot proposals from China or others that might directly harm Western national security interests.

Finally, despite a strong government presence and clear efforts to steer participation, the diversity of Chinese commercial interests prevents the consistent alignment of positions by Chinese companies, further limiting overall influence by China. Instead, observers note a diversity of views and positions not only within standards bodies but also in subsequent activities related to managing IP rights, product design, and business strategy. One interview source went so far as to suggest that Chinese companies may not only see Huawei as a rival but also as a firm on which they want to minimize their dependence. Strong ties with Western companies help to achieve this goal.

The developments surrounding audio and video standards—what are called "codecs"—illustrate how competing commercial interests among Chinese corporations preclude the creation and implementation of a single Chinese standard. Some Chinese companies have supported the creation of a Chinese standard, AVS, but many others, particularly downstream users such as device makers, have preferred to align with and use codecs developed primarily in the United States and Europe, including the various versions of MPEG, which have been codified in the ITU and global industry consortia. At a minimum, these latter Chinese companies choose to endorse several standards and to participate in multiple patent pools in order to hedge their bets and keep their technology and business options open. In this regard, their behavior is consistent with typical ICT companies from around the world.

## The Unintended Consequences of Attempted Isolation

Ironically, one source of China's potential strength in the standards world centers on the unintended consequences of U.S. government efforts to isolate and slow Chinese technological advances. The most significant action in this regard may be the May 2019 decision to put Huawei on the U.S. Commerce Department's Bureau of Industry and Security (BIS) Entity List, a central tool in the United States' export control playbook. Adding Huawei to the list may have been justified on national security grounds or as a way to help Western telecom firms gain commercial advantage, but policies always have trade-offs. In this case, the decision has had negative consequences for U.S. leadership in technology standards, which could potentially weaken Western technological leadership more broadly.

The Entity List action, which specifically cited the risks to international standards bodies, put U.S. companies and others at risk of violating U.S. export control laws if they shared sensitive, non-public information with Huawei in international SDOs. The original announcement was accompanied by a "temporary general license" to permit continued limited interaction with Huawei in several international standards organizations developing 5G standards, but it set such high conditions for compliance that U.S. participants interpreted the rules as creating serious risks if they interacted with Huawei in these groups at all. Several months after the initial announcement, the Commerce Department updated its guidelines, eliminating the original exception permitting exchanges in the context of 5G standards, thereby confirming U.S. participants' earlier fear and raising the risks even further.[266]

Amid the U.S. government's actions, at least four organizations—the IEEE, Wi-Fi Alliance, Bluetooth Special Interest Group (BSIG), and SD Association—took actions against Huawei. The IEEE announced that Huawei representatives could continue to participate individually in their standards work but that representatives from the Chinese company could no longer serve as editors or reviewers of IEEE publications. The Wi-Fi Alliance, BSIG, and SD Association went further, suspending Huawei's membership and participation entirely.[267]

Given the uncertainty in standards organizations resulting from the U.S. government's May 2019 decision, Google announced that it would cut off new Huawei smartphones and other devices from using its Google Mobile Services, thereby blocking those devices—and their users—from Google's Play Store, YouTube, and Gmail accounts. Although Huawei could continue to use the open-source version of Android, doing so immediately became less valuable when the company's customers could not access Google's proprietary services and extensive ecosystem.

In the case of the standards bodies, none of the participants were happy with either themselves or Huawei being constrained. Western companies did not believe that their actions warranted restrictions because they do not share proprietary secrets in standards meetings. Moreover, Western companies feared that isolating Huawei could result in the fragmentation of the global standards system and all of the technology ecosystems built on them. Within days of their initial decisions and in response to complaints from all sides, the four groups mentioned above reversed their suspensions of Huawei completely. In contrast, it took several years for the U.S. government to sufficiently water down its warning to Western participants, with the Biden administration issuing revised guidance in 2022 and 2024.[268]

These policy actions by the U.S. government had two significant negative consequences. First, Western participants temporarily limited their own involvement in some standards organizations for fear of being hit with civil and criminal penalties. This meant fewer proposals, less engagement, and reduced influence by Western companies. Second, Huawei concluded that being locked out of standards bodies would slow its own product development and leave it 6 to 18 months behind its competitors. Moreover, because Huawei could not be sure how long restrictions on participation would last, the Chinese company decided to invest in a series of technologies less dependent on Western providers and to be more assertive in developing alternative standards.

Three developments deserve highlighting here. The most well known is Huawei's development of HarmonyOS, an operating system—and its related ecosystem—that could run its devices, given the limited access to Android and the denial of access to Google Mobile Services.[269] The initial version of HarmonyOS was built on top of Android, but the 2024 edition, HarmonyOS 2, which premiered with the Huawei Mate 70 Pro, is entirely separate from Android and supported by an ecosystem of tens of thousands of apps. As of late 2025, the latest versions of HarmonyOS were running on 36 million Huawei devices.[270] Although only a de facto standard, the result was the emergence of a third mobile operating system to rival Android and Apple's iOS.

Less well known than its HarmonyOS, but potentially equally consequential, is Huawei's effort to develop NearLink as a single alternative to at least Bluetooth and possibly also Wi-Fi, an effort it launched simultaneously with HarmonyOS. Huawei began development of NearLink in 2019, then spearheaded the issuance of an association-level standard within China in 2022 and created the SparkLink Alliance to develop support from the wider global industry.[271] Technically, NearLink could feasibly replace both Bluetooth and Wi-Fi, but one industry interview source said the main target has been Bluetooth, a 30-year-old technology which has high latency, making it increasingly problematic for users; by contrast, Wi-Fi has repeatedly improved and should be even better with the upcoming release of Wi-Fi 8.

Huawei's NearLink initiative is reminiscent of WAPI, the Chinese alternative to Wi-Fi proposed in 2003, discussed above. That effort failed miserably, as China tried to mandate use of WAPI even though it was opposed by almost all industry leaders, including top Chinese companies such as Lenovo. There is no guarantee NearLink will fare much better. Given the strong network effects that accrue to entrenched technologies such as Bluetooth and Wi-Fi, change would require either buy-in from a large part of the global industry or the technology would have to gain initial dominance in China and then be forced on others, no easy feat even for a company as massive as Huawei, even if the Chinese government made this a priority. Nevertheless, these potentialities need to be taken seriously. The Chinese government is currently developing a national standard for the NearLink technology, and Chinese representatives have been able to get consideration of the technology on the agenda of ITU-T. Equally important are the reach of Huawei's existing technologies and ecosystem and its progress in attracting other companies in Europe, Japan, and elsewhere to include a NearLink option in their devices.[272] What is currently a potential backup could gain steam if Huawei is further isolated or if there is broader technological fragmentation in other areas that then makes NearLink a more viable (and necessary) alternative.

As a final reaction emerging from the original effort to isolate the company, Huawei and other Chinese ICT firms have sought to foster the growth of industry-based standards consortia groups in Huawei's hometown of Shenzhen. Most standards consortia with a global reach, such as the Wi-Fi Alliance or BSIG, are based in the United States or Europe. China seeks to change this. Interviews suggest that an important incentive for establishing these groups in Shenzhen is that they are outside the United States and not subject to U.S. jurisdiction, including its export control rules. In addition to the SparkLink Alliance mentioned above, other groups include the UHD World Association, the Global Intelligent Internet of Things Consortium, the Network Innovation and Development Alliance, the Global

Computing Consortium, and the World WLAN Application Alliance. Most of these groups' members are Chinese, but they do have members from elsewhere in Asia and Europe.[273] If this minor development becomes a major trend, it would be another step toward fragmentation of the standards world.

## Conclusion

Chinese influence in the setting of international standards has grown in a manner consistent with the expectations of this study's key analytical question about the implications of China's expanding technological capabilities. Decades of experience and a large domestic market have been valuable sources of growing influence for Chinese participants in standards-setting bodies, but these complementary sources of influence would mean little without the foundational strength provided by the progress of Chinese companies and research organizations. Given China's continued investment in R&D and the complementary spillovers among industries, one should expect Chinese influence in international standards, especially in ICT, to continue to grow.

There are several major standards initiatives underway that will have a huge effect on technological innovation and leadership in the coming decades. For one, 3GPP and the ITU have recently begun work on 6G standards, which will focus heavily on integrating AI into mobile broadband, and early signs are that Chinese participation is as high as ever. In addition, some Chinese companies have become big players in the O-RAN Alliance, an industry group which was originally conceived to develop software-based solutions to facilitate interoperability among different telecom equipment vendors as a way to get around Chinese dominance of telecom hardware.[274] Chinese technology firms and research organizations have also become substantial participants in RISC-V International, a group dedicated to developing instruction-set architectures for processors that are not dependent on the two proprietary (and dominant) versions provided by the British ARM Holdings and U.S.-based Intel. The organization, which was originally created in Berkeley and moved to Switzerland in 2020, has over 4,500 members from 70 countries.[275] One could imagine Chinese participants will want to increase their contribution to the various elements of 6G standards, ensure any kind of solution by the O-RAN Alliance does not hurt the interests of Chinese telecom equipment firms such as Huawei, and help promote semiconductor architectures less dependent on the current dominant incumbents. Observers should expect the same across the globe. With intensive participation from tech leaders worldwide, it is impossible to predict the outcomes in advance.

*Ironically, the least effective way that the U.S. government has responded to growing Chinese influence has come from efforts to constrain Chinese participation.*

The story of technology standards shows that there are limits to Chinese influence. Quantitative data may overstate the value of Chinese contributions, and the global standards ecosystem has displayed a high degree of robustness in resisting certain kinds of behaviors—such as an overabundance of poor submissions or coordinated voting—that would otherwise undermine key governance and unfairly threaten the interests of Western industry and governments. Moreover, the diversity of Chinese commercial interests serves as a reminder that even in today's China there remain substantial tensions between a techno-nationalist policy orientation and the actual behavior of industry actors.

Ironically, the least effective way that the U.S. government has responded to growing Chinese influence has come from efforts to constrain Chinese participation. Attempting to isolate Huawei from standards bodies, even though only temporarily enacted, actually generated pressures and incentives for technological fragmentation, an outcome that would necessarily reduce the coverage of international standards and unintentionally undermine the leadership position of U.S. and other Western technology firms.

These trends in China's influence on international standards, the nature of the standards ecosystem, and the effect of U.S. policy steps to date have important implications for U.S. policy choices going forward. These are the subject of this report's final chapter.

# Chapter 7

## *Calibrated Coupling*

This report seeks to answer a core question: Is there a relationship between China's technological trajectory and its international power? The answer is a clear "yes." China's innovation ecosystem and overall performance have improved dramatically, and these improvements are reflected in progress in its military-civil fusion (MCF) initiative and its efforts to increase its influence in international technical standards development. At the same time, progress is far from uniform, with weaknesses in various industries, MCF, and international standards. Progress in these areas falls short of Chinese policymakers' aims and Western governments' fears. As a result of these mixed technological outcomes, the key thread tying together this report's policy advice is for the United States to develop a robust view of technology leadership and then adopt a multifaceted policy approach, with focused efforts to promote its technological advancement and properly calibrate the extent and nature of interdependence with China. The precise mix of tactics needs to account for China's growing overall prowess, its variation in performance across industries, and the mix of opportunities and risks that exist in different policy domains. Equally important, an effective strategy must be built on collaboration with many other countries.

### General Findings

Claims that Chinese industry cannot innovate no longer hold water. As this report shows, quantitative data that tracks trends over time and in comparison to others, observation of Chinese companies and research organizations, and the testimony and behavior of multinational companies (MNCs)—their growing yet grudging praise of their Chinese competitors and the value they see in conducting research and development (R&D) activities in China—all speak unmistakably to genuine progress over the past two decades. Yet this progress is far from perfect or uniform. Weak institutions, continued support for state-owned enterprises (SOE), and an inefficient financial system all hamper innovation and slow growth. This is visible in sectors with substantial overcapacity, such as the electric vehicle (EV) industry, and in industries that have struggled to gain ground on the world's leading incumbents, such as in commercial aircraft and advanced semiconductors. This overall pattern of constrained progress is likely to be an ongoing feature of China's technological trajectory.

This mixed picture is reflected in different elements of China's international power and influence. Claims that China is either inevitably rising or has already peaked do not align with the evidence presented here. Instead, more nuanced assessments that identify substantial strengths, limited by certain persistent weaknesses, seem more accurate. The Chinese military's capabilities have been aided by commercial contributions in a variety of areas, such as AI, space, drones, and renewable energy; however, MCF does not appear to have had much direct appreciable impact on Chinese weapons systems, and progress has been hampered by continued unease in relations between the People's Liberation Army (PLA) and commercial industry.

Similarly, China has become a heavyweight actor in international technical standards development. Chinese contributions to standards have risen with each generation of mobile broadband, and Chinese companies are poised to provide significant leadership in standards for sixth-generation (6G) mobile technology and its implications for AI. Yet Chinese firms are not outright dominant in this sphere; although they have contributed substantially to many international standards, Chinese companies have not forced a single domestic technical standard on the rest of the world or substantially changed the governance norms of the international standards regime. This is due to the continued technological advances made by others and the resilience of the standards system to maintain its core character of open, voluntary, and consensus-based standards, even in the face of substantial challenges. To the extent China may be trying to revise the basic norms of technical standards regimes to more closely align with its domestic governance system, it has not been successful.

These findings have enormous implications for the policy options of the United States. The overall challenge for the United States is how to deal with a technologically more capable—though not dominant—China with growing international influence in an era characterized by both deep strategic rivalry and extensive interdependence between the two countries. Effectively tackling this challenge involves coordinating solutions to three interrelated problems: (1) developing a robust view of technological leadership; (2) determining the extent to which the United States should adopt industrial policy to improve its competitiveness; and (3) deciding how the United States should view and act on the risks and opportunities that are a product of its deep interdependence with China. Of course, in all three issues, figuring out how to effectively cooperate with like-minded countries is crucial to success. The discussion below sets out general principles for how to address these challenges, then applies the insights to the specific sectors and the issue areas of MCF and standards discussed in earlier chapters.

## Technological Leadership

The Biden administration set as a central goal of its technology policy "to maintain as large a lead as possible." Although initially discussed in the context of export controls (which previously had developed a "sliding scale" approach of seeking to remain one to two generations ahead), this philosophy animated the administration's view of technology advancement more broadly.[276] Similarly, the second Trump administration has stated that its aim is "unrivaled world leadership in critical and emerging technologies."[277]

*The United States is no longer in a clear position of universal technological leadership relative to China.*

The first obvious conclusion to draw from this report's findings is that the United States is no longer in a clear position of universal technological leadership relative to China. China is ahead in some areas (e.g., EVs and solar), a peer in others (mobile phones and AI), and gaining ground quickly in still other areas (e.g., pharmaceuticals). Hence, it is no longer tenable for the core question animating American technology policy to simply be how the United States can maintain its leadership when that leadership no longer exists in a range of sectors.

Moreover, the goals as stated leave ambiguous two important issues. The first is whether leadership should only be measured in relative terms (especially relative to just China) or in absolute terms. If only relative position matters, then it is appropriate to use any means necessary to keep that lead even if some of those tactics may also slow down the United States. By contrast, if overall absolute progress in technology is important, then any policies that could inadvertently slow oneself down should be discarded even if they also slow down China's progress. To use a basketball analogy, the United States could beat China by a score of 8-6 or 80-78; in either case, the margin of victory would be two points, but the nature of the game and quality of play would be different. This report would argue that winning in a high-scoring game is far more preferable than in a low-scoring game. That is, it is as important, if not more, for the United States to achieve major advances in technology as it is to do better than China.

Second, it is important to have a clear sense of the components of technological leadership. Most often the emphasis has been on being at the cutting edge of individual areas of science or technology. But if the analysis of China's progress teaches observers anything, it is that technological leadership includes at least three other essential features: a vibrant innovation ecosystem, the ability to massively scale production, and well-developed pathways to diffuse the technology to users at home and abroad.[278] Focus on the cutting-edge, particularly when technology is viewed through a foreign policy lens, is common because being at the cutting edge is most closely tied to immediate questions of national security. While true, the other components of technology leadership are, indeed, relevant to national security. A strong ecosystem is critical for a country's national economic foundations; manufacturing is central to being able to produce weapons systems, dual-use technologies, and other goods and services that help in both war and peacetime;

and diffusion is vital to generating revenue for American innovators and having as much of the world operate within the U.S. technological ecosystem as possible. In that regard, again, to use the sports analogy, the U.S. team not only wants to win high-scoring games, it wants games to be played within its stadiums.

Understanding that the United States is not ahead in many technologies and that technological leadership is about more than relative position means that there are potentially difficult choices policymakers need to consider. Choosing policies that advance U.S. technological progress are as important, if not more, than ones that slow down China. Although policies meant to slow down China's technological progress in the context of its military preparedness are necessary, policymakers need to be aware of the trade-offs in terms of the effects on the United States' own progress that such policies may entail. In addition, it is also clear that promoting the different components requires different sets of policies and that they are not always mutually supportive. It is important to ensure that foreign adversaries do not gain access to America's technological crown jewels; at the same time, it is also vital to attract high-quality talent from China and elsewhere to study and work in the United States to help foster innovation. Finding the right balance when elements of technological leadership seem at odds with each other is critical to an effective approach.

## Industrial Policy Options

With a clearer sense of the goals of technological leadership and the potential trade-offs among different approaches, the second policy question for the United States is to decide to what extent it should adopt industrial policy, which tools it should use, and how it should measure progress. Because China is such an infamous user of industrial policy and some believe markets left to their own devices will not propel U.S. technological advancement quickly enough, the United States has begun to employ industrial policy, and calls for shifting away from a free-market approach to one more dependent on government intervention are growing.

The Biden administration enthusiastically embraced industrial policy as a key component of its efforts to strengthen U.S. technological progress. The CHIPS and Science Act, the Inflation Reduction Act (IRA), and other measures focused first and foremost on expanding government funding and encouraging greater private sector investment in certain areas of science and technology. It also imposed high tariffs on a select number of products (e.g., semiconductors, EVs, batteries, and solar cells).[279] The second Trump administration heavily backed off on most of the industrial policy initiatives that involved U.S. federal government spending. Instead, it has focused on a combination of extremely high tariffs and pressure on businesses and financial institutions from foreign countries to invest in high-tech sectors in the United States.

*It is also clear that some of China's successes have been despite its use of industrial policy, not because of it.*

Those who conclude China's recent progress is largely due to industrial policy also tend to advocate for the wide adoption of more active industrial policy by the United States.[280] The current study finds a more mixed record of industrial policy in China, with overall progress but also tremendous waste, growing debt, and a surprising number of failures. It is also clear that some of China's successes have been despite its use of industrial policy, not because of it. Chinese private automakers, such as Geely, jumped into the industry in defiance of central government policies blocking new entrants. BYD originally focused on batteries for laptops and mobile phones, with batteries for cars being an afterthought.

There are three positive elements of China's industrial policy that emerge out of the current study that the United States can draw on:

1. Sufficient spending and regulatory support for well-chosen targeted sectors, which conveys a consistent policy commitment to attract potential investors and businesses.
2. The building and utilization of technology clusters and hubs with various components from the entire ecosystem, which facilitates tacit learning, innovation and scaled manufacturing, and the transfer of spillover benefits to multiple sectors.
3. The consistent diffusion of technologies across the economy to businesses, households, and government, both at home and abroad.

That said, given China's uneven record, it would be a mistake for the United States to copy China's entire industrial policy playbook. China spends far more than the United States could afford; the United States would need to expand industrial policy spending tenfold as a percentage of GDP to rival China. Moreover, too much funding in China goes to politically favored firms and industries, and corruption is endemic. While it may have broadly greased the bureaucratic wheels in the early reform era to promote growth, it is likely that corruption has become a substantial drag on growth, led to a rise in inequality, and eroded popular support for the government.[281] Furthermore, China's highly nationalistic framing of industrial policy has led to excess discrimination against foreign industry, slowing its overall technological advancement and creating unnecessary diplomatic fights.

As a result, to the extent the United States utilizes industrial policy, it would be wise to draw on the experiences of other, smaller countries who have used industrial policy with a higher rate of success. Key lessons include the following:

1. Do not aim to win the industrial policy spending race; instead, aim to help critical industries make progress.
2. Invest in all four areas of technological leadership: the cutting edge, the ecosystem, manufacturing, and diffusion.
3. Make support highly targeted on key priorities, for firms to either catch up to competitors or to develop unique technological advantages that have market potential at home and abroad.
4. Provide support based on clear criteria and only to recipients who can prove they will use the support effectively.[282]

## Managing Interdependence: From De-Risking to Calibrated Coupling

With regard to interdependence, the original view underlying the long-pursued strategy of engagement with China is that building deep economic and social connections between the two countries would inevitably bring economic and security benefits to the United States (and China) by pushing China to integrate into the international rules-based order and align its domestic and international behavior to be less antagonistic to Western interests and norms. Over the last decade, a growing number of voices concluded that this strategy has failed, mainly because China itself decided to pursue a non-integrationist approach by seeking primacy in Asia and began promoting an international order that would be supportive of authoritarian, mercantilist countries like itself.[283]

As a result, the original assumptions justifying engagement have been turned on their head, and the dominant view has become that interdependence with China offers few benefits and comes with substantial economic costs and national security risks. These costs are frequently cited in the context of advanced technology because of a variety of dangers, including technology leakage (particularly dual-use technologies), the overreliance on China as a source of inputs (such as rare earths or active pharmacological ingredients) or as a market for products, and potential threats to the West's data security. A corollary of this conclusion has been to advocate for policies aimed at attenuating the relationship in order to reduce U.S. vulnerabilities.

In the first Trump administration (2017–21) and early Biden administration (2021–23), policy analysts and officials primarily used the terms "disengagement" or "decoupling" and occasionally added modifiers—such as "partial," "managed," or "strategic"—to stress they were not advocating for a complete ending of ties.[284] In March 2023, European Commission President Ursula von der Leyen put forth the concept of "de-risking," which she differentiated from decoupling by emphasizing that the goal was not to isolate China and fragment the global economy and that ties should be maintained where the risks from overdependence and other economic security risks could be mitigated.[285] Although "decoupling" still surfaces occasionally, de-risking has since become the dominant framework.[286]

On this basis, the Biden administration and both Trump administrations have taken a variety of steps to ameliorate a range of risks to advanced technologies. These include: (1) high tariffs on EVs, batteries, solar cells, semiconductors, medical products, and other items; (2) an expansion of the number of Chinese companies on the U.S. Department of Commerce's Bureau of Industry and Security (BIS) Entity List and the creation of the Pentagon's list of PLA-related companies; (3) studies on the supply chain vulnerabilities of several industries, followed by initiatives in several of them, particularly rare earths and other critical minerals; (4) expanded limits on Chinese investment in the United States; (5) an information and communications technology and services (ICTS) initiative to protect the United States against data security risks from adversaries, including a rule regarding connected vehicles from China and Russia; and (6) restrictions on the provision of advanced semiconductors and semiconductor equipment to China.[287] Although such restrictions may be needed and are a necessary course correction to unfettered engagement, overreliance on such defensive measures reflects an incomplete understanding of the risks and opportunities in the relationship, particularly given China's recent advances–and could make the underlying problems worse, not better.

The evidence from this report shows that a defensive approach that stresses reducing ties may not sufficiently appreciate the difficulties and risks that are accompanied by focusing on strategic decoupling or de-risking. First, implementing such a policy is extremely difficult because of the existing deep interdependence and complexities of the technologies themselves; it invariably generates new tensions between policymakers and industry and between the United States and other countries involved in the value chains. Second, it is challenging to achieve the targeted level of technology denial and de-risking that one is aiming for. There is a tendency for restrictions to end up going far beyond one's original plans, because policymakers did not originally recognize where restrictions should be placed, because of how industry responds, or because of the tit-for-tat dynamics between the United States and China. The Biden administration said that it was pursuing a "small yard, high fence" strategy, meaning it would put heavy restrictions on a small number of discrete technologies.[288] It started that way, but by the end of the administration, restrictions had expanded from the most advanced semiconductors to legacy chips, and then to the entire auto industry.

The third risk is for the strategy to backfire and, instead of slowing China's progress, unintentionally incentivize Chinese industry to make advances faster than it otherwise would.[289] Although in the short run, it does appear that restrictions on semiconductors and semiconductor equipment have slowed China's progress in "compute," Chinese investment has ramped up rapidly, and there are signs that Chinese firms are making progress in GPUs, memory, and some areas of equipment, none of which are on par with world leaders but could eventually be adequate substitutes. In addition, restrictions on advanced chips have pushed Chinese firms to emphasize legacy chips, expanding their market share there and hurting the bottom lines of Western firms. Restrictions on the American market are also pushing China to expand exports and investment to other parts of the world, and this may end up propelling China to technological leadership in wide swaths of the globe.

The fourth and final risk of a de-risking strategy is that even if it is possible to reduce connectivity with China and be less dependent on its inputs and markets, there is no guarantee that China will alone be isolated and that the United States will remain highly integrated with the rest of the world. It is equally possible that either the global economy will fragment or that it will be the United States, and not China, that grows more isolated. Although there is great anxiety in other countries about expanding Chinese exports and investment, countries do not appear to be adopting sufficient policy measures to slow that trend. In sum, the chances of a de-risking strategy backfiring are quite high.

Conversely, a strategy centered around technology denial and isolation also ignores the benefits of properly managed connectivity in advanced technology.[290] These include: (1) sales to Chinese customers that generate revenue that is plowed back into R&D, leading to further innovations; (2) maintenance of U.S. technology leadership by keeping Chinese industry within Western-led ecosystems; (3) access to technologies in those parts of the value chain where China has an advantage and which could be a *part* of a solution to accelerate U.S. industrial progress; (4) access to China's large pool of talent to help aid the United States' innovation drive; (5) pressure from

China's demanding business and household customers to improve one's products and services; (6) the ability to benchmark China's technological capabilities because of continued competition and cooperation; and (7) maintenance of leverage and the ability to impose costs on China when it threatens economic coercion or other measures against the United States and its allies.[291]

Aside from neglecting these benefits, there may be other misconceptions about a strategy based on properly calibrating the level of connectivity in advanced technologies to maximize U.S. interests. The first is to mistakenly see this as a conflict between narrow business interests and U.S. national security. Holding this assumption would overlook the clear national security elements of the above benefits, including advancing American technological innovation, being able to benchmark China's technological capabilities, and maintaining leverage on China.

The second is the notion that efforts to keep China connected are doomed to fail because China is fully committed to a strategy of technological self-reliance. This overstates the ease with which Chinese leaders can translate policy into commercial behavior and technological success. Remaining connected and being a reliable supplier (of technologies that do not directly aid China's military) make a self-reliance strategy harder to implement. Chinese companies have been less inclined to invest in replacement technologies when better foreign options are available, a price that goes up because of how network effects raise the value of using (and costs of switching away from) incumbent technologies. In addition, even if it is not possible to stop China from developing domestic alternatives, any progress in delaying such a switch would benefit American technology providers and extend the time Chinese industry operates within Western ecosystems.

The third misunderstanding is the assumption that maintaining ties through technology requires high levels of trust, for example, taking Chinese interlocutors on their word that they will not repurpose U.S. technology for military purposes, engage in economic coercion, or inappropriately acquire and abuse Americans' data. Although not foolproof, there is a variety of mechanisms U.S. policymakers and industry can use to bridge the trust gap that now undergirds the relationship. These include: (1) export control onsite verification inspections; (2) detailed reviews by the Committee on Foreign Investment in the United States (CFIUS) on Chinese investments that raise potential national security risks; (3) requirements for Chinese investors in targeted industries to agree to joint ventures with U.S. majority ownership and technology transfer to their U.S. partners; (4) vigorous data security rules for Chinese investments in the United States with regard to data collection, storage, and use; (5) review of Chinese products with any China-based software; (6) tracking tools to ensure U.S. technology is not misused or transferred without approval, including digital watermarks on semiconductors and embedded coding on videos made using AI; and (7) highly detailed global monitoring of supply chains for internationally traded products to serve as an alarm system to identify overdependence on China as well as alternative supplier options. There are practical solutions in each of these areas. Of course, where the trust gap cannot be bridged, some form of de-risking would likely be the necessary choice.

The variance in circumstances in different industries and issue areas means that the United States and its allies need to make iterative choices with regard to industrial policy and managing interdependence with China. That is why this strategy, most broadly conceived, might most appropriately be called “calibrated coupling.”[292] The United States should adjust the nature and extent of the relationship to best serve American interests based on the particular circumstances that exist in different sectors and issue areas.

Without endorsing any specific decision, the Trump administration’s approach to TikTok and its decision regarding the sale of certain kinds of advanced GPU chips from Nvidia and AMD could potentially be viewed as aligned with this perspective. The administration pushed the transfer of TikTok’s ownership and other regulatory constraints to help address the underlying trust gap.[293] And it appears to have approved sales of certain chips to Chinese buyers provided that stringent requirements are met to help maintain the United States’ technological advantage while also not simultaneously supporting the development of China’s most advanced AI models, which could benefit its military.[294] That said, these two individual policy steps—which could be portrayed as self-serving to the administration and its allies or, alternatively, as unworkable in practice—do not add up to a clear and consistent strategy.[295]

## Applying Industrial Policy and Calibrated Coupling to Priority Sectors

The next step is determining how to apply these general insights about targeted industrial policy and calibrated coupling to the industries and issue areas analyzed for this report.

This study has illuminated China’s mixed record of success using an across-the-board approach to industrial policy, suggesting such a strategy would be detrimental for the United States to follow. It likely makes sense to focus on strategic sectors that will be engines of future growth, aid national security, and reduce vulnerabilities from overdependence on others. The U.S. federal government has identified an evolving list of such technologies over the years.[296] Another potentially valuable approach is to focus on potent leapfrog technologies that could potentially yield outsized gains and where China and others have yet to put their full attention, such as semiconductors based on materials other than silicon or various forms of breakthrough energy sources.[297] This report suggests combining these various insights by focusing on key forward-looking sectors, including those where Chinese entrants have already created disruption, but not losing sight of other areas where there is potential for the United States to extend its lead even further.

Recalling the four categories of industries analyzed in Chapter 4 (see Table 4.1), industrial policy and substantial restrictions on connectivity are likely not necessary, or less so, in sectors where China has achieved “conforming success” (e.g., pharmaceuticals and smartphones) or where the result for China has been “conforming failure” (e.g., aircraft manufacturing). In such industries, Chinese activity has not caused market failures, which are usually an important precondition for justifying extensive government intervention. Moreover, from an economic perspective, these are also industries where radical decoupling between the United States and China, or even substantial de-risking by imposing significant conditions on connectivity, would not be necessary. In these industries, doing business with China has not resulted in the loss of U.S. competitiveness or harm to the industries’ overall trajectories. To the contrary, the opposite has been the case. Chinese progress in biopharma so far has been helpful to the United States by providing, first, support for clinical trials and, second, developing new innovative drugs that have then been licensed to Western firms, who then bring them to market. That said, there may be a need in such sectors to impose some kinds of constraints or guardrails for economic security purposes, for example, with regard to data security (e.g., in the context of clinical trial data), supply chain diversification (e.g., for active pharmacological ingredients), or avoiding technology leakage (e.g., for jet engines).[298]

By contrast, U.S. industrial policy to promote technological advancement and protect a competitive landscape is particularly needed in areas where China has achieved "disruptive success," such as EVs, solar, wind, and telecommunications equipment. It may also be helpful in areas of "disruptive failure" (e.g., advanced semiconductors), where Chinese industrial policy may be creating global distortions and distracting leading firms from focusing on over-the-horizon innovations. The kind of industrial policy response depends in part on the source of this disruption, whether it be from subsidies and other support that allow Chinese firms to sell at unreasonably low prices or technological breakthroughs that challenge existing technologies and business models. In many of these industries, both sources of disruption exist, requiring a multilayered approach that likely includes steps to: (1) de-risk from unfair competitive distortions, overdependence on China, and data security vulnerabilities; (2) utilize the innovation benefits of being connected to China; (3) invest with like-minded countries in potential leapfrogging innovations; and (4) support the widespread diffusion of technological products and services as widely as possible at home and abroad.

For example, in the case of EVs, and the auto sector more generally—since at least half of Chinese auto exports are still internal combustion engine (ICE) vehicles—it is entirely appropriate for the United States and others to impose tariffs high enough to counteract extensive dumping by Chinese car companies. To avoid an escalatory spiral of tariffs (with China and others) and maintain the legitimacy of such restrictions, it would be best for the United States to impose rates based on actual levels of dumping or subsidization (as the European Union has done), as opposed to arbitrarily setting extremely high tariffs meant to block sales altogether.[299] Price undertakings, such as those being considered by the European Union, or quotas, such as those set by Canada in January 2026, are also possible options.[300]

*U.S. companies need to find pricing and distribution strategies to accelerate the popularization of their technologies. Otherwise, they will be outflanked by China and other competitors, and the American public's support for industrial policy and these companies' products will wane.*

Although the market in China is shifting in the direction of domestic producers, it is still valuable for MNCs to be there to partner with Chinese companies in different parts of the supply chain, produce and sell in the market, and use China as an export platform, particularly in the Indo-Pacific. The United States can also explore opening up to Chinese exports (with tariffs or quotas still in place) as well as Chinese investments in joint ventures controlled by their American partners and that come with technology transfer. Although there are potential data security risks covered by the ICTS rules on connected vehicles, Peter Cowhey of University of California-San Diego has outlined a credible approach to mitigating such risks, akin to the TikTok solution and the requirements for Tesla in China. Beyond the ownership and technology transfer requirements, this would also include local data storage, only processing anonymized data related to the car and its passengers, and use of U.S. technology systems for data collection, mapping, and global positioning (GPS or Starlink).[301] Equally important would be for the industry to aggressively pursue innovations in multiple systems related to the vehicles, including energy and propulsion, autonomy, and business models. Solid-state batteries that would double the current range of EVs are only one to two years away, but the industry needs to look out much further to experiment with non-lithium-based chemistries, particularly sodium, and new kinds of charging systems.[302] Finally, U.S. automakers and the entire supply chain need to orient themselves toward diffusing their products and related technologies as rapidly as possible.[303] This is China's true technology superpower; U.S. companies need to find pricing and distribution strategies to accelerate the popularization of their technologies. Otherwise, they will be outflanked by China and other competitors, and the American public's support for industrial policy and these companies' products will wane.

## The Challenge of Limiting Civilian-Military Technology Flows

Much like the industrial policy measures deployed across sectors, the right strategy and tactics will vary across policy domains. These domains can be divided into two broad categories. The first is the group of policy spaces that support the nurturing of innovation ecosystems, including financing, knowledge creation and protection, manufacturing, and diffusion. The second is economic security risks, including technology leakage to the military, supply chain resilience, data security, economic coercion, cybersecurity, financial security, and energy security. It should not be a surprise that, almost by definition, the tendency with issues in the first category is to encourage connectivity and reduce barriers to interchange, but the opposite with the latter, to impose restrictions in order to protect national security.

That difference in posture toward growth and security-oriented issues–welcoming or resistant–applies to the domains that are analyzed in this report, but the contrast is not absolute, as there are good reasons for a nuanced approach to both strategies.

The power of the Chinese state, the weaknesses of private property rights and corporate governance rules, and the legal requirement for Chinese companies to comply with data-sharing mandates in the context of national security all make it extremely challenging for the U.S. government to ensure that American technology does not end up supporting the Chinese military while allowing widescale commercial interchange that benefits American companies and consumers. Although it would be understandable for the U.S. government to throw up its hands and impose country-wide restrictions on all potentially dual-use technologies, it is in the broad U.S. national interest to seek to achieve both goals simultaneously.

The MCF initiative makes this task even harder. The number of Chinese commercial firms providing services to the PLA has grown substantially over the last decade as MCF-related systems supporting the certification of companies and online tendering systems have proliferated. Some of this business involves dual-use technologies, such as AI and drones, while some involves ordinary commercial products that are sold to the PLA (such as food and clothing). But determining who does business with the PLA and for what kinds of technologies with any sort of detail is extremely difficult.

As discussed in Chapter 5, the primary way the U.S. government manages this challenge is through the Commerce Department's Export-Administration Regulations (EAR), including its Entity List, the Commerce Control List, and their related rules. Well over 1,000 of the almost 3,200 entities on the Entity List are Chinese, and they are included because of the conclusion that they are providing technology to help China's military modernization. The number of covered entities seems large, but this is because some companies have multiple subsidiaries, each of which is individually listed, including (as of early 2026): Huawei (185), the China Electronics Technology Group Corporation (CETC) (65), the Aviation Industry Corporation of China (AVIC) (34), and the China Aerospace Science and Industry Corporation (CASIC) (9). Being placed on the list generally means that entity cannot gain access to U.S. technology without a license, and often there is the presumption of denial for these applications. It is hard to quibble with the individual entity listings and the restrictions since the U.S. government decisions are typically based on intelligence and other classified information.

If there is an area of export control rules that may deserve a re-evaluation, it may be regulations concerning specific technologies. The covered technologies have expanded dramatically over the last decade under the logic that digital technologies may be more inherently dual-use and that China is likely repurposing technologies acquired for commercial reasons to aid China's military. This is why the range of advanced semiconductors and semiconductor equipment has expanded extensively over this period. There may be two types of problems with this approach. The first is the difficulty in properly drawing the boundary of what is permitted and what is not. The standards set in 2022 have been shifted several times because what is considered cutting edge has shifted, U.S. technology providers have figured how to develop China-specific products that are just under the restricted thresholds, and China's own abilities at the high end have also improved, making earlier restrictions less meaningful. Moreover, as China has been pushed to emphasize producing chips of larger nodes ("legacy chips"), this has put strain on its competitors from elsewhere, which may require other policies to ameliorate.

The second is the invocation of extraterritoriality via the foreign direct product rule (FDPR) to force other countries to restrict sale of semiconductors, supercomputer components, and semiconductor manufacturing equipment made with U.S. technology. The dangers with this step are alienating allies who oppose the policy and the broader legitimation of the use of extraterritoriality by any government who wants to weaponize any technology over which they have a monopoly and which is required by others as part of their supply chain. China's October 2025 rules on rare earth elements and magnets was certainly inspired by the United States application of the FDPR on semiconductors. The underlying policy issue is whether the proliferating boundaries in terms of items and jurisdictions are short-sighted—helping the U.S. restrict technology flows to China in the short run but potentially creating a series of negative side effects that may end up undermining the original aims of the policy.

The most important complementary policy initiatives to address this challenge are two other lists of PLA-related entities. As of January 2025, the Pentagon's "1260H" list of PLA-related companies had over 50 separate companies, or roughly as many as 130 if you include their listed subsidiaries. Companies placed on the list are believed to do business with the PLA and also have business, directly or indirectly, in the United States. Some are traditional defense enterprises, such as AVIC and CETC; others are commercial firms which the Pentagon believes have some sort of business ties with the PLA, such as the Contemporary Amperex Technology Company (CATL), the Commercial Aircraft Corporation of China (COMAC), and Tencent. The main purpose of this list appears primarily to be to "name and shame." Companies on the list are not currently restricted from U.S. defense contracts, though this is set to change in June 2026 as a result of the FY 2024 National Defense Authorization Act's Section 805. Nor are they inevitably treated as "military end users," which would subject them to other restrictions.

The other list is the Treasury Department's "Non-SDN Chinese-Military Industrial Complex Companies List," which as of January 2025 also had roughly 130 firms. Unlike the 1260H list, companies on this list face substantive sanctions, as Americans are prohibited from investing in these firms' publicly traded securities.

As with the BIS Entity List, there is no strong basis for challenging the specific designations of who is and is not included. That said, the existence of multiple lists, with different criteria, managed by different government agencies, is both confusing to outsiders (to not only China but also U.S. allies) and creates the possibility for insufficient coordination and strategic assessments by the U.S. government as a whole. Hence, it may make sense to look for ways to merge these lists or unify their oversight under a single entity, perhaps composed of representatives from multiple agencies.

## Technical Standards: Calibrate to Build Vigilant Openness

The challenge of reducing technology leakage that aids China's military development involves improving the process for screening entities and right-sizing the extent of restrictions for specific technologies. By contrast, the evidence from this report suggests that the dial for managing China's role in technical standards should be calibrated to a position of "vigilant openness." In this case, the United States has a strong interest in maintaining a unified technical standards system, if at all possible. This is the best way to provide and maintain a truly globally innovation ecosystem and continued U.S. leadership within that system. Any sort of fragmentation guarantees unchallenged Chinese technological leadership in a large part of the standards world. That danger is most likely to occur as a reaction to U.S. efforts to isolate China from this system.

*The United States has a strong interest in maintaining a unified technical standards system, if at all possible. This is the best way to provide and maintain a truly globally innovation ecosystem and continued U.S. leadership within that system.*

Chinese participants have tried to game the system by, among other things, flooding standards development organizations (SDO) with proposals and influencing the selection of committee leaders and proposals. The standards system is robust enough to effectively manage these kinds of risks. International SDOs often have strong governance rules and norms, including a high degree of transparency to the participants. There is also the opportunity to "forum shop," or to focus on SDOs with better governance norms. When Chinese participants seemed to corner the International Telecommunication Union (ITU), Western MNCs shifted their attention to parallel technical committees within the International Organization for Standardization (ISO) and 3GPP. Shifting attention away from the ITU raised the danger to the ITU of becoming irrelevant. As a result, the ITU has tried to strengthen its credibility. One element of its response was to change its leadership, replacing former Chinese official Houlin Zhao as its director-general with American Doreen Bogdan-Martin.

Interview subjects also consistently stressed that it is important not to exaggerate the potential cybersecurity and intellectual property (IP) theft risks from participating in SDOs. In addition to internal checks, officials from Western governments regularly attend the working-level meetings of high-tech standards organizations and can flag for others if any "risky" proposals are submitted by Chinese participants. Moreover, as standards participants said during interviews for this report, it is highly unlikely that a standard, as a whole or through its various components, would carry inherent security risks. It is far more likely that serious problems (such as "backdoors") are created when companies and other organizations develop technology products and services, not when standards are being created. Relatedly, participant interviewees consistently emphasize that IP theft as a consequence of participating in SDOs is exceedingly rare and unlikely, as corporate participants do not bring proprietary secrets to meetings, let alone their "crown jewels."

The ultimate proof that the system works is that there still are no examples of China successfully forcing a domestic standard on an international SDO or taking an international standard where it is the dominant contributor and implementing it at home as a mandatory technical regulation that everyone must obey.

The most serious risks to the United States' genuine interests have occurred when it has tried to keep China from fully participating or others from interacting with it. Although there may have been other good reasons for placing Huawei on the BIS Entity List in 2019, including a reference to SDOs was clearly a huge mistake because it pushed some of these organizations to suspend work with Huawei and drove others to constrain their behavior for fear of potentially violating export control laws. As a direct result, Huawei created HarmonyOS and abandoned Android, developed NearLink as a substitute for Bluetooth and possibly Wi-Fi, and, along with other Chinese companies, decided to champion new industry consortia based in China. Given China's substantial technical capabilities and wide market reach, efforts to isolate Chinese participants from mainstream SDOs simply result in growing China's leadership role and reducing the influence of American participants and the value of their contributions.

Now that Huawei and some other Chinese companies have started down a divergent path in a small number of areas, there is no guarantee that the standards world will not further fragment. However, a strategy of vigilant openness is far more likely to starve alternative standards and SDOs of oxygen and to reduce the chances of further fragmentation. This is because keeping China involved will substantially reduce the relative value of it taking a divergent path. In short, ensuring an open—yet well-governed system—will make it more likely that these initial efforts will be seen as unpursued hedging options that never amount to much.

Beyond being vigilant and open to Chinese participation, there are several other steps U.S. policymakers should take to help maintain U.S. leadership in international technical standards:

1. **Review the United States' standards strategy.** In May 2023, the Biden administration issued a national standards strategy.[304] It identified 14 priority technologies and said the United States should achieve greater influence in international standards by investing in SDOs, facilitating wider participation by American companies in SDOs, supporting workforce training, and ensuring that SDOs adhere to the norms of integrity and inclusivity. The White House's Office of Science and Technology Policy (OSTP) and the Commerce Department's National Institute of Standards and Technology (NIST) should lead an evaluation of the strategy: what steps were taken, what was achieved, and how might the strategy be revised in light of those results. Relatedly, it may make sense to reconsider the technological priorities; in 2022, AI was mentioned, but primarily as a narrow machine-learning technology, not the more all-encompassing field—with a multilayered technology stack—into which it has since evolved. Finally, as part of this process, the U.S. government should consider the latest strategy document developed by the American National Standards Institute (ANSI) and look to align and coordinate on meeting strategic priorities.[305]
2. **Turbo-boost U.S. participation.** Consistent with the U.S. government's and ANSI's strategies, the United States needs to promote greater involvement in SDOs by technical experts from U.S. industry and research organizations. This includes not only expanding the number of general participants but also more assertively seeking positions of leadership in standards bodies at the working level and above. The United States should also seek to host more secretariats for the ISO and the ISO-IEC JTC1 committees (which are focused on ICT issues) and renew their activism in the ITU. It should also look to increase U.S. participation in China's state-based technical committees as well as the growing number of industry consortia based in China.
3. **Facilitate the United States as an attractive home for the headquarters of international SDOs and as a host of international SDO meetings.** In the standards world, geography matters. Having standards organizations based in the United States and international meetings here benefits Americans. It gives U.S. participants a greater role in directing SDOs and shaping the standards they work on. But in the past few years, as a result of the pandemic, growing strategic tensions with China, and changing policies toward international visitors who are science and technology experts, it has been increasingly difficult for international participants to attend international SDO meetings in the United States.[306] As a result, several SDOs have begun to shift to holding more meetings in other countries. The solution for this is straightforward: fast-track visa approval for short-term visitors attending international SDO meetings in the United States, or even better, permit visa-free travel for such experts. The United States could seek to sign reciprocal visa-free arrangements either bilaterally or

with multiple countries. Easing travel would quickly strengthen the United States' role in international standards and reduce pressure for fragmentation.

4. **Protect IP and promote technology diffusion.** Many technical standards do not have any IP in them. But in the ICT space, particularly telecommunications, IP and standard essential patents (SEP) are more common. Typically, SEPs are declared as a standard is being made, and then there is a negotiation and a system created to manage and pay out royalties, with the goal of doing so on a "fair, reasonable and non-discriminatory" basis. Often the various parties—the innovators and users—end up arriving at a mutually agreed upon arrangement, but occasionally that is not the case and the parties end up in court. Chinese technology firms have become deeply involved on all sides of these negotiations, as both innovators and users, with many companies being in both positions (e.g., device makers who also innovate in network technologies). Their growing involvement also coincides with greater participation from platform companies, such as Facebook, Google, and Baidu, who often support reducing the value of certain kinds of IP, such as copyrights of artistic works. The U.S. government has an interest in both protecting the IP of innovators while also promoting access to technologies and knowledge as widely as possible. It would be valuable for the White House's OSTP to organize a multiagency study of the evolving challenges to achieving a balanced outcome due to evolving technologies, emerging markets, and greater participation by Chinese industry in international SDOs and IP arrangements.[307] This report could be the basis for proposing potential reforms to ensure that economic and geopolitical dynamics do not undermine the health of the international standards system.

## America Aligned

It should go without saying that any effective strategy toward managing interdependence with China on issues related to advanced technologies—whether unconditional engagement, decoupling, de-risking, or calibrated coupling—will only be effective if done in concert with a large number of countries around the world. Despite the United States's own highly developed innovation ecosystem, a record of innovation success and leadership across many industries, and other elements of international power, China's technological capabilities and related international power and influence have grown dramatically. Although the country faces substantial macroeconomic headwinds, occasionally fails to achieve leadership in various technologies, and has a political system with distinct weaknesses, China should not be underestimated as a global participant. China's scale, technological capabilities, and deep, multilevel connectivity with others dictate that the United States must find common ground with others in managing this challenge.

*Despite the United States's own highly developed innovation ecosystem, a record of innovation success and leadership across many industries, and other elements of international power, China's technological capabilities and related international power and influence have grown dramatically.*

Doing so is easier said than done. Interviews for this project with officials from multiple U.S. partners in Europe and the Indo-Pacific during the past few years reveal that these countries share the United States' concerns about China's growing technological capabilities, their potential military applications, and other economic security issues—and all of them are eager to collectively implement appropriate measures to protect themselves and others from these risks. At the same time, they are opposed to a strategy purely centered around decoupling or de-risking. All of them see substantial economic and security benefits from maintaining ties with China. Policymakers from multiple countries, without prompting, said that one of their goals was to remain "indispensable" to China as a provider of the technologies China did not have at home. Several also suggested that while they need to limit access for certain kinds of Chinese technologies, such as telecommunications equipment, they expressed some confidence in their ability to manage the attendant competitive and economic security risks from having Chinese goods and producers in their countries.

In this context, it is not surprising that U.S. allies have found recent U.S. policy approaches problematic.

The Biden administration worked diligently to align with like-minded countries in Europe, the Indo-Pacific, and elsewhere. This included a variety of mechanisms, such as the U.S.-EU Trade and Technology Council, the Quadrilateral Security Dialogue (involving Australia, India, Japan, and the United States), and the Indo-Pacific Economic Framework for Prosperity (IPEF). Through these and other mechanisms, the United States was able to expand areas of consensus on how to manage the China tech challenge. At the same time, the agenda was heavily titled in the direction of de-risking and imposing restrictions on elements of the relationship. As discussed above, many of these steps were a necessary course correction to previous policies, but it was a one-sided, largely zero-sum approach with very limited ambition on a positive agenda vis-à-vis U.S.-China technological competition or in seeing how to utilize elements of the technology relationship with China to realize collective advantage.

The second Trump administration has also said that it values cooperation with long-time allies in Europe and Asia on managing the China challenge. It has aimed to set reciprocal tariffs on China higher than it imposes on other countries, and it has attempted to negotiate framework arrangements with others that include limits on the trans-shipment of Chinese goods through these countries and restricts the supply of certain advanced technologies to China. It has also attracted new investments from several of these countries in high-tech sectors and agreed on a plan to develop alternative sources of critical minerals to reduce dependence on China.

At the same time, as noted above, it has sent mixed signals about being open to a continuing technology relationship with China. It made the deal on TikTok and gave approval for advanced GPU sales, provided the sellers and China meet very stringent conditions. Yet the administration has criticized allies for cutting their own deals with China, including Canada's decision to permit imports of a limited number of EVs.[308] Equally important, it has unilaterally imposed steep tariffs on allies, criticized the European Union for its digital technology policies, and abandoned its own commitment to the energy transition and mitigating climate change. These steps not only damage the United States' bilateral relationships, they reduce potential sources of cooperation and undermine the multilateral rules-based order, which these countries view as a central foundation to a predictable and fair global order.

As a consequence, the United States is far from building a united front to tackle the technology challenge with China. Countries have offered grudging, superficial support on a small number of issues but are unlikely to cooperate deeply with the United States because of its seeming insensitivity to their concerns and its unpredictable approach toward China, alternating between heavy restrictions and new deals without a clear roadmap for where it wants to go. If the United States continues down its current path, primarily acting alone with minimal support from others, China will more rapidly make advances in technological areas for which it was once dependent on the United States and others. This would eventually make U.S. restrictions on advanced technology obsolete, undermine U.S. competitiveness, and ease China's efforts to expand its influence in global economic governance, including in technical standards.

However, the United States does not need to accept a future that cedes technology dominance to China in particular industries, policy domains, or regions of the world. It should seek to deploy a prudent, middle-ground strategy that promotes U.S. technological advancement–in each of its dimensions–while calibrating the relationship with China across various sectors to maximize the benefits and minimize the risks to America's economy and national security.

# About the Author

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307 For a view of the evolving challenges around IP, see Jonathan M. Barnett, *The Big Steal: Ideology, Interest, and the Undoing of Intellectual Property* (Oxford, UK: Oxford University Press, 2024).

308 Matina Stevis-Gridneff, “Trump Threatens Canada with Tariffs as Post-Davos Fallout Continues,” *New York Times*, January 24, 2026, https://www.nytimes.com/2026/01/24/world/canada/trump-canada-tariffs.html.

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