



# THE WORLD CHINA MADE

**“MADE IN CHINA 2025” NINE YEARS LATER**



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**“Made in China 2025” Nine Years Later**

Project for Strong Labor Markets and National Development  
The Office of Senator Marco Rubio

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# FOREWORD

## Senator Marco Rubio: Meeting the China Challenge

Communist China is the most powerful adversary the United States has faced in living memory. This is no exaggeration. We sometimes forget that past enemies, including Nazi Germany and Soviet Russia, had smaller economies than we did. Each tried to take over its neighbors and hurt our country in the process. Each failed because America out-built and outgunned it.

However, the Chinese Communist Party is playing a better hand, as it controls the largest industrial base in the world, fuels its factories with market-distorting subsidies and rampant theft, and, as this report highlights, now leads in many of the industries that will determine geopolitical supremacy in the 21<sup>st</sup> century, from shipbuilding to electric vehicles. This means Beijing will have greater sway over which set of values defines the 21<sup>st</sup> century: liberty and representative government, or authoritarianism and oppression.

To make matters worse, the United States is in a weaker position than it was in the past. Decades of overregulation and “free trade” with adversarial economies like China’s have eroded our industrial base. Shuttered factories, drugs, and illegal immigration have destroyed small-town communities. Four years of the Biden-Harris Administration appeasing our adversaries abroad, raising the cost of living at home, and undermining our economy with red tape, endless reviews, and woke diversity mandates haven’t helped.

For years, I’ve raised the alarm about this. I’ve introduced countless bills to stop Beijing’s predatory behavior and start the process of rebuilding America’s factories and communities. These include efforts to protect American technology from espionage, empower the American auto industry to beat heavily subsidized Chinese competitors, and hold companies accountable for using Uyghur slave labor, among many others.

This report is my latest effort. It’s a wakeup call about how serious the threat we face has become. No longer can we fall back on old dogmas and stale talking points. If we want to win, we must take bold action to rebuild our country, overcome the China challenge, and keep the torch of freedom lit for generations to come.

Sincerely,



Marco Rubio  
U.S. Senator

# INTRODUCTION

In 2019, the Office of Senator Marco Rubio released a report, “Made in China 2025 and the Future of American Industry,”<sup>1</sup> which raised the alarm about China’s ambitious plan, “Made in China 2025” (MIC2025), to overtake the United States in high-value, high-technology sectors. Now, with 2025 looming, it is time to assess how China has done.

Since it was unveiled in 2015, MIC2025 has undergone changes in marketing and emphasis. The changes in marketing have occurred in response to external criticism by China’s trading partners. The policy has gone underground, communicated in new slogans away from the glare of international media attention. The changes in emphasis reflect China’s experience with industrial policy, as it shifts additional resources and focus to sectors that are succeeding. Despite these changes, the main goals of the strategy remain the same: turn China into a “manufacturing powerhouse,” make the country self-reliant, and achieve technological leadership, supply chain dominance, and global economic supremacy.

This report finds that China has reached, or is near to reaching, the technological cutting edge in most of the sectors it has targeted. Of the 10 sectors targeted by MIC2025, China can credibly claim to be the world leader in four (Electric Vehicles, Energy and Power Generation, Shipbuilding, and High-Speed Rail); China is therefore shaping up to be a superpower of green energy and advanced logistics, often in areas of technology with obvious military application. In five sectors, China has made substantial progress toward the technology frontier, but is not yet a leader: Aerospace and Aviation, Biotechnology, New Materials, Robotics and Machine Tools, and Semiconductors. In just one sector, Agricultural Machinery, has China fallen short of its aims. If Xi Jinping were a fund manager, he would have every reason to be pleased with the performance of this portfolio. China’s investments have generated outsized returns in not one, but several sectors.

In addition to targeting high-tech sectors, MIC2025 included a variety of other macro goals. It is difficult to assess China’s performance using these goals, though generalizations can be made. In sum, China is by far the world’s leading exporter, and the composition and destination markets of its exports are shifting in response to its rise and the world’s reaction to that fact. China has built a formidable system for research and development, though the quality of its research is uneven. China has produced household-name brands, but far fewer than the scope of its industrial base would suggest. China has a highly connected and automated industrial base and is the world leader in the manufacture of “green” products, though its integration of those systems into its electrical grid is incomplete.

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<sup>1</sup> Office of Senator Marco Rubio, “Made in China 2025 and the Future of American Industry,” February 12, 2019, <https://www.rubio.senate.gov/rubio-releases-report-outlining-china-s-plan-for-global-dominance-and-why-america-must-respond/>.

The developed world is accustomed to looking down on China as a second-rate power. The default attitude is that we have specialized knowledge and abilities that China lacks; that we are the teacher, China the pupil. This position naturally lends itself to a merely defensive strategy, to keep China from stealing or otherwise obtaining what we already have. It is also outdated, limited to a shrinking number of sectors where we retain genuine and significant advantages. A defensive strategy is still warranted to prevent China from preying on us further. But it cannot be our only response.

The United States must act now to avoid living in a world where China is the teacher, and we are the pupil. Unfortunately, this is the world China is making, in part through MIC2025.

## CHINA'S INDUSTRIAL STRATEGY

MIC2025 is sometimes presented as a modern-day policy innovation on the part of the Chinese state, but it is the continuation of decades of industrial policy engrained in the DNA of communist countries, and nearly two decades of industrial policy explicitly focused on transforming China into a technologically advanced and innovative power.

An important predecessor to MIC2025 was the “National Medium and Long-Term Plan for the Development of Science and Technology” (MLP), released in 2006 and concluded in 2020. That plan was one of China’s first forays into industrial policy with an explicit focus on innovation and high technology, as opposed to “traditional” industrial sectors like metals, mining, and basic manufactures. The MLP was notable for announcing 16 “Megaprojects” that China would complete by 2020. Some of these projects, like the effort to build China’s first wide-body passenger aircraft, would later be included in MIC2025.

The Chinese government unveiled MIC2025 in May 2015. The document announcing the policy was characteristically sweeping and grandiose. Its preamble identified manufacturing as a matter of world-historic importance, stating that “without a strong manufacturing industry, there will be no country and no nation.”<sup>2</sup> The document stated that China has a “great historical opportunity” to become a world power, owing to the fact that globalization has placed China at the center of the world’s supply chains. By the time the document was released, the “China Shock” that followed the country’s accession to the World Trade Organization had already rippled across the globe, decimating textile, apparel, furniture, and other important industries in the United States and other developed nations.<sup>3</sup> China was already the world’s factory.

MIC2025 nevertheless took a critical view of the Chinese industrial base. The document described China as being “still in the process of industrialization, [still having] a major

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<sup>2</sup> State Council of the People’s Republic of China, “Notice of the State Council on the Publication of ‘Made in China 2025,’” May 8, 2015, [https://cset.georgetown.edu/wp-content/uploads/t0432\\_made\\_in\\_china\\_2025\\_EN.pdf](https://cset.georgetown.edu/wp-content/uploads/t0432_made_in_china_2025_EN.pdf).

<sup>3</sup> David Autor, David Dorn, and Gordon Hanson, “The China Shock: Learning From Labor Market Adjustments to Large Changes in Trade,” National Bureau of Economic Research, Working Paper 21906, January 2016, [https://www.nber.org/system/files/working\\_papers/w21906/w21906.pdf](https://www.nber.org/system/files/working_papers/w21906/w21906.pdf).

gap with advanced countries.” It is worth quoting the document’s criticism at length, to give a sense of where the Chinese Communist Party (CCP) thought the country needed to improve:

The manufacturing industry is large but not strong. The capacity for independent innovation is weak, and key and core technologies and high-end equipment are highly dependent on foreign countries. The manufacturing innovation system with enterprises as the mainstay is not perfect. Product quality is not high, and there is a lack of world-renowned brands. The efficiency of resource and energy utilization is low, and the problem of environmental pollution is more pronounced. The industrial structure is unreasonable, and the development of high-end equipment manufacturing and producer services lags behind other countries. The level of informatization is not high, and the depth of integration with industrialization is insufficient. The degree of industrial internationalization is not high, and the globalization of enterprises is inadequate.

The goal of MIC2025 was therefore to upgrade China’s industrial base and capacity for innovation so that, within the policy’s 10-year span, China would “enter...the ranks of the manufacturing powerhouses.”

MIC2025 outlined nine “strategic tasks and priorities” to accomplish this goal (emphases added):

1. Improve National Manufacturing **Innovation** Capabilities
2. Promote the Deep Integration of **Informatization** and Industrialization
3. Strengthen **Basic Industrial Capabilities**
4. Strengthen Quality **Brand Building**
5. Fully Implement **Green Manufacturing**
6. Promote **Breakthrough Development** in Key Fields
7. Deep[en] Promotion of **Structural Adjustments** to the Manufacturing Industry
8. Actively Develop Service-Oriented **Manufacturing and Producer Services**
9. Improve the Level of **Internationalized Development** of the Manufacturing Industry

The sixth goal, concerning breakthrough developments, connects to 10 “strategic sectors” in high-value fields that the CCP wished to heavily subsidize and dominate by 2025. A companion document to MIC2025 listed ambitious goals for each sector, including export targets and the percentage of the domestic market that the CCP expected to be met by domestic firms.

If not for these aggressive targets, MIC2025 may not have occasioned much attention. But the plan’s emphasis on exports and import substitution posed an obvious threat to non-Chinese firms and countries that produced and sold in the China market. MIC2025 therefore generated a firestorm of criticism that only grew with China’s industrial base over the next decade.

Beijing altered its messaging on MIC2025 in 2019, as U.S.-China trade tensions intensified and the Trump Administration imposed its first round of tariffs on Chinese goods. Chinese officials and propaganda organs stopped mentioning the policy. Beijing adopted a conciliatory tone on trade and promised an end to discrimination against foreign firms. Behind the scenes, however, Beijing continued to implement MIC2025 without disruption.

If there was any doubt, recent pronouncements by CCP leaders show Beijing's continued focus on manufacturing. Late last year, General Secretary Xi Jinping introduced a new slogan, "new quality productive forces."<sup>4</sup> This slogan was emphasized at the National People's Congress earlier this year. Premier Li Qiang's annual work report states that "moderniz[ing] the industrial system and developing new quality productive forces at a faster pace" are the top priorities of the government.<sup>5</sup> Supporting documents released by the Ministry of Industry and Information Technology elaborated on what this slogan means.<sup>6</sup> The documents identify sectors and technologies that the state will promote. The list of technologies includes humanoid robots, quantum computers, brain-computer interface, 6G network equipment, deep-sea drilling and mining technology, and advanced aviation equipment.<sup>7</sup> There is considerable overlap between the technologies and sectors on this list and MIC2025. Indeed, analysts have referred to "new quality productive forces" as "the next evolution of the 'Made in China 2025' strategy."<sup>8</sup>

Far from abandoning aggressive industrial strategy, Beijing appears to be preparing for another decade of manufacturing- and export-oriented development. That decision will have dramatic consequences for the world, just as MIC2025 reshaped China and global trade during the past decade.

## ASSESSING "MADE IN CHINA 2025"

Has MIC2025 been a success? This is not a straightforward question to answer, since China's "goals" for the project were often vague or undefined, while at other times, China set very precise goals that are nonetheless impossible to measure without access to proprietary (and often CCP-controlled) data.

This report seeks to shed light on the problem in the following ways. It examines in detail the 10 industries China targeted for "breakthrough development." It then

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<sup>4</sup> Yanzi Xu, "China's Focus on New Quality Productive Forces," Information Technology & Innovation Foundation, May 28, 2024, <https://itif.org/publications/2024/05/28/chinas-focus-on-new-quality-productive-forces/>.

<sup>5</sup> Li Qiang, "Report on the Work of the Government," Second Session of the 14<sup>th</sup> National People's Congress of the People's Republic of China, March 5, 2024, [https://npcobserver.com/wp-content/uploads/2024/03/2024-Government-Work-Report\\_EN.pdf](https://npcobserver.com/wp-content/uploads/2024/03/2024-Government-Work-Report_EN.pdf).

<sup>6</sup> Ministry of Industry and Information Technology of the People's Republic of China, "Implementation opinions of the Ministry of Industry and Information Technology and other seven departments on promoting the innovation and development of future industries," January 29, 2024, [https://www.miit.gov.cn/zwgk/zcwj/wjfb/yj/art/2024/art\\_ad15bofo8a714fd8888coe31468b8c54.html](https://www.miit.gov.cn/zwgk/zcwj/wjfb/yj/art/2024/art_ad15bofo8a714fd8888coe31468b8c54.html).

<sup>7</sup> Ministry of Industry and Information Technology of the People's Republic of China, "Implementation opinions of the Ministry of Industry and Information Technology and other seven departments on promoting the innovation and development of future industries."

<sup>8</sup> Xu, "China's Focus on New Quality Productive Forces."



examines the other eight “strategic tasks and priorities” laid out by China in MIC2025 and China’s progress toward those goals.

This report does not attempt to determine whether China’s specific mix of policy tools was the right one relative to alternate approaches. Instead, it answers the related, but different question of whether China has met the goals it set for itself in its industrial strategy, regardless of whether the tools it used helped or harmed its mission. In other words, this report attempts to answer whether China has, in fact, developed into the “strong” industrial power it hoped to become when embarking on this strategy almost a decade ago.

The answer to that question is yes.

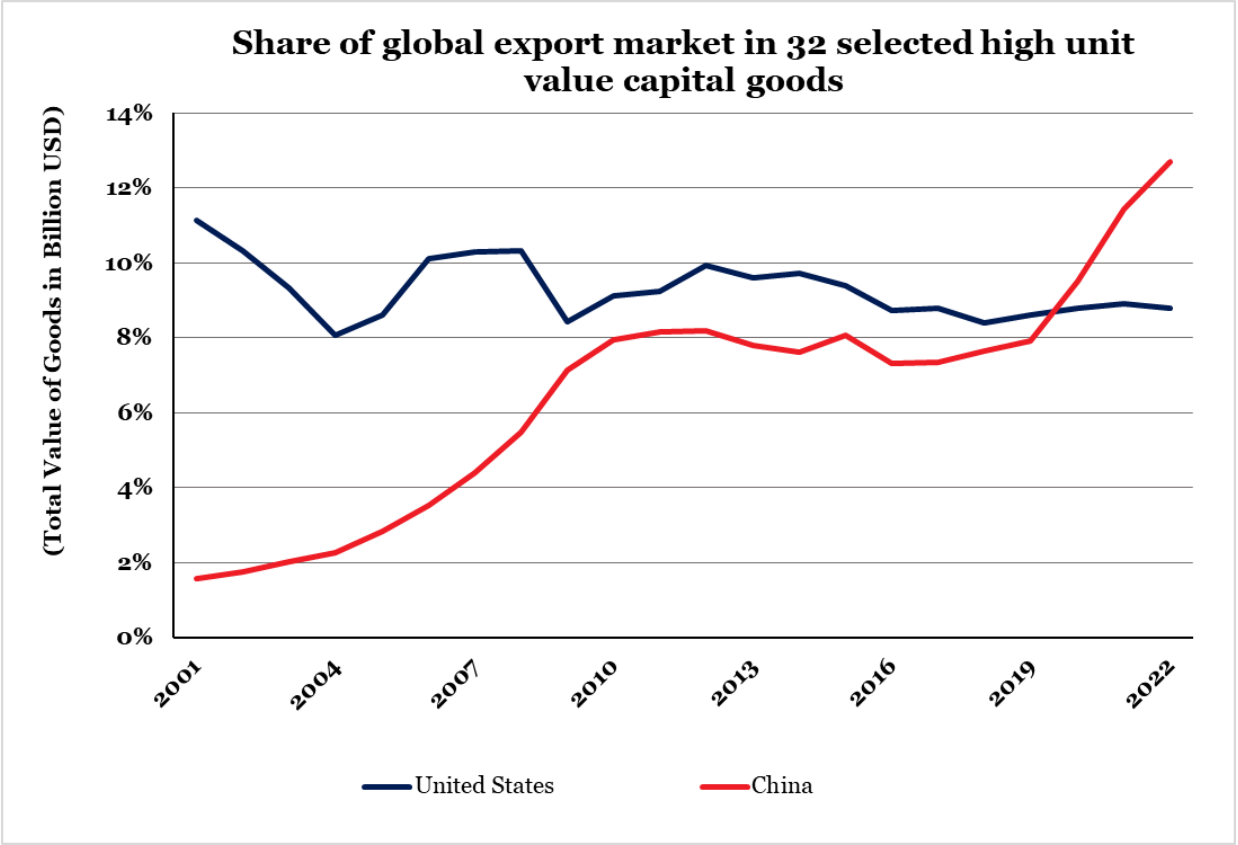
## **Strategic Industries**

The goal of MIC2025 that has drawn the most attention is to “promote the rapid development” of 10 strategic industries. This goal came with ambitious export targets for each sector, raising alarm that the world would be engulfed by another wave of heavily subsidized, inexpensive Chinese exports, this time of high-value-added, high-technology manufactures.

In 2019, the Rubio office charted the global export share of the United States and China in 32 groups of high-value goods, roughly corresponding to the products China targeted in MIC2025. That exercise showed that by 2017, China had “increased its global market share to nearly match the U.S. in some high-price, high-value products.”<sup>9</sup> Updating the chart, as this report does below, shows that China’s progress in exporting these goods has continued unabated, surpassing the United States and rising from there. Focusing on this basket of high-value goods shows that China has had considerable success climbing the value chain of global trade. While the country is still a massive producer of cheap toys, apparel, and electronics, it is now among the world’s most competitive producers of just about *everything*, from machine tools to dock cranes.

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<sup>9</sup> Office of Senator Marco Rubio, “Made in China 2025 and the Future of American Industry.”



Source: UN International Trade Centre, Trade Map, accessed August 28, 2024, <https://www.trademap.org/>.

Note: Selected four-digit lines include: **8406** Steam turbines and other vapor turbines; **8408** Compression-ignition internal combustion piston engine; **8411** Turbojets, turbopropellers and other gas turbines; **8414** Air or vacuum pumps; **8426** Ships' derricks, cranes; **8429** Self-propelled bulldozers, angledozers, graders, levelers, scrapers, mechanical shovels, excavators, shovel loaders, tamping machines and roadrollers; **8430** Moving, grading, levelling, scraping, excavating, tamping, compacting, extracting or boring machinery; **8456** Machine tools for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electro-discharge, electro-chemical, electron beam, ionic-beam or plasma arc processes; **8457** Machining centers, unit construction machines and transfer machines for working metal; **8458** Lathes for removing metal; **8459** Machine tools, including way-type unit head machines, for drilling, boring, milling, threading or tapping; **8460** Machine tools for deburring, sharpening, grinding, honing, lapping, polishing or otherwise finishing metal; **8461** Machine tools for planing, shaping, slotting, broaching, gear cutting, gear grinding or gear finishing, sawing, cutting-off; **8462** Machine tools, including presses, for working metal; **8479** Machines and mechanical appliances not specified or included elsewhere in this chapter; **8486** Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers, semiconductor devices, electronic integrated circuits or flat panel displays; **8501** Electric motors and generators; **8502** Electric generating sets and rotary converters; **8504** Electrical transformers, static converters, and inductors; **8543** Electrical machines and apparatus, having individual functions; **8601** Rail locomotives powered from an external source of electricity or by electric accumulators; **8602** Rail locomotives (excluding those powered from an external source of electricity or by accumulators), locomotive tenders; **8603** Self-propelled railway or tramway coaches, vans and trucks; **8605** Railway or tramway passenger coaches, luggage vans, post office coaches; **8701** Tractors; **8703** Motor cars and other motor vehicles principally designed for the transport of persons; **8704** Motor vehicles for the transport of goods; **8705** Special purpose motor vehicles (e.g. breakdown lorries, crane lorries, fire fighting vehicles, lorries, mobile workshops and mobile radiological units); **8901** Cruise ships, excursion boats, ferry-boats, cargo ships, barges and similar vessels for the transport of persons or goods; **8902** Fishing vessels; **8904** Tugs and pusher craft; **8905** Light-vessels, fire-floats, dredgers, floating cranes, floating docks, floating or submersible drilling or production platforms; **8906** Vessels, incl. warships and lifeboats. Headings are shortened for length.

This section provides an overview of China's progress in all 10 strategic sectors identified in MIC2025. As we will see, China has succeeded beyond expectations in a few areas, made progress while remaining behind the pack in others, and fallen well short of its goals in at least one.

Even this mixed assessment represents an undeniable victory for the CCP. China led in zero of these cutting-edge industries a decade ago. Now it is the undisputed leader in several, and it can use this leadership to coerce and control the rest of the world.

## **AEROSPACE AND AVIATION**

- China's passenger-jet champion, COMAC, has notched success in the domestic market, but is not yet a viable competitor of the Boeing-Airbus duopoly.
- China has developed impressive space-launch capabilities and satellite systems, but is still weaker than the United States in space.
- China's aviation success story is in commercial drones, where it possesses dominant market share and has built world-leading companies like DJI.

MIC2025 targeted aviation and space technology for promotion. The emphasis of MIC2025's aviation agenda was commercial jet aircraft, while the emphases of its space agenda were heavy-lift rockets and satellites. This section discusses both. It also discusses a third group of technologies—airial drones and their manned cousins, electric vertical take-off and landing aircraft—which were not envisioned by MIC2025, but which have emerged in recent years as a driver of China's economy.

Recent, high-profile stumbles by Boeing have led to speculation that China could seize the opportunity to break into the major leagues in commercial aviation. That is certainly what Beijing hopes for, and it has spent decades and billions to build its state-owned champion, the Commercial Aircraft Corporation of China (COMAC), into a competitor of Boeing and Airbus. This possibility is still far off, as China has struggled to bring its commercial aerospace offerings to the industry cutting edge. At present, it is behind not only Airbus and Boeing, but also Embraer, the widely respected Brazilian firm that, far more than COMAC, deserves the title of understudy to the Big Two.

COMAC's most important offering is the C919, a narrow-body passenger jet similar in profile to the Airbus A320 and Boeing 737. More than a decade and a half after it was announced, the C919 is still in the infant stages of commercial operation. The plane's maiden testing flight was in 2017, and it entered commercial service last year.<sup>10</sup> The plane first flew internationally this year—to Singapore, the easiest of overseas jaunts. The plane appeared at the Singapore Airshow, where COMAC hoped to drum up interest with foreign airlines.

COMAC has racked up an impressive domestic order list for the jet and is expanding its manufacturing facilities, but it has yet to attract international clients. The plane has only

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<sup>10</sup> Sophie Yu and Brenda Goh, "China's C919 15-year journey to maiden commercial flight," *Reuters*, May 26, 2023, <https://www.reuters.com/article/idUSL1N37NoEF/>.

been approved by Chinese regulators and ordered by Chinese airlines, all of which have a vested interest in the success of their champion.

COMAC will struggle to break the Airbus-Boeing duopoly in large part because the C919 is still technologically inferior to those companies' offerings. The plane is heavier than the most popular version of the Boeing 737 by roughly a ton and has a shorter range by about 1,000 nautical miles.<sup>11</sup> Those specifications likely rule COMAC out for airlines seeking to increase fuel economy and utilization rates.

An even more awkward fact for Beijing is that the C919 is not close to being a fully "Chinese" plane. Chinese state media admits that 40 percent of the plane's components are imports, and the true figure is likely higher.<sup>12</sup> The plane's electrical system, landing gear, flight recorder, flight control and fuel system, weather radar, and tires are all foreign-made—in fact, American-made. Most significantly, the C919's jet engine is the product of a joint venture between GE Aviation and France's Safran Aircraft Engines. Beijing has made replacing this engine a priority, clearing roadblocks for the regulatory approval of a home-grown turbofan engine by Aero Engine Corporation of China. That engine is still in testing and is likely years from commercial operation.

China has had more success in space. The country is one of three capable of independently launching humans into outer space, alongside the United States and Russia. Since 2021, China is also the only country with an independent, permanently crewed space station. The launch of the *Tiangong* ("Sky Palace") represented the culmination of a two-decade-long effort to develop China's manned space program.

MIC2025 focused on developing China's rockets and satellites. China's Long March rockets are the backbone of its space-launch capabilities. China has several proven medium-lift launch vehicles and one proven heavy-lift launch vehicle of this type, though the payload and cost of delivering payload into orbit of these rockets are significantly worse than those of American workhorses like SpaceX's Falcon 9. China is also developing two super heavy-lift launch vehicles, the Long March-9 and Long March-10, which bear striking resemblance to their American competitors, SpaceX's Starship and NASA's Space Launch System. China fantasizes that the Long March-9 will one day, like Starship, be a reusable rocket, though that capability will likely remain out of its reach for many years. The Long March-10, a more realistic blueprint, is slated for its first launch in 2027.

China has increased the tempo of its rocket launches in recent years to bolster its impressive constellation of satellites. Georgetown's Center for Security and Emerging Technology (CSET) reports that Beijing has performed 322 orbital launches between 2013 and 2022, with 64 launches occurring in 2022.<sup>13</sup> The United States launched more

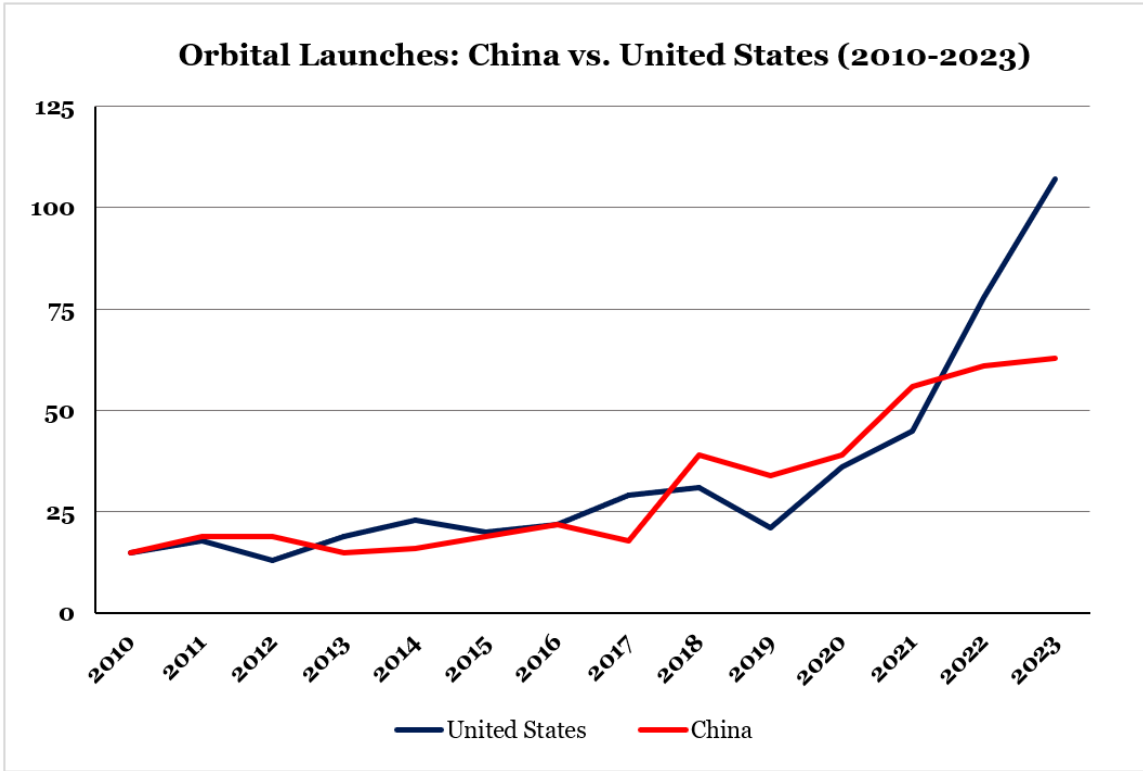
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<sup>11</sup> Tatenda Karuwa, "The COMAC C919 vs Boeing 737 – An Aircraft Comparison," *Simple Flying*, June 13, 2023, <https://simpleflying.com/comac-c191-boeing-737/>.

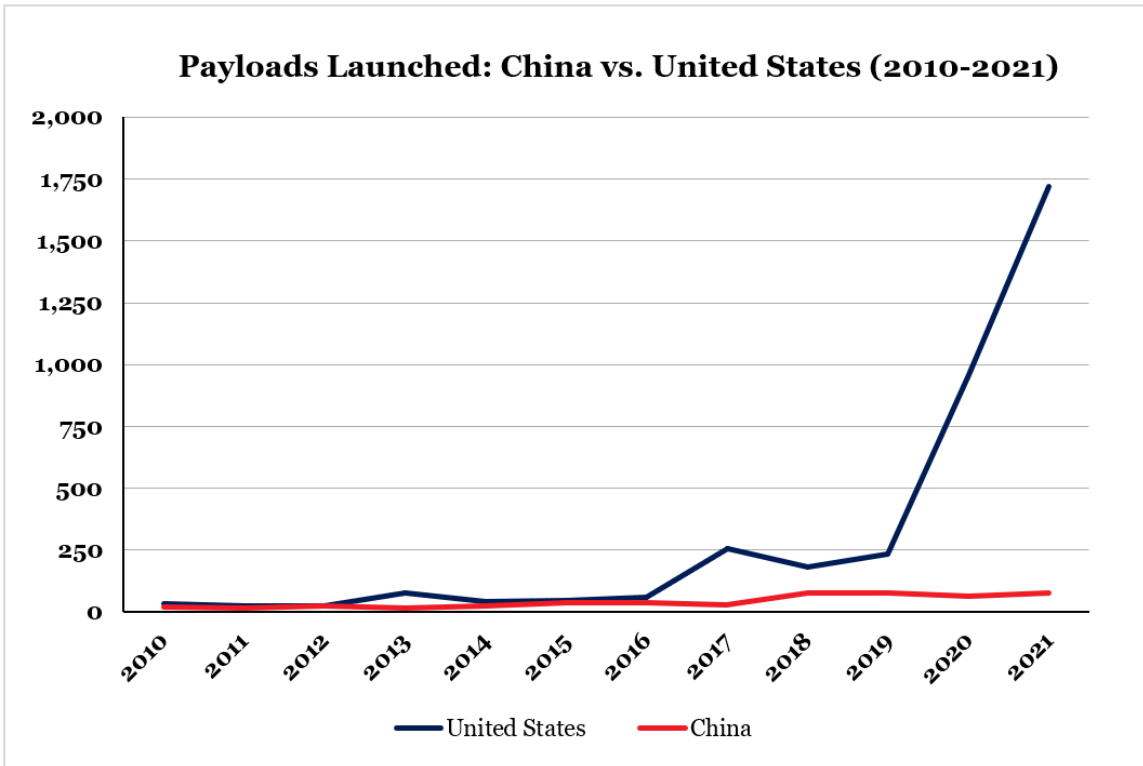
<sup>12</sup> Michelle Toh, "China's answer to Boeing and Airbus isn't as 'homegrown' as it seems. Here's why," *CNN*, June 2, 2023, <https://www.cnn.com/2023/06/02/tech/comac-c919-china-aircraft-intl-hnk/index.html>.

<sup>13</sup> Corey Crowell and Sam Bresnick, "Defending the Ultimate High Ground: China's Progress Toward Space Resilience and Responsive Launch," Georgetown University Center for Security and Emerging Technology, July 2023, <https://cset.georgetown.edu/wp-content/uploads/CSET-Defending-the-Ultimate-High-Ground.pdf>.

rockets in both periods, due mainly to a sharp increase in launches beginning in 2019. America's continuing advantage in space is best illustrated by the number of payloads it has launched into orbit over the past decade. In 2019, U.S. payloads went vertical, while China's increased only marginally.



Source: Gunter's, "Orbital Launches of 2023," [https://space.skyrocket.de/doc\\_chr/lau2023.htm](https://space.skyrocket.de/doc_chr/lau2023.htm)



Source: Center for Strategic and International Studies, "Space Environment: Payloads Launched by Country," <https://aerospace.csis.org/data/space-environment-total-payloads-launched-by-country/>

In the past five years, CSET reports that China has launched 419 satellites. Some of these satellites are constituents of the BeiDou Navigation Satellite System, which China developed in the wake of the 1995–96 Taiwan Strait Crisis to end the “humiliation” of its dependence on the U.S. Global Positioning System (GPS).<sup>14</sup> That effort has paid dividends. BeiDou is now twice the size of GPS, is more accurate—particularly in the developing world, and has more features. As Chinese electronics and influence proliferate across the world, BeiDou will take on greater significance as a tool of Chinese diplomacy and, potentially, espionage.

The final aviation and aerospace technology worth noting is one that China’s industrial planners largely did not foresee a decade ago: aerial drones. The United States pioneered the use of drones for military purposes, and the U.S.-led smartphone revolution perfected the lightweight sensors and semiconductors that power small commercial drones. However, the U.S. commercial drone industry has since been all but wiped out by Chinese drone makers like DJI and Autel, which have received heavy state subsidies.<sup>15</sup> Today, China has captured 90 percent of the U.S. market for commercial drones.<sup>16</sup> Countless Chinese drones are flying over American skies, collecting—and potentially transmitting—treasure troves of data.

China’s dominance of the commercial drone sector has led to the emergence of what Beijing calls the “low-altitude economy.” China envisions a future where armies of coordinated drones perform everyday tasks from package delivery to crop dusting to, one day, taxi services. A Chinese eVTOL aircraft recently completed its maiden flight in Nanjing, which means even the more fantastic applications of this technology may be closer to reality than many believe.<sup>17</sup>

## **AGRICULTURAL MACHINERY**

- MIC2025’s prioritization of agricultural machinery reflects the CCP’s—and General Secretary Xi’s—preoccupation with food security.
- China has failed to build internationally competitive manufacturers of agricultural machinery. By some metrics, China’s mechanization of agriculture has gone into reverse.
- China remains deeply reliant on foreign sources, including the United States, for food, despite a crash program to increase the supply of arable land.

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<sup>14</sup> Sarah Sewall, Tyler Vandenberg, and Kaj Malden, “China’s BeiDou: New Dimensions of Great Power Competition,” Harvard Kennedy School Belfer Center, February 2023,

[https://www.belfercenter.org/sites/default/files/files/publication/Chinas-BeiDou\\_V10.pdf](https://www.belfercenter.org/sites/default/files/files/publication/Chinas-BeiDou_V10.pdf).

<sup>15</sup> Cate Cadell, “Drone company DJI obscured ties to Chinese state funding, documents show,” *Washington Post*, February 1, 2022, <https://www.washingtonpost.com/national-security/2022/02/01/china-funding-drones-dji-us-regulators/>

<sup>16</sup> David Lynch, “Chinese subsidies for drones, chips put U.S. at risk, House panel says,” *Washington Post*, June 26, 2024, <https://www.washingtonpost.com/business/2024/06/25/china-subsidies-house-panel/>.

<sup>17</sup> Jennifer Meszaros, “ET9 eVTOL Prototype’s Maiden Flight Signals Nanjing’s Low-Altitude Progress,” APAC Aviation Insights, April 27, 2024, <https://medium.com/apac-aviation-insights/evitechs-successful-maiden-flight-marks-advancement-in-nanjing-low-altitude-development-5fa28ed3f50f>.

China's prioritization of agricultural machinery may seem odd in a list dominated by cutting-edge technology like semiconductors and airplanes. To make sense of it, one must realize the unique vulnerability of China in agriculture. Simply put, China does not make enough food. Beijing knows that self-reliance in agriculture is critical to breaking free from the West, particularly if it hopes to absorb Taiwan by force.<sup>18</sup> The evidence shows that China's insecurity in this area is growing worse, not better, despite feverish efforts to reclaim farmland, mechanize agriculture, and grow food.

China has run a trade deficit in agriculture every year for at least two decades. That deficit has ballooned since 2015, growing from \$45 billion to \$135 billion in 2023.<sup>19</sup> China maintains vast stockpiles of staples like rice and grain to feed its population, but relies heavily on imports to feed livestock that meet the Chinese peoples' demand for meat.

China runs especially large deficits in soybeans, which it imports mainly from Brazil and the United States to use as feedstock.<sup>20</sup> But its list of dependencies is long, encompassing beef (imported mainly from Brazil, Argentina, Australia, and the United States), corn (imported from Brazil and the United States), and dairy (imported from New Zealand). As this list demonstrates, many of China's most acute needs come from the United States and allied countries, which poses a strategic challenge for Beijing.

Xi, a leader old enough to remember the terrible famine that accompanied the CCP's Great Leap Forward, has spoken on multiple occasions about the importance of food security. He has warned that failure to address this problem will leave China at the mercy of foreign powers. "We will fall under others' control if we can't hold our rice bowl steady," he has said.<sup>21</sup>

China has thus started a crash program of land conversion to increase the amount of arable land for agriculture, reversing an earlier policy of reforestation. In some parts of the country, planting of trees is forbidden, and recently planted trees—including trees that grow valuable commodities like fruit—are being uprooted.<sup>22</sup> Authorities have reclaimed more than 400,000 acres of land since 2021 for corn and soybean production. But Chinese official statistics show this campaign has yet to right the ship. The amount of cultivated land in China fell from 333 million acres in 2015 to 315 million in 2022, close to the level that Beijing believes is a bare minimum for food security.<sup>23</sup>

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<sup>18</sup> Edward Luttwak, "The clue China is preparing for war: Xi is laying the groundwork while the West looks away," *UnHerd*, July 19, 2023, <https://unherd.com/2023/07/the-clue-china-is-preparing-for-war/>.

<sup>19</sup> Xin Ou, "Trade balance of agricultural product imports and exports in China from 2005 to 2023," Statista, accessed March 1, 2024, <https://www.statista.com/statistics/1301293/china-balance-of-trade-in-agricultural-products/>.

<sup>20</sup> UN International Trade Centre, "List of supplying markets for a product imported by China, Product: 1201 Soya beans, whether or not broken," accessed March 1, 2024, <https://www.trademap.org/>.

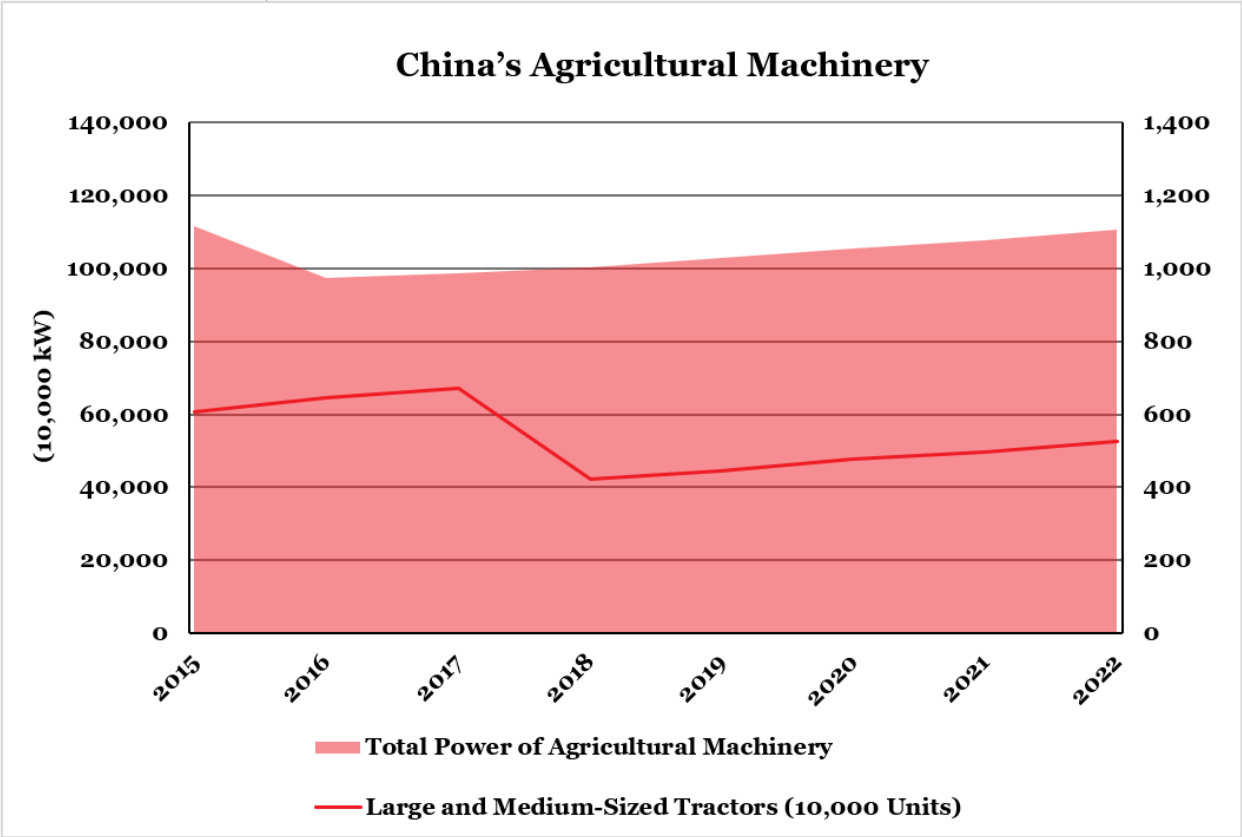
<sup>21</sup> Sun Yu, "China expands farmland in bid to cut foreign food reliance," *Financial Times*, August 13, 2023, <https://www.ft.com/content/6702e861-24c1-4383-be1c-bb0ba3b09c8a>.

<sup>22</sup> Frederic Lemaitre, "China imposes deforestation in the pursuit of food independence," *Le Monde*, June 27, 2023, [https://www.lemonde.fr/en/environment/article/2023/06/27/china-imposes-deforestation-in-the-pursuit-of-food-independence\\_6038140\\_114.html](https://www.lemonde.fr/en/environment/article/2023/06/27/china-imposes-deforestation-in-the-pursuit-of-food-independence_6038140_114.html).

<sup>23</sup> National Bureau of Statistics of China, "China Statistical Yearbook 2023: 8-20 Area of Cultivated Land by Region," accessed March 1, 2024, <https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm>.



China’s mechanization of agriculture has also fared poorly. Despite great advances in manufacturing, China has failed to raise a manufacturer of agricultural equipment that can compete with the likes of John Deere. In fact, last year, China’s agriculture ministry opened investigations into machinery subsidy fraud, alleging that the \$3 billion in funds Beijing had allocated to help China’s farmers mechanize was stolen or wasted on shoddy equipment.<sup>24</sup> Earlier this year, Beijing announced a further corruption probe—into China’s agriculture minister, Tang Renjian.<sup>25</sup> While China has a trade surplus in tractors and related parts, it is nowhere near the size of its surplus in other automotive goods. China’s major export market for tractors is Russia, a market that has quadrupled since Russia’s war in Ukraine; this speaks to the unique circumstances of Russia’s isolation, as well as the dual-use nature of heavy equipment, more than any commercial success on China’s part.<sup>26</sup>



Source: National Bureau of Statistics of China, “China Statistical Yearbook 2023: 12–4 Major Agricultural Machinery at Year-end,” accessed June 21, 2024, <https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm>.

<sup>24</sup> Cyril Ip, “‘Cash cow’ subsidies: China targets fraud in farm machinery sales scheme,” *South China Morning Post*, December 4, 2023, <https://www.scmp.com/news/china/politics/article/3243671/cash-cow-subsidies-china-targets-fraud-farm-machinery-sales-scheme>.

<sup>25</sup> Colleen Howe, “China probes agriculture minister for suspected disciplinary violations,” *Reuters*, May 18, 2024, <https://www.reuters.com/world/china/china-probes-agriculture-minister-suspected-disciplinary-violations-2024-05-18/>.

<sup>26</sup> UN International Trade Centre, “List of partner markets for a product commercialized by China, Product: 870194 Tractors, of an engine power >75 kW but <=130 kW,” accessed March 1, 2024, <https://www.trademap.org/>.

Most strikingly, official Chinese statistics of machinery power and number of tractors of all sizes employed in agriculture have declined since MIC2025 began.<sup>27</sup> China's consumption of chemical fertilizer has also declined.<sup>28</sup>

These facts indicate that China's food security problem is growing and represents a persistent dependency on the West, especially the United States. China cannot yet claim to hold its rice bowl steady, as Xi so clearly desires it to.

## **BIOTECHNOLOGY**

- Chinese biotech companies are now producing novel drugs and therapies in small numbers, though they remain rare.
- China still relies on talent, technology, and capital from foreign biotechnology and pharmaceutical companies.
- China has built internationally successful genomics companies with strong ties to U.S. and other Western pharmaceutical companies and research institutions.

China's vast chemical industry has made it a world leader in the production of low-end active pharmaceutical ingredients (APIs), which are used in generic drugs. By some estimates, India and China together produce between 60 and 70 percent of generic drugs for the U.S. market—and India is deeply reliant on China for APIs, meaning China's role is even larger than topline statistics indicate.<sup>29</sup>

But Beijing's ambitions in biotech are far bigger than generic drugs. The CCP wants China to become a "biotech superpower" with companies capable of competing with Western pharmaceutical multinationals on the frontier of medicine.<sup>30</sup>

Not long ago, China's biotech sector was disparaged as far behind, mostly producing copy-cat drugs and therapies that built on research performed by other countries. There are signs that reputation is outdated, that China is positioned to transition from a "fast follower" to a biotech leader in the years ahead. However, despite considerable investment, China still struggles to produce novel drugs and therapies and remains deeply reliant on Western resources in this sector.

The Australian Strategic Policy Institute's (ASPI) Critical Technology Tracker finds that China leads in research of four out of seven biotech categories: synthetic biology, biological manufacturing, genome and genetic sequencing and analysis, and novel

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<sup>27</sup> National Bureau of Statistics of China, "China Statistical Yearbook 2023, 12-4 Major Agricultural Machinery at Year-end," accessed March 1, 2024, <https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm>.

<sup>28</sup> National Bureau of Statistics of China, "China Statistical Yearbook 2023, 12-5 Irrigated Area of Cultivated Land and Consumption of Chemical Fertilizers," accessed March 1, 2024, <https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm>.

<sup>29</sup> Mary Van Beusekom, "Cost of China-made drug ingredients more than doubled during the pandemic," University of Minnesota Center for Infectious Disease Research and Policy, June 21, 2024, <https://www.cidrap.umn.edu/resilient-drug-supply/cost-china-made-drug-ingredients-more-doubled-during-pandemic>.

<sup>30</sup> Anna Puglisi and Chryssa Rask, "China, Biotechnology, and BGI: How China's Hybrid Economy Skews Competition," Georgetown University Center for Security and Emerging Technology, May 2024, <https://cset.georgetown.edu/publication/china-biotechnology-and-bgi/>.

antibiotics and analysis.<sup>31</sup> In one of those categories (synthetic biology), ASPI judges there is a “high” risk of China monopolizing that technology. By contrast, the United States leads in research in just three areas: vaccines and medical countermeasures, genetic engineering, and nuclear medicine and radiotherapy.

China’s biotech industry has benefited from an influx of foreign capital, technology, and talent. In 2021, \$2 billion in venture capital and private equity flooded into the sector.<sup>32</sup> Most of the Western multinationals have major footprints in the country, often entering joint ventures with Chinese firms in the hunt for new drugs. Earlier this year, Fierce Pharma reported that “the CEOs of AstraZeneca, Bayer, Bristol Myers Squibb, GSK, Novartis, Pfizer, and Takeda came together in Beijing to show the companies’ continued interest in China” at a development forum.<sup>33</sup> Perhaps most important of all, China’s indigenous firms rely on so-called “sea turtles,” or Chinese nationals who study in the West and work at top pharmaceutical firms before returning to the mainland to run those firms’ competitors.<sup>34</sup>

These efforts are starting to bear fruit, although China remains behind the pack in drug discovery. Chinese pharmaceutical companies have started to produce “first in class” drugs in small numbers. These drugs employ novel mechanisms of action to treat medical conditions, and are thus viewed as a reliable sign of true innovation. However, they are still rare. One Chinese drug regulator lamented in 2021 that “original new drugs” were “as rare as morning stars.”<sup>35</sup>

China has had more success in the field of genomics. Its national champion is the now partially blacklisted BGI Group, which began as a research institute of the (also now blacklisted) Chinese Academy of Sciences and runs the country’s gene bank.<sup>36</sup> BGI and its subsidiaries, in particular MGI Tech and Complete Genomics, are significant producers of gene-sequencing instruments, equipment, and reagents, as well as gene-sequencing services. MGI Tech has undergone a significant commercial expansion. The company increased its domestic market share from 13 percent to 39 percent in the three years after the Covid-19 pandemic, in part due to government purchasing policies that privileged domestic firms. It also captured more than a five percent market share globally, allowing it to now earn more than half of its revenue overseas. Before federal restrictions fell in place, MGI Tech had even received research grants from the U.S. military, a disturbing fact given BGI Group’s close ties to the People’s Liberation Army

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<sup>31</sup> Jamie Gaida, Jennifer Wong Leung, Stephen Robin, & Danielle Cave, “ASPI’s Critical Technology Tracker: The global race for future power,” Australian Strategic Policy Initiative, 2023, [https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2023-03/ASPIs%20Critical%20Technology%20Tracker\\_o.pdf](https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2023-03/ASPIs%20Critical%20Technology%20Tracker_o.pdf).

<sup>32</sup> Anna Nishino, “Pharmacy of the world: China’s quest to be the No. 1 drugmaker,” *Nikkei Asia Review*, December 23, 2021, <https://asia.nikkei.com/static/vdata/infographics/chinavaccine-2/>.

<sup>33</sup> Angus Liu, “Big Pharma CEOs gather in Beijing to show continued interest in China, offer policy advice,” *Fierce Pharma*, March 26, 2024, <https://www.fiercepharma.com/pharma/big-pharma-ceos-gather-beijing-continued-interest-china-policy-advice-local-drug-industry>.

<sup>34</sup> Nishino, “Pharmacy of the world.”

<sup>35</sup> *Bloomberg News*, “China’s \$220 Billion Biotech Initiative Is Struggling to Take Off,” May 15, 2023, <https://www.bloomberg.com/news/articles/2023-05-15/china-biotech-stumbles-despite-220-billion-investment>.

<sup>36</sup> Philip Wang and Kathleen Magramo, “US adds Chinese genetics firms to trade blacklist over surveillance allegations,” *CNN*, March 2, 2023, <https://www.cnn.com/2023/03/02/business/us-blacklist-bgi-chinese-genetics-surveillance-companies-intl-hnk/index.html>.

(PLA). The company has reportedly performed genetic collection and analysis of foreign persons and ethnic minorities within China on behalf of the Chinese government.<sup>37</sup>

Another Chinese biotech player is WuXi AppTec, a contract research and manufacturing company that provides a host of services to its clients. WuXi has a client base and manufacturing facilities in the United States, boasting that its customers include all of the top 20 pharmaceutical companies.<sup>38</sup> An industry association of American biotech companies found that 79 percent had at least one contract or product agreement with a Chinese manufacturer; the “vast majority” were with WuXi or a subsidiary.<sup>39</sup> WuXi’s presence in the American market risks exposing U.S. intellectual property to theft. Earlier this year, a U.S. intelligence report claimed that the company transferred the data of an American client to China without its consent.<sup>40</sup>

Suspicion of China’s biotech companies likely will worsen the outlook for these companies in the years ahead, which will test the strength of its research base and native talent. Given its dependence on Western talent, technology, and capital, China’s biotech industry may not be able to rise to the challenge.

## **ELECTRIC VEHICLES**

- China is the world leader in EV technology and production.
- China’s growing export of automobiles of all types threatens a second “China Shock” that could degrade auto industries elsewhere in the world.
- China’s EV companies are locked in a brutal price war that will winnow the field and battle-harden the most competitive Chinese firms in the years ahead.

Perhaps no technology better exemplifies China’s rise in manufacturing than electric vehicles (EVs). The daily news is filled with articles about the threat that Chinese EVs pose to Western automakers. These EVs are cheap. Some entry-level models, such as the BYD Seagull hatchback, sell for as little as \$10,000. But it would be a mistake to view Chinese EVs merely as cheap. Thanks to sustained investment and focus on battery technology, drivetrains, and other fundamentals, Chinese automakers are producing EVs of impressive quality, with strong range, innovative features, and luxury stylings. China is a force to reckon with in EVs. The question now is how much damage it will do to the U.S. auto industry.

China did not start from zero on autos or even EVs. When MIC2025 was announced, the country already had a large auto industry, dominated by China’s Big Four state-owned

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<sup>37</sup> Kirsty Needham and Clare Baldwin, “China’s gene giant harvests data from millions of women,” *Reuters*, July 7, 2021, <https://www.reuters.com/investigates/special-report/health-china-bgi-dna/>.

<sup>38</sup> WuXi Biologics (Cayman) Inc., “Interim Report 2023,” <https://www.wuxibiologics.com/wp-content/uploads/2023-Interim-Report.pdf>.

<sup>39</sup> Karen Freifeld, “US bill to restrict WuXi AppTec, Chinese biotechs revised to give more time to cut ties,” *Reuters*, May 10, 2024, <https://www.reuters.com/technology/us-bill-restrict-wuxi-apptec-other-chinese-biotech-cos-revised-give-more-time-2024-05-10/>.

<sup>40</sup> Angus Liu, “In new letter to Defense Department, WuXi AppTec refutes claim of secret data transfer,” *Fierce Pharma*, May 13, 2024, <https://www.fiercepharma.com/pharma/would-never-approve-does-not-condone-wuxi-apptec-refutes-claim-secret-ip-transfer-letter-dod>.

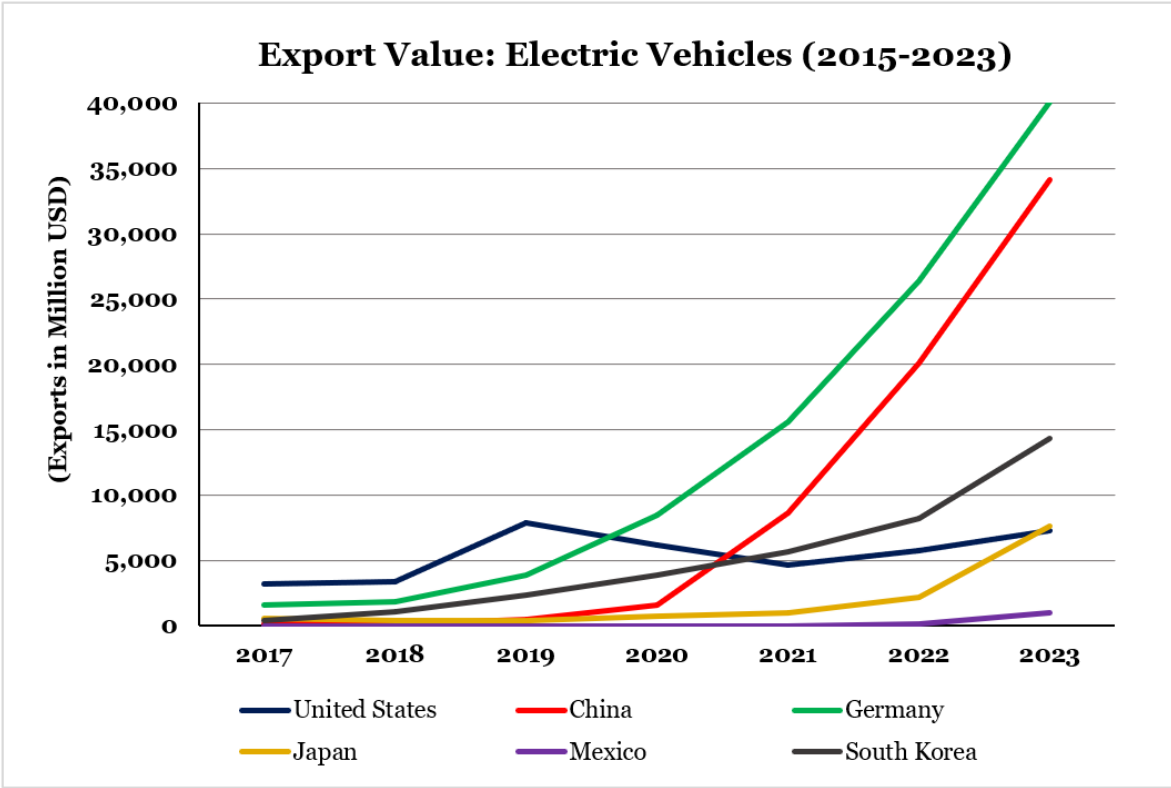
car companies: Shanghai Automotive Industry Corporation (SAIC), Dongfeng Motor, FAW Group, and Changan Automobile. These companies mostly served the domestic market, though they had a modest export business to rogue nations such as Iran and Venezuela.

Zeyi Yang of the *MIT Technology Review* credits one man, Wan Gang, for jumpstarting China's EV industry.<sup>41</sup> Wan was an Audi engineer who returned home and, in 2007, was named minister of science and technology. Wan knew that China would struggle to catch up with Western automakers in internal-combustion engines and hybrids, so he set China on the path to "leap ahead" by developing EV technology. Subsequent Chinese policy, including MIC2025, reflected this decision. Chinese authorities began subsidizing EV purchases and production, waiving expensive license-plate registration fees for EV buyers, and slashing red tape for factory construction. The Center for Strategic and International Studies (CSIS) has calculated that China's subsidies to its EV industry exceeded \$60 billion in the 2009-2017 timeframe, more than the United States devoted to semiconductors in the CHIPS Act.<sup>42</sup>

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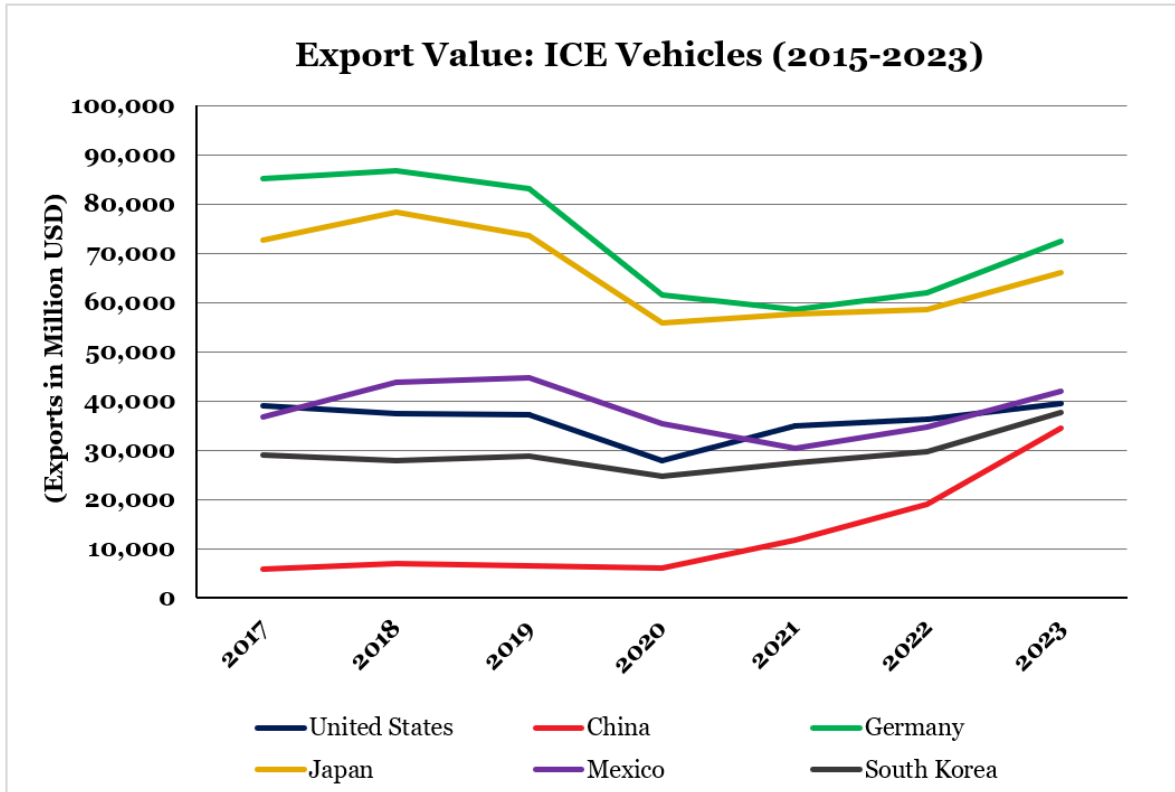
<sup>41</sup> Zeyi Yang, "How did China come to dominate the world of electric cars?," *MIT Technology Review*, February 21, 2023, <https://www.technologyreview.com/2023/02/21/1068880/how-did-china-dominate-electric-cars-policy/>.

<sup>42</sup> Luke Patey, "The Great EV Glut," *The Wire China*, May 19, 2024, <https://www.thewirechina.com/2024/05/19/the-great-ev-glut-european-union-electric-vehicle-china-chinese-electric-vehicles-evs-eu/>.



Source: UN International Trade Centre, Trade Map, accessed August 28, 2024, <https://www.trademap.org/>.

Note: Selected six-digit line: **870380** Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only electric motor for propulsion; Heading is shortened for length.



Source: UN International Trade Centre, Trade Map, accessed August 28, 2024, <https://www.trademap.org/>.

Note: Selected six-digit lines include: **870322** Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only spark-ignition internal combustion reciprocating piston engine of a cylinder capacity > 1.000 cm<sup>3</sup> but <= 1.500 cm<sup>3</sup>; **870323** Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only spark-ignition internal combustion reciprocating piston engine of a cylinder capacity > 1.500 cm<sup>3</sup> but <= 3.000 cm<sup>3</sup>; and **870324** Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only spark-ignition internal combustion reciprocating piston engine of a cylinder capacity > 3.000 cm<sup>3</sup>; Headings are shortened for length.

China’s intense focus on EVs led to the emergence of a new crop of EV and battery manufacturers. The proliferation of Chinese EV companies is due in part to policy support and in part to the relative simplicity of EV technology—EVs have far fewer parts and far more prepackaged parts than do internal-combustion engine vehicles. Whatever the exact cause, these startup companies proved far more innovative and successful than the state-owned enterprises that came before.

The outstanding case is BYD, a Shenzhen-based company founded as a manufacturer of lithium-ion batteries for cell phones. Before BYD received consistent support from the state, it benefited from an infusion of American capital: Warren Buffet’s Berkshire Hathaway invested \$230 million in the company in 2008, the same year that Tesla delivered its first vehicle, the Roadster.<sup>43</sup> BYD rocketed to the head of the pack in

<sup>43</sup> Arjun Kharpal and Evelyn Chang, “Musk once laughed off BYD as a threat. Now the Chinese giant has taken Tesla’s EV crown — here’s how,” *CNBC*, January 4, 2024, <https://www.cnbc.com/2024/01/05/how-byd-grew-from-a-phone-battery-maker-to-ev-giant-taking-on-tesla.html>.

Chinese EVs due to its innovative battery technology (batteries make up approximately 40 percent of the cost of an EV). BYD's history as a battery maker allowed it to create a lithium-ion phosphate battery, dubbed the Blade, that was thinner, cheaper, and safer than competitors on the market. This innovation in turn allowed BYD to slash prices on its vehicles, contributing to booming sales at home and abroad. In the final quarter of 2023, BYD dethroned Tesla in new EV sales, though it has since fallen back to second place.<sup>44</sup> Its market capitalization is currently higher than that of Ford or GM.<sup>45</sup>

MIC2025 set an ambitious goal of 3 million domestically made EV sales per year by 2025. China shattered that goal. In 2014, roughly 75,000 EVs were sold in China.<sup>46</sup> In 2023, 6 million EVs were sold at home, plus an additional 2.8 million plug-in hybrids.<sup>47</sup> Incredibly, China's supply has far outstripped substantial domestic demand. It exported nearly five million cars of all kinds last year, dethroning Japan as the world's largest auto exporter. Of those, more than one million were EVs, which have begun piling up in European ports like Rotterdam and Amsterdam-Bruges.<sup>48</sup>

China's auto industry threatens a second China Shock that could decimate industry in the developed world. Already, countries are adopting a variety of strategies to mitigate this risk and remain competitive. The Biden Administration has pegged its hopes on the Inflation Reduction Act, with the unintended consequences of directing subsidies to Chinese battery and EV companies and miring U.S. automakers deeper in a segment of the market undergoing a brutal price war. The Biden Administration has also imposed stiff tariffs on EVs that are made in China while ignoring the threat posed by Chinese gas-powered vehicles and EVs that are made in China's expanding network of transplant factories. Europe is also contemplating tariffs, which, in a Faustian bargain, it may use to encourage greater investment by Chinese automakers on European soil.

As the developed world struggles to respond to China's EV dominance, China itself is undergoing a ferocious winnowing. There are hundreds of Chinese EV companies at present, all trapped in a war of price and production as government subsidies begin to phase out. Many, if not most of these companies will not survive the threshing that is underway. The few companies that do, however, will be battle-hardened and ready to take on the rest of the world. As Lan Xiaohuan of Fudan University explains, "it is exactly in this stage of brutal competition that the industry is developing quickly, numerous small firms rise and fall fast, and resources and technologies are quickly concentrated in the hands of leading companies."<sup>49</sup> Automakers in the developed world

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<sup>44</sup> Laura He, "A brutal elimination round is reshaping the world's biggest market for electric cars," *CNN*, April 25, 2024, <https://www.cnn.com/2024/04/24/business/china-ev-industry-competition-analysis-intl-hnk/index.html>.

<sup>45</sup> Selina Cheng, River Davis, and Raffaele Huang, "Having Overtaken Tesla, BYD Is Running Into Problems Overseas," *The Wall Street Journal*, March 12, 2024, <https://www.wsj.com/business/autos/having-overtaken-tesla-byd-is-running-into-problems-overseas-7d883fo2>

<sup>46</sup> Report Buyer, "China Electric Vehicle Industry Report, 2014-2015," *PR Newswire*, September 14, 2015, <https://www.prnewswire.com/news-releases/china-electric-vehicle-industry-report-2014-2015-300142619.html>.

<sup>47</sup> CK Tan, "China's 2023 auto sales grow 12% on overseas demand for EVs," *Nikkei Asia Review*, January 11, 2024, <https://asia.nikkei.com/Business/Automobiles/China-s-2023-auto-sales-grow-12-on-overseas-demand-for-EVs>.

<sup>48</sup> Matko Rak, "European ports filling up with Chinese autos," *World Cargo News*, May 2, 2024, <https://www.worldcargonews.com/ports-terminals/2024/05/european-ports-filling-up-with-chinese-autos/>.

<sup>49</sup> Zichen Wang, "Lan Xiaohuan on China's Local Government Competition and Overcapacity," *Pekingology*, March 30, 2024, <https://www.pekingology.com/p/lan-xiaohuan-on-chinas-local-government>.



will need to think carefully about how best to compete in an EV world increasingly dominated by China.

## **ENERGY AND POWER GENERATION**

- China has built a commanding position in solar-energy technology, with a share of the global supply chain exceeding 80 percent.
- China is the technology leader in nuclear power, although construction at home and abroad is proceeding at a slower pace than desired.
- China is developing international standards and bidding aggressively on ambitious overseas projects for the electricity grid.

China is now the world's dominant power in energy and power generation equipment. This may seem over-bold, but a brief review of the facts leaves little room for doubt.

The gulf between China and the rest of the world is most obvious in solar energy, one of the “new three” technologies that China is prioritizing, along with batteries and EVs.<sup>50</sup> The U.S. Department of Energy's deeply researched report on the world's solar photovoltaic supply chain makes for sobering reading on this score. According to that report, China's share of the global supply chain exceeds 80 percent. In 2021, China had 70 percent of the world's production capacity for metallurgical grade silicon, 98 percent of ingot capacity, 97 percent of wafer capacity, 81 percent of solar cell capacity, and 77 percent of solar module capacity.<sup>51</sup>

This dominance, according to the U.S. Department of Labor, means that nearly half of the globe's polysilicon supply is sourced in China's Xinjiang Uyghur Autonomous Region, where it is mined and purified with Uyghur slave labor. The rapid scaling of solar production worldwide is not expected to change that fact. Per the Department of Energy report, “By the end of 2024, global manufacturing capacity for PV modules will increase another 40% to 1,100 GW, with China maintaining an 80-95% share (depending on the manufacturing segment) of the supply chain.”<sup>52</sup>

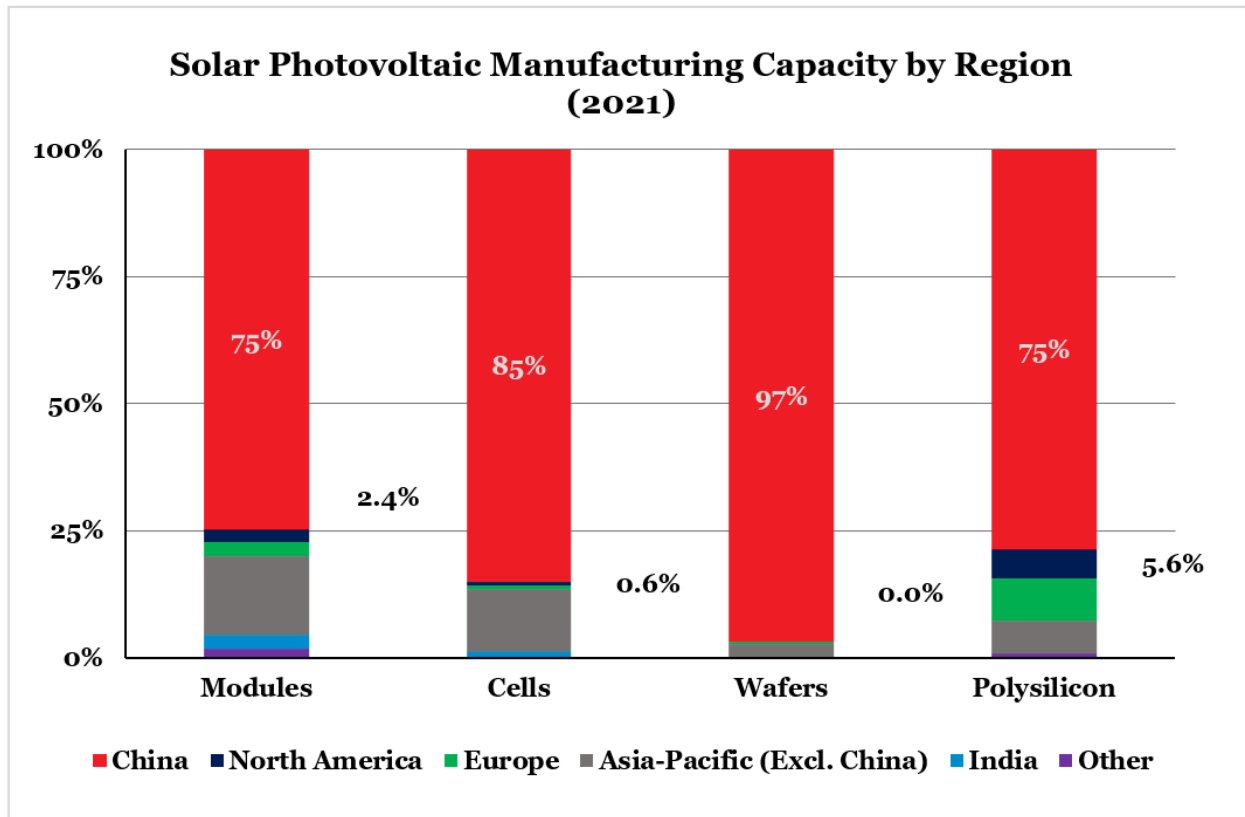
By contrast, the United States produced zero ingots, wafers, or cells last year. That may change this year, when a Georgia factory capable of making ingots, wafers, and cells opens—but even then, American production will be a rounding error compared to production in China.

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<sup>50</sup> *Guangming Daily*, “Looking at the resilience and momentum of foreign trade from the perspective of the “internet of things,” August 10, 2023, [https://www.gov.cn/yaowen/liebiao/202308/content\\_6897581.htm](https://www.gov.cn/yaowen/liebiao/202308/content_6897581.htm).

<sup>51</sup> Paul Basore and David Feldman, “Solar Photovoltaics: Supply Chain Deep Dive Assessment,” U.S. Department of Energy, February 24, 2022, <https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf>.

<sup>52</sup> Basore and Feldman, “Solar Photovoltaics: Supply Chain Deep Dive Assessment.”



Source: International Energy Agency, “Solar PV Global Supply Chains,” accessed June 20, 2024, <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary/>

As China ramps up production, it has flooded the world with cheap solar panels. Five percent of China’s gargantuan trade surplus in 2023 came from solar cells alone.<sup>53</sup> Meanwhile, prices of solar cells are in freefall, declining by half in 2023, with further price cuts expected. Chinese solar panels are so cheap they are being used as fencing and paving materials in some parts of Europe. This wave of cheap production has also crushed the solar industry throughout the rest of the world.

China has also snatched the lead from the United States in nuclear technology, although its dominance is not nearly as complete as in solar. As with other fields, China established its footing in nuclear through joint ventures with Western companies, notably Westinghouse (U.S.) and Areva (France). The condition for market access in China was technology transfer to China’s two nuclear state-owned enterprises, China National Nuclear Corporation and China General Nuclear Corporation. These firms then collaborated on a design for their own third-generation nuclear reactor, heavily copied from foreign sources, and climbed the value chain in components, construction, and operation. As a result, China is now in an exclusive club of countries that have designed

<sup>53</sup> Author calculation from UN International Trade Centre, “Bilateral trade between China and World, Product: 854143 Photovoltaic cells assembled in modules or made up into panels,” “Bilateral trade between China and World, Product: 854142 Photovoltaic cells not assembled in modules or made up into panels,” and “Bilateral trade between China and World, Product: TOTAL All products,” accessed March 1, 2024, <https://www.trademap.org/>.

their own nuclear reactors and have the capacity to construct them using entirely domestic firms.

China has also pushed to the frontier of nuclear technology—with vital assistance from the U.S. government. Late last year, a consortium that includes the China National Nuclear Corporation began commercial operations at the world’s first fourth-generation nuclear reactor, located in Shandong Province south of Beijing.<sup>54</sup> Fourth-generation reactors are designed with passive safety systems to render catastrophic accidents impossible, while increasing energy yield and flexibility of fuel types. Chinese regulators also greenlit the country’s first molten salt experimental reactor last year, which uses thorium for fuel instead of uranium.<sup>55</sup> The United States built a test reactor of this type in the 1960s, but subsequently abandoned the effort. During the Obama Administration, Oak Ridge National Laboratory signed a cooperation agreement with the Chinese Academy of Sciences that transferred the plans for a thorium reactor to China.<sup>56</sup> “The U.S. government seems to welcome Chinese scientists into Department of Energy labs with open arms,” one physicist noted.<sup>57</sup>

Despite these advances, China’s nuclear expansion has fallen short of the CCP’s ambitious goals. The country did not meet its target of 85 GW of installed capacity by 2020 and is still just shy of that target.<sup>58</sup> It has also struggled to export reactors overseas, despite its grand vision of building a “Nuclear Belt and Road” of 30 overseas reactors by 2030. So far, Pakistan is the only country with Chinese nuclear reactors.

Finally, China’s investments in power generation equipment are also bearing fruit. State Grid is China’s largest state-owned utility. It is the third-largest company in the world by revenue, after Walmart and Saudi Aramco, and has more than a million employees. State Grid has overseen construction of more than 30 ultra-high voltage (UHV) transmission lines to connect inland power plants with coastal population centers, all part of an effort to create a “super grid” that connects the entire country.<sup>59</sup> The largest of these projects, a collaboration between State Grid and a subsidiary of Japan’s Hitachi, stretches almost the length of the country, from northern Xinjiang to the central seaboard. It transmits enough power for 12 million people.<sup>60</sup>

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<sup>54</sup> Colleen Howe, “China starts up world’s first fourth-generational nuclear reactor,” *Reuters*, December 8, 2023, <https://www.reuters.com/world/china/china-starts-up-worlds-first-fourth-generation-nuclear-reactor-2023-12-06/>

<sup>55</sup> Nuclear Engineering International, “China’s experimental molten salt reactor receives license,” June 20, 2023, <https://www.neimagazine.com/news/newschinas-experimental-molten-salt-reactor-receives-licence-10952226>.

<sup>56</sup> David Lague and Charlie Zhu, “Special Report: The U.S. government lab behind China’s nuclear power push,” *Reuters*, December 20, 2013, <https://www.reuters.com/article/idUSBREqBJORN/>.

<sup>57</sup> Lague and Zhu, “Special Report.”

<sup>58</sup> Howe, “China starts up world’s first fourth-generation nuclear reactor.”

<sup>59</sup> Ye Ruolin and Yuan Ye, “Untangling the Crossed Wires of China’s ‘Super Grid,’” *Sixth Tone*, March 9, 2021, <https://www.sixthtone.com/news/1006932>.

<sup>60</sup> Hitachi Energy, “The world’s most powerful transmission system facilitated by Hitachi ABB Power Grids Technologies,” December 7, 2020, <https://www.hitachienergy.com/us/en/news/features/2020/07/the-world-s-most-powerful-transmission-system-facilitated-by-hi>.

State Grid is investing heavily in transmission infrastructure, at home and overseas. It plans to invest \$70 billion in the Chinese grid in 2024.<sup>61</sup> It is also “going out” to build overseas, with business in 51 countries in 2021, including the construction and operation of thousands of miles of transmission lines in Brazil.<sup>62</sup>

An important goal of MIC2025’s overseas project was to “establish a China-led international standard system” for UHV equipment. China has made progress toward creating such a system. From 2019 to 2022, the International Electrotechnical Commission (IEC) was led by Yinbiao Shu, a former president of State Grid and chairman of China Huaneng Group, another state-owned utility.<sup>63</sup> The number of IEC executive positions held by China increased by 100 percent between 2011 and 2021—although China still lags other powers, such as the United States, Germany, and Japan.<sup>64</sup>

Despite the immense scale of State Grid’s operations and efforts, China’s power grid is still seen as insufficient to meet the country’s voracious demand for energy. Many of the UHV transmission lines are operating well under capacity, or else are delayed.<sup>65</sup> State Grid is a long way off from achieving its goal of a national “super grid.”

What’s not in doubt is that China is a world leader in energy of virtually all kinds, and is the dominant producer of solar in particular.

## HIGH-SPEED RAIL

- China has by far the largest high-speed rail network in the world, but its infrastructure building spree has come at a staggering cost.
- China uses high-speed rail as a diplomatic tool to integrate foreign countries into the Belt and Road network and develop export markets.
- The export performance of China’s state-owned rail companies is underwhelming, and China has failed to meet the export targets it set in MIC2025.

China has laid more high-speed rail than the rest of the world combined, despite the country’s late start at developing such a network. Today, China’s high-speed rail stretches 28,000 miles, twice its length a decade ago, when MIC2025 was announced.<sup>66</sup>

China developed its rail industry using the time-tested strategy of forced joint ventures and technology transfer. China invited foreign rolling-stock companies to participate in

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<sup>61</sup> *Bloomberg News*, “China’s State Grid to Keep Spending High to Match Renewables,” January 14, 2024, <https://www.bloomberg.com/news/articles/2024-01-15/china-s-state-grid-to-keep-spending-high-to-match-renewables>.

<sup>62</sup> People’s Republic of China Belt and Road Portal, “Light up the World, Link with the Globe: State Grid Corporation of China on the Belt and Road,” accessed August 29, 2024, <https://eng.yidaiyilu.gov.cn/z/230718-1/index.shtml>.

<sup>63</sup> Yinbiao Shu, Biography, International Electrochemical Commission, accessed August 29, 2024, <https://www.iec.ch/basecamp/yinbiao-shu>.

<sup>64</sup> The U.S.-China Business Council, “USCBC Comments on China’s Influence in International Standards Setting for Emerging Technologies,” December 6, 2021, <https://www.uschina.org/advocacy/regulatory-comments-on-china/uscbc-comments-china%E2%80%99s-influence-international-standards-setting-emerging-technologies>.

<sup>65</sup> Ye Ruolin and Yuan Ye, “Untangling the Crossed Wires of China’s ‘Super Grid.’”

<sup>66</sup> *Xinhua*, “China’s operating high-speed railway hits 45,000 km,” January 9, 2024, <https://english.news.cn/20240109/28b8075c73384fa894e90afd1b8dodbc/c.html>.

the construction of its high-speed rail network, promising massive potential profits for an equally massive infrastructure buildup. As a condition of market entry, China forced these companies to enter joint ventures with Chinese firms, leading to the diffusion of knowledge and technology. China's supposedly indigenous high-speed trains bear striking resemblance to the trains that foreign companies like Canada's Bombardier and France's Alstom brought to China years ago, as researcher Kyle Chan has pointed out.<sup>67</sup> As in so many areas, China copied and stole from the best, then kicked out its foreign competition.

During the Global Financial Crisis, China used high-speed rail as a form of debt-fueled stimulus—what one observer labeled “Railway Keynesianism.”<sup>68</sup> Construction of high-speed rail lines employed hundreds of thousands of workers laid off from factories during the economic slump. It also supported demand for cement and steel, preventing a collapse of those vital commodities' sectors. In return, Beijing aimed to connect the country, spurring economic development in and projecting greater control over small towns, many of which got high-speed rail stations. China's two-decade-long rail blitz recalls the United States' nation-building during the 19th century, which included construction of the Transcontinental Railroad and many smaller lines. The difference, of course, is that China's high-speed rail network is constructed and operated almost entirely by state-owned enterprises, whereas the U.S. infrastructure buildout was conducted mainly by private companies, albeit with considerable public support.

Creating the world's largest and fastest high-speed rail network has come at a staggering cost to the Chinese government. In late 2022, China State Railway Group reported holding more than \$890 billion in debt—an amount equal to five percent of China's GDP at the time, per *Nikkei Asia Review*.<sup>69</sup> Municipal governments have taken on even more debt to finance high-speed rail projects. This massive debt compounded with falling ridership during the pandemic to force a change. Beijing has sharply raised fares and ordered some local governments to cease spending on infrastructure, although it still envisions increasing the size of the network by thousands of miles this decade.<sup>70</sup> Clearly, Beijing views high-speed rail as a prestige project and public good essential for economic development and consolidation of control over the nation. It is willing to leverage massively to achieve those goals.

Another prominent player in Chinese high-speed rail is CRRC, a state-owned rolling stock manufacturer that is now the world's largest. CRRC's products may be imitative rather than innovative, but it is able to offer rolling stock at a significant discount due to subsidies it receives from the Chinese government. Today, CRRC supplies virtually all trains to the Chinese market, the world's largest.

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<sup>67</sup> Kyle Chan, “How China uses foreign firms to turbocharge its industry,” *High Capacity*, March 29, 2024, <https://www.high-capacity.com/p/how-china-uses-foreign-firms-to-turbocharge>.

<sup>68</sup> Dhaval Desai, “China's high-speed railways plunge from high profits into a debt trap,” Observer Research Foundation, June 23, 2021, <https://www.orfonline.org/expert-speak/chinas-high-speed-railways-plunge-from-high-profits-into-a-debt-trap>.

<sup>69</sup> Shin Watanabe, “China Railway expands high-speed network as profits take back seat,” *Nikkei Asia Review*, January 29, 2023, <https://asia.nikkei.com/Business/Transportation/China-Railway-expands-high-speed-network-as-profits-take-back-seat>.

<sup>70</sup> Keith Bradsher, “China Is Raising Bullet Train Fares as Debts and Costs Balloon,” *The New York Times*, May 13, 2024, <https://www.nytimes.com/2024/05/13/business/china-bullet-trains-ticket-prices.html>

However, CRRC's dominance at home has not translated to success abroad, at least not yet. The company earns less revenue today than it did a decade ago, brings in little revenue from exports, and has seen its revenue from sales of railway equipment decline by one third.<sup>71</sup> Interestingly, China's export of rail locomotives by value has plummeted the past decade, while many other categories of rail parts and coaches have stagnated.<sup>72</sup> These statistics are due, in part, to proactive measures by foreign countries to shield their markets from Chinese rolling stock and components. They are due, as well, to the fact that CRRC has established overseas manufacturing bases in more than 10 countries.

But they could also indicate that the Chinese government views its rail industry as more of a diplomatic tool than a moneymaker. Rail projects with foreign countries are an important component of China's Belt and Road Initiative, in particular the "New Silk Road" that connects China to countries across Asia and the Middle East. The most recent example is Indonesia's 88-mile-long Jakarta to Bandung high-speed rail line, which began commercial operation last fall.<sup>73</sup> The rail line was built as a joint venture between state-owned Indonesian firms and China Railway International Co., with trains provided by CRRC. It is likely that the Chinese government subsidizes such projects because it believes they will facilitate exports for other Chinese industries or draw foreign countries closer to its sphere of influence.

## NEW MATERIALS

- China has established a vast R&D base for new materials, though it has so far failed to produce epochal breakthroughs.
- China has made important incremental progress in key materials, such as advanced carbon fiber, that long served as bottlenecks to development in other areas of technology.

In 2023, the scientific community was abuzz about a non-peer-reviewed article, published by Korean scientists, claiming to have discovered a room-temperature superconductor—a discovery that, had it been validated, would have been a monumental breakthrough in physics and materials science, dramatically decreasing the amount of energy required to run machines as diverse as supercomputers and MRI machines.

Instantly, an international race began to recreate the crystalline material used by the Korean scientists and replicate their findings. These replication attempts ultimately failed, and the original paper was retracted. But a striking fact of this saga was the

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<sup>71</sup> CRRC Corporation Ltd, "2022 Annual Report," <https://www.crrcgc.cc/Portals/73/Uploads/Files/2023/5-4/638188141827907831.pdf>

<sup>72</sup> UN International Trade Centre, "Bilateral trade between China and World, Product: 86 Railway or tramway locomotives, rolling stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electromechanical) traffic signalling equipment of all kinds," accessed March 1, 2024, <https://www.trademap.org/>.

<sup>73</sup> Achimad Ibrahim and Niniek Karmini, "Indonesian president launches Southeast Asia's first high-speed railway, funded by China," *Associated Press*, October 2, 2023, <https://apnews.com/article/indonesia-china-high-speed-railway-jakarta-bandung-3f1e4b5be6a83a0b0f54981c2e93be60>

outsized role played by China. Chinese scientists—many of whom were affiliated with the country’s most prestigious national laboratories and universities—were among the first to recreate the material in question, and their preprint manuscripts flooded the internet.<sup>74</sup> This episode demonstrated beyond doubt Beijing’s ambitions in materials science. China still lags in many areas of materials science, but it has created a massive research and development (R&D) complex to catch up with its competitors—and ultimately, it hopes, leap ahead.

ASPI’s Critical Technology Tracker again provides valuable evidence about the seriousness of this effort. Of the 10 technology areas ASPI tracks related to advanced materials, China has a research lead in all, meaning Chinese institutions are publishing the most highly-cited, high-quality research in those fields.<sup>75</sup> An example is nanoscale materials, which are engineered materials up to 100 nm in size that hold great potential for medical, energy, and construction applications. ASPI finds that nine out of the top 10 institutions in this field measured by the Hirsch index—a metric of scholarly impact—are in China, led by the Chinese Academy of Sciences. Measured another way, by proportion of most-cited papers, the entire top 10 list is dominated by Chinese institutions.

A more circumspect view of China’s materials science industry was provided late last year by Yong Gan, a former vice president of the Chinese Academy of Engineering. Yong saw “grand opportunities” and rapid development in China’s output of new materials.<sup>76</sup> He reported that China’s new materials industry has had a compound annual growth rate of 20 percent since 2015, versus 10 percent globally. The scale of China’s new materials industry is also large, accounting for 30 percent of global output. Nevertheless, Yong criticized China’s research base for its failure to achieve breakthroughs and the “insufficient novelty” of its patents. Chinese scientists “have yet to make any epoch-making contributions in terms of breakthroughs in important materials,” he lamented. China’s investment intensity in new materials R&D also lags behind that of other developed countries, such as the United States, Japan, and United Kingdom. Ultimately, Yong placed China in the “second tier” of countries in new materials, alongside Korea and Russia, but behind the United States, Japan, and the European Union.

In a similar vein, technology analyst AJ Cortese notes that China has a talent problem in materials science.<sup>77</sup> Simply put, young Chinese do not seem to view the industry as a promising field, and are entering it in far fewer numbers than they are other high-tech fields, like computer science. Most materials science jobs are in “traditional” industries, located in China’s industrial heartland. They tend not to attract the country’s best talent.

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<sup>74</sup> Margaret Harris, “Room-temperature superconductor’ LK-99 fails replication tests,” *physicsworld*, August 15, 2023, <https://physicsworld.com/a/room-temperature-superconductor-lk-99-fails-replication-tests/>.

<sup>75</sup> Jamie Gaida, Jennifer Wong Leung, Stephen Robin, and Danielle Cave, “ASPI’s Critical Technology Tracker.”

<sup>76</sup> Yong Gan, “Research on the Innovative Development of New Materials Science and Technology in China,” *Engineering*, January 2024, <https://doi.org/10.1016/j.eng.2023.03.022>.

<sup>77</sup> AJ Cortese, “Materials Science Matters: The Talent Central to China’s Tech Pivot,” *Macro Polo*, August 8, 2023, <https://macropolo.org/materials-science-talent-chinas-tech-pivot/>.

Carbon fiber technology in China provides a case study, showing that China is catching up quickly, but has not yet cracked the top tier of materials science powers.

Lightweight, stiff, and strong, carbon fiber is an advanced material key to strategic industries. As Cortese documents, China is now the world's dominant producer of mid-range carbon fiber, responsible for 43 percent of global output, followed by the United States (18.5 percent) and Japan (9.6 percent).<sup>78</sup> The indigeneity of China's carbon fiber has also skyrocketed, climbing from 12.5 percent in 2015 to more than 60 percent today.<sup>79</sup> Cortese attributes China's success to its wind-power industry—wind-turbine blades are made of carbon fiber—which provided the demand signal for Chinese firms to invest.<sup>80</sup> However, China has long been locked out of the market for advanced carbon fiber (so-called T1000 carbon fiber), which is essential to aerospace and defense applications and has long been subject to multilateral export controls.

China is only now overcoming this hurdle. Late last year, Shenzhen University and Changsheng Technology announced a breakthrough in the mass manufacture of T1000 carbon fiber.<sup>81</sup> If China is able to scale production of this material, it could enter the first rank of powers in sectors like aerospace, where it lags to this day. In such a world, China's focus on advanced materials would be vindicated. But it has not been vindicated yet.

## **ROBOTS AND MACHINE TOOLS**

- China does not yet have a world-leading, home-grown robotics manufacturer. Its most valuable firm is an acquisition from overseas.
- Chinese robotics firms have nonetheless started to take over domestic market share from leading international firms, progressively moving into higher-value types of robots and reducing China's reliance on imports.

China has introduced robots into its factories on a scale and at a speed never before seen in history, as this report discusses at greater length in the section on Smart Manufacturing. It is in a race against time, as it attempts to automate its industry to make up for a shrinking pool of prime-age workers. The urgency of this task has made China dependent on foreign manufacturers of robots and advanced machine tools, like high-end computer numerical control machines. Beijing's goal in MIC2025 was to end this dependency.

China has not yet built a national champion in robotics capable of challenging the world's leading companies. Japanese firms, along with the Swedish-Swiss giant ABB,

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<sup>78</sup> AJ Cortese, "The Curse of Success: Can China Level Up on Carbon Fiber?," Macro Polo, October 26, 2023, <https://macropolo.org/can-china-take-carbon-fibers-to-the-next-level/>.

<sup>79</sup> Cortese, "The Curse of Success."

<sup>80</sup> Ibid.

<sup>81</sup> Zhang Tong, "Chinese tech could break barrier to making crucial defence and aerospace material," *South China Morning Post*, August 23, 2023, <https://www.scmp.com/news/china/science/article/3231954/chinese-tech-could-break-barrier-making-crucial-defence-and-aerospace-material>.



dominate the list of top industrial robotics companies by revenue, taking six out of the top 10 spots in one informal ranking.<sup>82</sup> No home-grown Chinese company made the cut.

Instead, China bought a champion. The country's most important robotics asset is KUKA, a more than century-old Bavarian manufacturer. The Chinese electrical appliance manufacturer Midea absorbed KUKA in 2016, one year after MIC2025 was launched. Midea initially took a small stake in the company before expanding that stake to 95 percent of outstanding shares and pushing aside its CEO.<sup>83</sup> Midea claimed not to want full control of the company, but nonetheless purchased all outstanding shares in 2022, completing the takeover. KUKA's specialized knowledge in robotics for the automotive industry is of particular importance as China ramps up its EV industry. KUKA currently supplies major European, American, and Chinese automakers. Tesla, for example, reportedly relies on KUKA robotic arms in its Gigafactories, including the Austin Gigafactory that produces the Cybertruck.<sup>84</sup> Midea undoubtedly hopes to digest the technology and knowledge that KUKA has built over the past century to improve China's standing in robotics.

China's homegrown firms are smaller, but growing quickly in the domestic market. The main players are Suzhou Inovance Technology, Estun Technology, and Efort Intelligence Equipment. Inovance is the most significant firm of the three, with more than \$2 billion in revenue and a market cap of \$25 billion. The company was founded by a group of former Huawei engineers and is referred to as the "little Huawei."<sup>85</sup> The firm's billionaire founder, Zhu Xingming, has signaled that his goal is to break into the top three companies in the sector within five years, which would require a significant international expansion. The product page on the company's website for the European market says Inovance's industrial robot offerings are "coming soon."

Already, "the little Huawei" and other homegrown Chinese firms are helping China break its dependence on imported robots and machine tools. Despite record installations, China's imports of industrial robots have declined the past two years.<sup>86</sup> This is due to the steadily increasing business of Chinese firms, which had an estimated 35.5 percent domestic market share in 2022, up from 17.5 percent a decade ago.<sup>87</sup> China's position in the highly fragmented machine-tool market is even stronger, with Chinese producers accounting for nearly a third of *global* production in 2022; Germany

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<sup>82</sup> Marcus Law, "Top 10 industrial robotics companies in the world in 2023," Technology Magazine, February 10, 2023, <https://technologymagazine.com/top10/top-10-industrial-robotics-companies-in-the-world-in-2023>

<sup>83</sup> Cynthia Wrage and Jakob Kullik, "After Kuka—Germany's Lessons Learned from Chinese Takeovers," China Observers in Central and Eastern Europe, July 21, 2022, <https://chinaobservers.eu/after-kuka-germanys-lessons-learned-from-chinese-takeovers/>.

<sup>84</sup> Rebecca Ren, "How does appliance giant Midea bulk up robotic arms for Tesla and the entire EV industry," *Pingwest*, January 9, 2023, <https://en.pingwest.com/a/11293>.

<sup>85</sup> William Langley and Gloria Li, "Chinese robot maker says protectionism will not stop its march," *Financial Times*, April 4, 2024, <https://www.ft.com/content/ocdf78f9-e2cc-48ff-ba65-027f1cf83334>.

<sup>86</sup> International Trade Centre, "Bilateral trade between China and World, Product: 847950 Industrial robots, n.e.s.," accessed March 1, 2024, <https://www.trademap.org/>.

<sup>87</sup> *Caixin Global*, "Homegrown robots are marching into Chinese factories," June 16, 2023, <https://www.thinkchina.sg/technology/homegrown-robots-are-marching-chinese-factories>.

and Japan, the world's second and third largest producers of machine tools, each made about 13 percent of the world's machine tools that year.

Foreign CEOs are waking up to the fact that the tables are turning against them in China. Earlier this year, the Japanese robotics giant, Omron, performed a mass layoff—its first since the dot-com bubble.<sup>88</sup> The firm's president acknowledged that “we've become increasingly dependent on China” and are “struggling against the rise of local Chinese makers.”

China has not yet become a major exporter of industrial robots and has a limited footprint in the high end of the robotics and machine tool market, but its firms are becoming more sophisticated as they learn to service industrial clients at home. As the former general manager of Estun remarked last year: “In the past, domestic industrial robots were mainly used for tasks such as handling, palletising, loading and unloading, and low-end welding. Now, they are gradually expanding into high-end tasks such as assembly, polishing, gluing, and spraying, and are entering industries previously monopolised by foreign robot manufacturers.”<sup>89</sup>

## **SEMICONDUCTORS**

- China remains deeply reliant on foreign countries for key inputs, including lithography equipment, Electronic Design Assistance software, and advanced materials.
- Chinese semiconductor manufacturing companies like SMIC are pushing the boundaries of what is possible in the face of export controls, but are several generations behind the leading edge.
- China is developing a dominant position in legacy chips, which have immense commercial and military significance, as well as assembly, testing, and packaging.

General Secretary Xi has described information technology, in particular semiconductors, as the “heart” of Chinese industry.<sup>90</sup> “When your heart isn't strong, no matter how big you are, you're not really strong,” he has said.<sup>91</sup> Accordingly, MIC2025 targeted semiconductors for special attention and support.

Today, China still trails much of the developed world in cutting-edge semiconductor fabrication, semiconductor manufacturing equipment, Electronic Design Assistance (EDA) software, and advanced materials like substrates and gases. It also runs a substantial trade deficit in semiconductors, relying on imports, mostly from Taiwan and Korea, to meet the voracious demands of its internal market and manufacturers. However, it is developing home-grown alternatives in each area. China is also well-positioned to dominate the production of less advanced chips (so-called legacy chips)

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<sup>88</sup> Hirotaka Tamaoka, “China automation slump lays bare Omron's dependence on market,” *Nikkei Asia Review*, March 15, 2024, <https://asia.nikkei.com/Business/Electronics/China-automation-slump-lays-bare-Omron-s-dependence-on-market>.

<sup>89</sup> *Caixin Global*, “Homegrown robots are marching into Chinese factories.”

<sup>90</sup> Geoffrey Cain, “The Purges that Upended China's Semiconductor Industry,” *American Affairs*, Winter 2022, <https://americanaffairsjournal.org/2022/11/the-purges-that-upended-chinas-semiconductor-industry/>.

<sup>91</sup> Cain, “The Purges that Upended China's Semiconductor Industry.”

and other parts of the semiconductor supply chain, like assembly, testing, and packaging (ATP).

China has invested heavily to develop an indigenous semiconductor industry, spending potentially more than \$150 billion in the past decade through state-led investment funds like the National Integrated Circuit Industry Investment Fund (the “Big Fund”) and a host of smaller, local funds.<sup>92</sup> Recently, Beijing has concentrated control of its semiconductor investments in a secretive government-run working group, which indicates the importance the CCP places on semiconductor technology and its desire to avoid further sanctions from the U.S. government.<sup>93</sup>

This state-directed investment has produced expensive failures, notably Tsinghua Unigroup, whose overextension and decline led to a round of corruption probes, prosecutions, and purges of company executives and managers at the Big Fund.<sup>94</sup>

However, it has also produced successes. China’s memory champion, Yangtze Memory Technologies Corp. (YMTC), was formerly owned by Tsinghua Unigroup, and has similarly benefited from massive state investment. YMTC appears to be succeeding despite a U.S. government blacklisting, reportedly producing the world’s most advanced commercially available NAND memory product.<sup>95</sup> The company is successful enough that in 2022, Apple considered using its memory products in devices for the Chinese market, although it scrapped that plan due to political backlash.<sup>96</sup>

China’s premier manufacturer of logic chips is Semiconductor Manufacturing International Corp. (SMIC), a state-owned firm with close ties to the Chinese military. SMIC has also battled U.S. sanctions with considerable success. Multilateral export controls on semiconductor manufacturing tools have cut off SMIC’s access to the most advanced chipmaking equipment produced by firms like ASML. In response, SMIC has pushed the boundaries of what is possible with older equipment. Last year, Huawei stunned industry observers by releasing a new smartphone powered by a SMIC logic chip at the 7 nm node of production, just a few generations away from the cutting edge. SMIC produced this chip using older tools, although it is unclear whether this workaround can produce chips in sufficient quantities and with a high enough yield to be profitable. Nevertheless, the appearance of this chip was widely touted in Chinese state media as a victory for indigenous Chinese chipmakers over U.S. technology controls.

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<sup>92</sup> Economist Intelligence Unit, “China boosts state-led chip development,” March 13, 2024, <https://www.eiu.com/n/china-boosts-state-led-chip-investment/>.

<sup>93</sup> Paul Triolo, “A New Era for the Chinese Semiconductor Industry: Beijing Responds to Export Controls,” *American Affairs*, Spring 2024, <https://americanaffairsjournal.org/2024/02/a-new-era-for-the-chinese-semiconductor-industry-beijing-responds-to-export-controls/>.

<sup>94</sup> Triolo, “A New Era for the Chinese Semiconductor Industry.”

<sup>95</sup> Anton Shilov, “China’s YMTC Starts Producing Mysterious New Memory, Ups 3D NAND Prices,” *Tom’s Hardware*, July 18, 2023, <https://www.tomshardware.com/news/ymtc-ups-3d-nand-price-starts-production-of-mysterious-memory>

<sup>96</sup> Office of Senator Marco Rubio, “Rubio to Apple: Deal with CCP Chipmaker Would Threaten U.S. National Security, Strengthen China,” April 1, 2022, <https://www.rubio.senate.gov/rubio-to-apple-deal-with-ccp-chip-maker-would-threaten-u-s-national-security-strengthen-china/>

Despite these advances, China remains substantially behind the cutting edge in virtually all areas of semiconductor manufacturing. In particular, China lags in lithography equipment and EDA software and remains reliant on a handful of Western firms for such products. Its problems will grow if a future U.S. administration is more diligent about denying export licenses to China's blacklisted chip champions, particularly SMIC and YMTC, and sanctioning Chinese suppliers to those firms and Huawei.

The picture changes when one looks at legacy or "mature" chips, as well as other parts of the supply chain, like ATP. These areas have not been the subject of as much attention or concern in Washington. But China's semiconductor industry is robust in them, posing a distinct threat to manufacturers elsewhere in the world. SMIC and other Chinese chipmakers have been on a construction spree of fabs producing less advanced chips, which go into automobiles, airplanes, and countless weapons systems. Last year, the U.S. Director of National Intelligence noted that China plans to build "dozens" of semiconductor factories by the end of 2024, "most of which will be dedicated to producing older, more mature technologies."<sup>97</sup> China is therefore poised to capture a significant share of the global market for these vital chips in the years ahead; China already controls 27 percent of global foundry capacity in the 20-45 nm range, and as much as 80 percent of global foundry capacity in this range could be located in mainland China and Taiwan within the decade, according to the Rhodium Group.<sup>98</sup> This consolidation would further raise the stakes of a Taiwan contingency.<sup>99</sup>

Another strength of China's, and point of dependency for the United States, is ATP. Two of the four largest ATP companies, Amkor Technology and JCET Group, are Chinese. Virtually all of the operations in this back-end segment of the semiconductor supply chain are concentrated in a few countries in Asia. And China is aggressively buying factories from and buying stakes in non-Chinese ATP firms, like Taiwan's ASE Group and Powertech Technologies. While ATP is typically low-value and labor intensive, it is a bottleneck that could be used against Western chipmakers. Increasingly, that bottleneck runs through China.

## **SHIPBUILDING**

- China is by far the world's largest shipbuilding power by tonnage, outbuilding the United States by a margin that is difficult to fathom.
- China has demonstrated the ability to produce quality as well as quantity, building highly capable aircraft carriers, large LNG tankers, and cruise ships.
- China's growing fleet of "research" vessels and RORO ships enables it to project power in the Asia-Pacific and propel its exports to distant markets.

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<sup>97</sup> Office of the Director of National Intelligence, "Annual Threat Assessment of the U.S. Intelligence Community," February 6, 2023, <https://www.dni.gov/files/ODNI/documents/assessments/ATA-2023-Unclassified-Report.pdf>.

<sup>98</sup> Jan-Peter Kleinhans, Reva Goujon, Julia Hess, and Lauren Dudley, "Running on Ice: China's Chipmakers in a Post-October 7 World," Rhodium Group, April 4, 2023, <https://rhg.com/research/running-on-ice/>.

<sup>99</sup> Kleinhans, et. al, "Running on Ice."

Last year, the Office of Naval Intelligence reported that China’s shipbuilding capacity exceeded our own more than 200 times over.<sup>100</sup> This remarkable statistic speaks to the equally remarkable rise of China as a shipbuilding power. Chinese shipyards now float as much tonnage each year as the rest of the world’s shipyards combined, while U.S. commercial shipbuilding has shrunk to a fraction of a percent of global output, behind small maritime powerhouses like Turkey.<sup>101</sup>

In addition to sheer output, China has climbed the value chain by demonstrating the ability to build some of the world’s largest and most sophisticated types of ships. The three “crown jewels” of the shipbuilding industry are aircraft carriers, liquefied natural gas (LNG) tankers, and luxury cruise ships. China has proven its mettle in all three areas. In May, the PLA Navy (PLAN) began sea trials of the *Fujian*, China’s third aircraft carrier and its first to be designed and built domestically, as well as its first to employ catapults; the PLAN is also allegedly building a smaller carrier for fixed-wing drones, which would be the first in the world.<sup>102</sup> China is competing fiercely with Korea for LNG tanker orders, with three shipyards taking contracts for the huge vessels in recent years.<sup>103</sup> China’s Hudong-Zhonghua shipyard recently released a design for the world’s largest such tanker, in collaboration with Qatar.<sup>104</sup> And last year, China’s first domestically built luxury cruise liner, the *Adora Magic City*, embarked on its maiden voyage.

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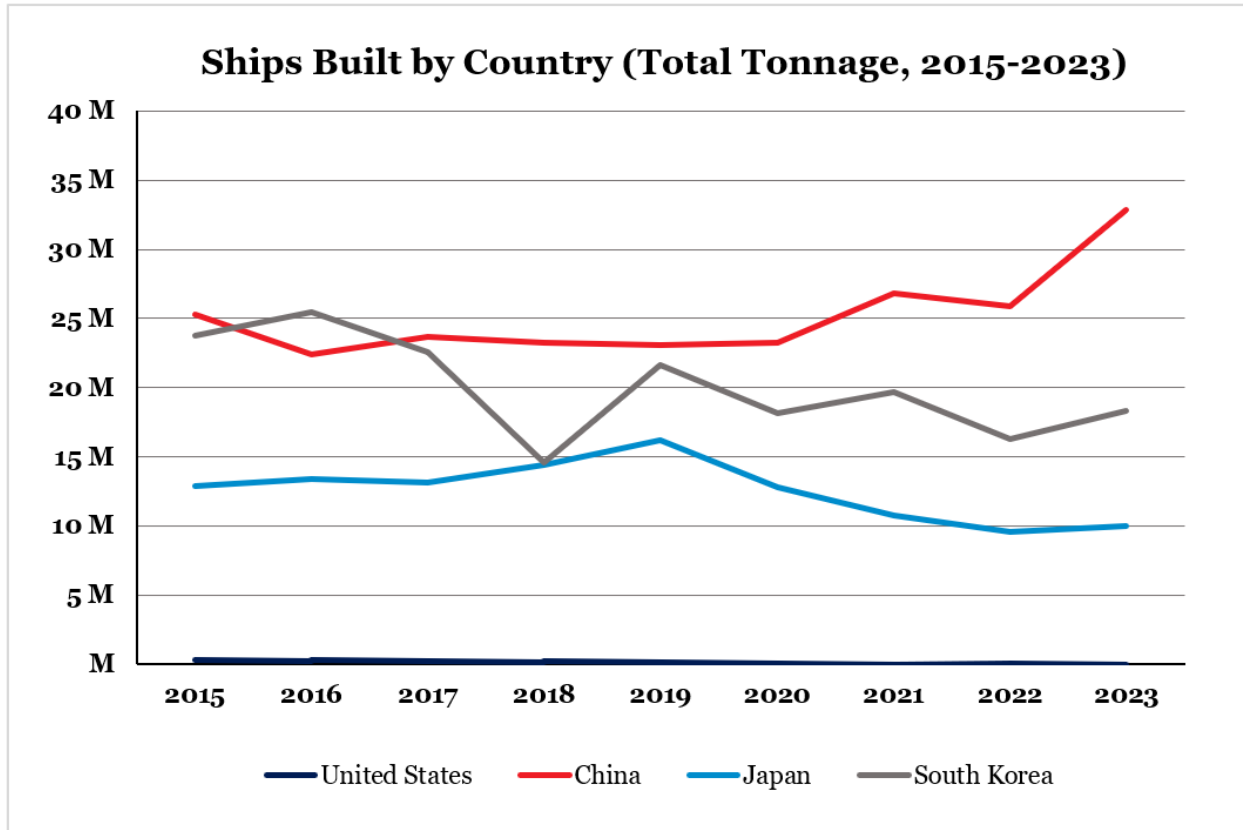
<sup>100</sup> Alexander Palmer, Henry Carroll, and Nicholas Velasquez, “Unpacking China’s Naval Buildup,” Center for Strategic and International Studies, June 5, 2024, <https://www.csis.org/analysis/unpacking-chinas-naval-buildup>

<sup>101</sup> UN Trade and Development, “Ships built by country of building, annual,” accessed May 22, 2024, <https://unctadstat.unctad.org/datacentre/dataviewer/US.ShipBuilding>.

<sup>102</sup> H.I. Sutton, “China Builds World’s First Dedicated Drone Carrier,” *Naval News*, May 15, 2024, <https://www.navalnews.com/naval-news/2024/05/china-builds-worlds-first-dedicated-drone-carrier/>.

<sup>103</sup> *The Maritime Executive*, “China Trounces Korea Taking Three-Quarters of Shipbuilding Orders in April,” May 8, 2024, <https://maritime-executive.com/article/china-trounces-korea-taking-three-quarters-of-shipbuilding-orders-in-april>.

<sup>104</sup> *The Maritime Executive*, “China Designs World’s Largest LNG Carrier,” September 5, 2023, <https://maritime-executive.com/article/china-designs-world-s-largest-lng-carrier>.



Source: UN Trade and Development, “Ships built by country of building, annual,” accessed May 22, 2024, <https://unctadstat.unctad.org/datacentre/dataviewer/US.ShipBuilding>.

Just because China has demonstrated the ability to build these cutting-edge vessels does not mean its shipbuilding industry as a whole is cutting-edge. The *Fujian* is not nuclear-powered (although the PLAN has a host of nuclear-powered attack submarines), and has fewer elevators and catapults than the U.S. Navy’s *Ford* class carriers. Korean shipyards remain the most sought-after destinations for LNG tankers. And the *Adora Magic City* is far from the world’s largest or most advanced cruise liner—and in fact, only 30 percent of the ship’s suppliers were Chinese.<sup>105</sup>

Still, China’s growing strength in shipbuilding is already having strategic consequences. Chinese-built roll-on/roll-off (RORO) ships are ferrying Chinese-made automobiles to foreign markets. BYD alone plans to own eight such vessels within two years, each capable of carrying thousands of cars.<sup>106</sup> RORO ships are also critical to war plans for Taiwan, as any such invasion would require an immense amount of amphibious sealift.

<sup>105</sup> Lin Yang, “China’s First Cruise Ship: Made in China, Sourced from Europe,” *POLYGRAPH.info*, February 14, 2024, <https://www.polygraph.info/a/fact-check-china-s-first-cruise-ship-made-in-china-sourced-from-europe/7487605.html>.

<sup>106</sup> Shizuka Tanabe, “BYD to deploy fleet of 8 car carriers to underpin global EV expansion,” *Nikkei Asia Review*, March 5, 2024, <https://asia.nikkei.com/Spotlight/Electric-cars-in-China/BYD-to-deploy-fleet-of-8-car-carriers-to-underpin-global-EV-expansion>.

Chinese merchant ferries take part in PLA exercises, demonstrating their ability to offload vehicles at sea, without the benefit of a developed harbor.<sup>107</sup>

China is also using its shipbuilding strength to expand its footprint in the Indo-Pacific. MIC2025 called for the development of offshore engineering and deep-sea exploration capabilities, including “deep-sea space stations.” The deep-sea space stations have yet to materialize, but China has made strides in less fantastic offshore engineering technology. In December 2023, a Chinese ultra-deepwater drilling vessel, the *Mengxiang*, conducted sea trials.<sup>108</sup> Around that time, a separate Chinese research vessel, the *Zhu Hai Yun*, circumnavigated Taiwan and entered its territorial waters at several points;<sup>109</sup> that vessel embarked from a research institute that collaborates with the PLAN on signals intelligence.<sup>110</sup> China hopes to use experimental vessels like these to project power, spy on its neighbors, and, as Baron Public Affairs notes, create a “blue economy” based on deep-sea mining and drilling primarily outside of its exclusive economic zone.<sup>111</sup> China has already secured exclusive rights to mine 92,000 square miles of international seabed in the Pacific, 17 percent of total licensed area.<sup>112</sup>

As one Chinese marine geologist has said: “[N]ow we have this equipment, we can make up for lost time. China can be its own master and can host and work with people in developing countries.”<sup>113</sup>

## Innovation

- China’s capacity for innovation has improved along a variety of metrics, including R&D spending, science and technology cluster development, and patents.
- By one account, China leads the world in producing high-quality research in 37 out of 44 critical technologies, including technologies with important military applications.

MIC2025 placed innovation “at the core” of China’s manufacturing industry.<sup>114</sup> In particular, the strategy called for strengthening R&D, improving innovative design capabilities, promoting applied research into science and technology, and strengthening China’s ability to set standards for manufacturing. By many metrics, China’s manufacturing sector is far more innovative today than it was a decade ago.

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<sup>107</sup> Conor Kennedy, “Ramping the Strait: Quick and Dirty Solutions to boost amphibious lift,” Jamestown Foundation, July 16, 2021, <https://jamestown.org/program/ramping-the-strait-quick-and-dirty-solutions-to-boost-amphibious-lift/>.

<sup>108</sup> Baron Public Affairs, “Deep-Sea Minerals: The Next Arena of U.S.-China Competition,” Winter 2024, <https://www.baronpa.com/library/deep-sea-minerals-the-next-arena-of-u-s-china-competition/>.

<sup>109</sup> Matthew Funaiole, Aidan Powers-Riggs, and Brian Hart, “Skirting the Shores: China’s New High-Tech Research Ship Probes the Waters Around Taiwan,” Center for Strategic and International Studies, February 26, 2024, <https://features.csis.org/snapshots/china-research-vessel-taiwan/>.

<sup>110</sup> Funaiole, et. al, “Skirting the Shores.”

<sup>111</sup> Baron Public Affairs, “Deep-Sea Minerals.”

<sup>112</sup> Lily Kuo, “China is set to dominate the deep sea and its wealth of rare metals,” *Washington Post*, October 19, 2023, <https://www.washingtonpost.com/world/interactive/2023/china-deep-sea-mining-military-renewable-energy/>.

<sup>113</sup> Kuo, “China is set to dominate the deep sea and its wealth of rare metals.”

<sup>114</sup> State Council of the People’s Republic of China, “Notice of the State Council on the Publication of ‘Made in China 2025.’”

The World Intellectual Property Organization (WIPO) produces the “Global Innovation Index,” which ranks countries by a basket of metrics associated with innovation. In 2015, the year MIC2025 was released, China ranked 29<sup>th</sup> in the world, above Portugal and Italy and below Spain and Slovenia (Hong Kong ranked 11<sup>th</sup>).<sup>115</sup> In 2023, China ranked 12<sup>th</sup> in the world, above Japan and Israel and below Korea and France (Hong Kong ranked 17<sup>th</sup>).<sup>116</sup> This represents a marked improvement in China’s position relative to other countries.

China scored highly on metrics related to innovation in manufacturing, including corporate R&D investment (2<sup>nd</sup>), gross capital formation (2<sup>nd</sup>), industry diversification (2<sup>nd</sup>), domestic market scale (1<sup>st</sup>), cluster development (2<sup>nd</sup>), patents (2<sup>nd</sup>), labor productivity growth (1<sup>st</sup>), high-tech manufacturing (13<sup>th</sup>), high-tech exports (5<sup>th</sup>), and industrial designs (2<sup>nd</sup>). It fared poorly in environmental metrics, “institutional” metrics related to its political and regulatory environment, and “online creativity” metrics related to software development and app creation. This distribution of strengths and weaknesses indicates that China is highly innovative in manufacturing, while struggling in areas of less obvious relevance to production.

WIPO also tracks science and technology clusters around the world, which are areas with a particularly high concentration of companies and institutions dedicated to scientific and technological pursuits. There, too, China has made significant progress. In 2023, for the first time, China had the most clusters in the top 100 (24), surpassing the

WIPO Global Innovation Index Rankings (2023)		
	United States	China
Corporate R&D Investment	1	2
Gross Capital Formation	81	2
Industry Diversification	6	2
Domestic Market Scale	1 (tie)	1 (tie)
Cluster Development	1	2
Patents	7	2
Labor Productivity Growth	50	1
High-Tech Manufacturing	24	13
High-Tech Exports	20	5
Industrial Designs	69	2

Source: World Intellectual Property Organization, 2023 Global Innovation Index

<sup>115</sup> World Intellectual Property Organization, “Global Innovation Index 2015 Rankings,” accessed June 20, 2024, [https://www.wipo.int/edocs/pubdocs/en/wipo\\_pub\\_gii\\_2015-intro5.pdf](https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2015-intro5.pdf).

<sup>116</sup> World Intellectual Property Organization, “Global Innovation Index 2023,” accessed June 20, 2024, <https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023-en-main-report-global-innovation-index-2023-16th-edition.pdf>.



United States' 21.<sup>117</sup> China has three clusters in the top 10 (Shenzhen/Hong Kong, Beijing, and Shanghai), compared to the United States' four (San Francisco, Boston/Cambridge, San Diego, and New York City). China, of course, is a much larger country than the United States, so on a per capita basis it has fewer innovation clusters. But the gap is shrinking.

Another measure of innovation is a country's research into critical technologies. ASPI tracks countries' progress in these technologies by looking at countries' shares of highly cited research papers, their score on the Hirsch index, and the number of top-performing research institutions they possess.<sup>118</sup> ASPI finds that China has established "a sometimes stunning lead" in the technology race, leading the world in research of 37 out of 44 critical technologies. China also has the lead in *every* technology related to manufacturing. ASPI judges that the risk of China establishing a technology monopoly is high in eight of those 37 technologies, including nanoscale materials and manufacturing, advanced radiofrequency communications (i.e. 5G), and electric batteries. The United States leads in research of the seven remaining areas of critical technology, mostly related to computing (including quantum computing), vaccine development, and space. In none of the fields where the United States leads in research is the risk of technology monopoly deemed high.

China's evident lead in high-quality research on critical technologies should serve as a wakeup call for U.S. policymakers, who have long consoled themselves that, while the United States has lost manufacturing to Asia (increasingly, China), we retain the world's best system for basic research. These findings cast doubt even on that consolation. China is capable of high-value research in a variety of fields, related to both production, where it excels, and theoretical fields, where the United States once enjoyed a comfortable lead. If this research produces breakthroughs and innovations, the Chinese state is well-positioned to apply those findings in its corporate sector. It is unlikely to make the same blunder the United States has. Since the disappearance of U.S. corporate laboratories, our nation has struggled with applied research and translating new scientific knowledge into commercial applications for U.S. producers.<sup>119</sup>

Finally, MIC2025 placed great emphasis on patents as a metric of innovation. As a consequence of this focus and China's broader industrialization, China's patent activity has risen dramatically.

An especially useful metric of innovation is the number of international patents filed under the Patent Cooperation Treaty (PCT), which allows filers to apply for a patent in multiple jurisdictions at once. Receiving a PCT patent is considered more challenging and valuable than simply receiving a patent from the filer's national patent office. Since 2020, China has filed the most international (i.e. PCT) patent applications of any country (70,015 in 2022), surpassing the United States (59,056), Japan (50,345), and

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<sup>117</sup> World Intellectual Property Organization, "Global Innovation Index 2023 Cluster Rankings."

<sup>118</sup> Gaida, et. al, "ASPI's Critical Technology Tracker."

<sup>119</sup> David Adler, "The American Way of Innovation and Its Deficiencies," *American Affairs*, Summer 2018, <https://americanaffairsjournal.org/2018/05/the-american-way-of-innovation-and-its-deficiencies/>.

Germany (17,530).<sup>120</sup> Huawei files by far the most international patent applications of any company (6,494 in 2022), followed by Korea’s Samsung (3,924). Besides Huawei, three Chinese companies—BOE Technology Group, Contemporary Amperex Technologies Ltd. (CATL), and Oppo Mobile Telecommunications—are in the top 10.

Many analysts note that the quality of Chinese research and patents is often low, and there is prodigious evidence this is the case. However, the statistics above indicate that China now has many companies, research institutions, and cities dedicated to high-quality research and innovation. It is not merely cribbing the work of others anymore.

## Smart Manufacturing

- China leads the world in installations of industrial robots and installed more robots in 2022 than the rest of the world did combined.
- China’s robot density surpassed the United States’ in 2021, a striking feat given the size of China’s manufacturing workforce and wage levels relative to our own.
- Chinese smart manufacturing is enabled by its vast 5G telecommunications network, composed of more than 3.5 million 5G base stations.

Beijing promotes “smart manufacturing” as a means of upgrading Chinese industry so that it is advanced, not merely large. Smart manufacturing integrates digital technology and automation into factory settings to monitor production, increase productivity, and reduce downtime and reliance on line workers. Widespread adoption of smart manufacturing technology is a priority for the Chinese government to ensure that production remains high in the future, even as the pool of Chinese workers shrinks due to demographic changes. As the economist Nicholas Eberstadt notes, if current trends hold, “China’s working-age population will be more than 20 percent smaller in 2050 than in 2020.”<sup>121</sup>

A review of the global manufacturing landscape shows that China has made great strides to upgrade its industry, dramatically increasing factory automation and building cutting-edge factories in large numbers. However, China still depends on foreign multinationals and imports to satisfy its voracious demand for advanced machine tools and robots. It also lags behind the most developed countries in its degree of automation, reflecting the fact that much of China’s mammoth industrial base is not yet cutting edge—though it is still formidable.

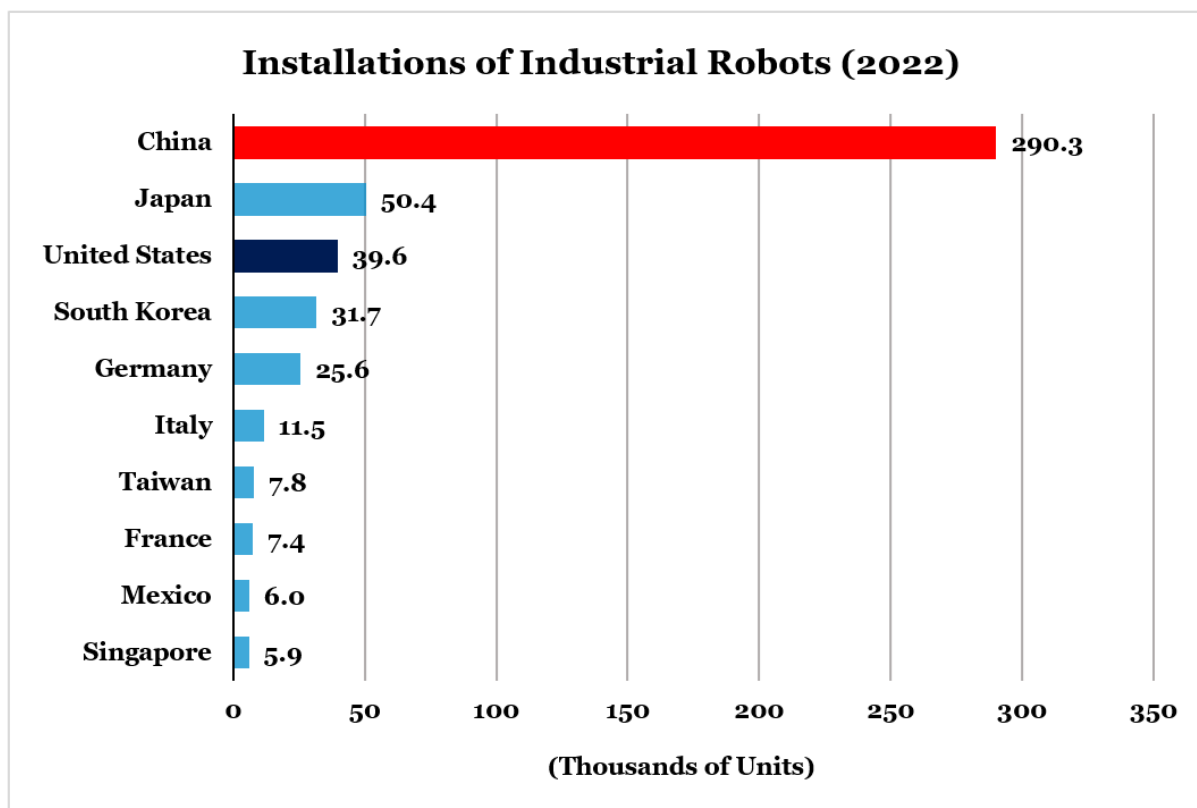
China’s installation of industrial robots is a useful proxy for the state of its manufacturing base. According to the International Federation of Robotics, China installed more industrial robots in 2022 (290,258) than the rest of the world did combined, and has been the world’s largest market for industrial robots for more than a

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<sup>120</sup> World Intellectual Property Organization, “PCT Yearly Review 2023,” 2023, <https://www.wipo.int/edocs/pubdocs/en/wipo-pub-901-2023-exec-summary-en-patent-cooperation-treaty-yearly-review-2023-executive-summary-the-international-patent-system.pdf>.

<sup>121</sup> Nicholas Eberstadt, “East Asia’s Coming Population Collapse,” *Foreign Affairs*, May 8, 2024, <https://www.foreignaffairs.com/china/east-asias-coming-population-collapse>.

decade.<sup>122</sup> Perhaps a more useful statistic than sheer volume of robots is robot density, which measures how many industrial robots a country has against the number of workers it employs in manufacturing. China has made strides here as well. In 2021, China surpassed the United States in robot density.<sup>123</sup> It now ranks fifth in the world, well below the world leaders of Korea and Singapore, but evenly matched with Germany and Japan.<sup>124</sup> This is an impressive feat, given the sheer size of China’s manufacturing sector; it employs roughly 38 million people in manufacturing. It is especially impressive because Chinese manufacturing workers are paid less than similar workers in richer countries like Germany and Japan, meaning Chinese firms are installing robots far in excess of what would be expected if their goal was to achieve cost savings through automation. Controlling for wage levels, China has by far the highest robot density of any country, as Robert Atkinson of the Information Technology and Innovation Foundation has noted.<sup>125</sup>



Source: International Federation of Robotics

<sup>122</sup> International Federation of Robotics, “World Robotics 2023 Report: Asia ahead of Europe and the Americas,” September 26, 2023, <https://ifr.org/ifr-press-releases/news/world-robotics-2023-report-asia-ahead-of-europe-and-the-americas>.

<sup>123</sup> International Federation of Robotics, “China overtakes USA in robot density,” December 5, 2022, <https://ifr.org/ifr-press-releases/news/china-overtakes-usa-in-robot-density>.

<sup>124</sup> International Federation of Robotics, “Global Robotics Race: Korea, Singapore and Germany in the Lead,” January 10, 2024, <https://ifr.org/ifr-press-releases/news/global-robotics-race-korea-singapore-and-germany-in-the-lead#:~:text=The%20top%20most%20automated%20countries,2023%20report%2C%20presented%20by%20IFR>.

<sup>125</sup> Robert Atkinson, “How Innovative Is China in the Robotics Industry?” Information Technology and Innovation Foundation, March 11, 2024, <https://itif.org/publications/2024/03/11/how-innovative-is-china-in-the-robotics-industry/>.

Another rough metric is to consider where the world's most advanced factories and supply chains are located. The World Economic Forum's Centre for Advanced Manufacturing and Supply Chains attempts to do this, compiling a list of factories that are putting "smart manufacturing" into practice. The center's most recent report identifies 132 such factories and end-to-end supply chains.<sup>126</sup> One third (45) are located in China, including nearly half of the factories under the heading "advanced industry." Most of the Chinese factories and supply chains are owned and operated by non-Chinese multinational corporations, such as Bosch (Germany), Foxconn (Taiwan), Western Digital (United States), and Siemens (Germany). However, many Chinese champions also appear on the list, including CATL, BOE, Foxconn Industrial Internet, Haier, and Sany Heavy Industry.

Chinese smart manufacturing is enabled by its world-leading telecommunications network. The CCP boasts that China has deployed 3.5 million 5G base stations.<sup>127</sup> The United States, by contrast, has deployed approximately 100,000 such base stations.<sup>128</sup> 5G is especially important in industrial applications, enabling automation, robotics, and advanced logistics. China claims more than 10,000 5G-powered industrial internet projects, and that number will surely grow as its 5G buildout continues at a rapid clip.<sup>129</sup>

There are also signs that China is breaking its dependence on foreigners in areas such as machine tools and robotics. It is common for multinationals to manufacture their products in China to sell into the China market. In many cases, the Chinese government requires foreign firms to manufacture in-country, enter into joint ventures with Chinese firms, and use Chinese firms as suppliers as conditions of market access.<sup>130</sup> This inevitably results in diffusion of technology and manufacturing know-how to the indigenous Chinese industrial base. Homegrown Chinese firms are beginning to compete with foreign competitors even for high-end, high-value goods, as we will see later in this report.

This sample of advanced manufacturing indicates that China still relies on the expertise and technology of foreign multinationals for some categories of high-end, high-value industrial goods. However, China's aggressive procurement of such technology, paired with its leadership in telecommunications, shows that its manufacturing sector is far more advanced than it was a decade ago.

## Basic Industry

- China is the undisputed king of basic industrial inputs, such as steel and cement.

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<sup>126</sup> Francisco Betti, Vincent Desnos, Yves Giraud, Federico Torti, Martin Becker, Youssef Benkhaira, and Enno de Boer, "Global Lighthouse Network: Shaping the Next Chapter of the Fourth Industrial Revolution," World Economic Forum, January 2023, [https://www3.weforum.org/docs/WEF\\_Global\\_Lighthouse\\_Network\\_2023.pdf](https://www3.weforum.org/docs/WEF_Global_Lighthouse_Network_2023.pdf).

<sup>127</sup> *Xinhua*, "China home to over 3.5 mln 5G base stations," April 6, 2024, [https://english.www.gov.cn/archive/statistics/202404/06/content\\_WS6610e145c6do868f4e8e5c84.html](https://english.www.gov.cn/archive/statistics/202404/06/content_WS6610e145c6do868f4e8e5c84.html).

<sup>128</sup> Ameya Paleja, "China's 5G dominance: 3.19 million base stations built, outpacing US," *Interesting Engineering*, October 23, 2023, <https://interestingengineering.com/culture/5g-base-stations-china-exceed-3-million>.

<sup>129</sup> Paleja, "China's 5G dominance."

<sup>130</sup> Chan, "How China uses foreign firms to turbocharge its industry."

- China’s position in these areas has been driven by its breakneck development of infrastructure and real estate.
- Debt crises in these sectors are leading to a painful rightsizing of China’s industry that is only partially offset by increased exports of commodities like steel.

MIC2025 and much of the discourse surrounding it focused on cutting-edge technology. However, one of the main goals of China’s industrial strategy was to promote strong basic capabilities in industry. MIC2025 singled out basic components, techniques, materials, and technology as the “four basics” in need of support. At least part of Beijing’s interest in basic industrial capabilities appears to be military. MIC2025 discussed dual-use capabilities and military-civil fusion at length in its section on basic industrial capabilities, indicating that the Chinese government understands that wars are won primarily on the strength of “legacy” and “mature” technologies, not theoretical capabilities that may never leave the lab or reach the battlefield. MIC2025 called for upgrading basic industry to use more advanced techniques, investing more in innovation, and coordinating development to prevent gluts.

Judged by gross production, China is the undisputed king of basic industry. We can see this most strikingly in steel and cement, complementary goods that are the building blocks of modern civilization. Nations produce these materials mostly for their internal markets, and only secondarily for export. A surge in steel and cement production therefore indicates a surge in construction and other downstream industries that rely on these inputs, such as the automotive and electricity sectors. Heavy producers of steel and cement can be said to be in a nation-building phase. They are the material precondition of development. Shortages of these materials can thus inhibit the process of development; for example, the high price of concrete has been identified as a factor limiting the production of new nuclear power plants in the United States.<sup>131</sup> By that standard, China has been on a tremendous nation-building tear that is only beginning to cool due to the country’s real-estate crisis.

China uses as much cement in two years as the United States did in the entire 20<sup>th</sup> century.<sup>132</sup> Virtually all of that cement is made at home by firms like Anhui Conch and the state-owned China National Building Materials Group. China produced 2.3 billion metric tons of cement in 2022, down from a high of 2.5 billion tons in 2014 and the lowest production volume since 2012.<sup>133</sup> Despite this downturn, China still produces and consumes more cement than the rest of the world does combined. The second-largest producer, India, made 356 million metric tons of cement in 2022—a mere 16 percent of China’s production.<sup>134</sup>

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<sup>131</sup> Thomas Hochman, “What’s holding back nuclear in America?,” Oxford Institute for Energy Studies Forum, February 2024, <https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/02/OEF-139-.pdf>.

<sup>132</sup> Hannah Ritchie, “China uses as much cement in two years as the US did over the entire 20th century,” *Sustainability by Numbers*, March 6, 2023, <https://www.sustainabilitybynumbers.com/p/china-us-cement>.

<sup>133</sup> Shin Watanabe, “China’s cement makers race to consolidate amid property woes,” *Nikkei Asia*, July 25, 2023, <https://asia.nikkei.com/Business/Materials/China-s-cement-makers-race-to-consolidate-amid-property-woes>.

<sup>134</sup> *Globe Newswire*, “India Cement Market Report 2022: A \$26+ Billion Market in 2022 - Analysis, Competition, Forecast & Opportunities 2018-2022 && 2023-2028,” November 28, 2022, <https://finance.yahoo.com/news/india-cement-industry-report-2022-101500273.html>.

A nearly identical story can be told about steel. In 2022, China produced more than one billion tons of crude steel, forged by China Baowu Group and a bevy of other, regional steelmaking conglomerates.<sup>135</sup> India again came in second, producing 125.3 metric tons of crude steel, followed by Japan (89.2 million tons) and the United States (80.5 million tons). China's output of crude steel is still near record highs, although, like that of cement, this figure has declined the past two years. Unlike in the cement industry, China's steelmakers have responded to falling prices and demand at home with an export blitz. China's steel exports rose by a third in 2023, to 90.26 million tons.<sup>136</sup> Most of those exports went to Southeast Asian countries like Thailand and Malaysia.<sup>137</sup>

Despite these impressive statistics, there is reason to doubt whether China's push to upgrade its basic industrial capabilities has been successful, and whether its gargantuan lead over the rest of the world is sustainable. China's building spree is coming to an end, with its major property and infrastructure developers overleveraged and on the brink of insolvency. Beijing is thus looking to other sectors, such as its energy grid and manufacturing sector, to drive demand for industrial inputs. China's steel and building materials industries are bracing for a long winter of consolidation and plant closures, which explains the recent scramble for exports by its steelmakers.

Some Chinese officials have also cast doubt on the resilience of China's basic industrial capabilities. In 2021, Miao Wei, a member of the CCP Central Committee and former minister of industry and information technology, said that China's "basic capabilities remain weak," and that too many Chinese business leaders and officials had ignored "the transformation and upgrading of traditional industries."<sup>138</sup> Some of these traditional industries are in for a painful period of adjustment in the coming years, though China is unlikely to be dethroned as the world's top producer any time soon.

## Branding

- Chinese companies dominate global rankings of the largest companies by revenue, although many of its largest companies are state-owned enterprises.
- China has built world-leading companies with strong brands, such as Huawei, TikTok, and BYD, although it has produced fewer such companies than the strength of its industrial base would suggest.
- Beijing's espionage and cutthroat trade practices threaten the brands of even its most important companies, triggering a wave of backlash in foreign markets.

MIC2025 called for "the transformation of Chinese products to Chinese brands," in recognition of the fact that China punches below its weight in establishing trusted and

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<sup>135</sup> World Steel Association, "World Steel in Figures 2023," May 18, 2023, <https://worldsteel.org/data/world-steel-in-figures-2023/>.

<sup>136</sup> Amy Lv and Tony Munroe, "China's steel sector has bigger worries than Biden tariff hike," *Reuters*, April 21, 2024, <https://www.reuters.com/markets/commodities/chinas-steel-sector-has-bigger-worries-than-biden-tariff-hike-2024-04-19/>.

<sup>137</sup> Tomio Shida, "China's surging steel exports risk new round of trade frictions," *Nikkei Asia Review*, December 20, 2023, <https://asia.nikkei.com/Spotlight/Comment/China-s-surging-steel-exports-risk-new-round-of-trade-frictions>.

<sup>138</sup> Miao Wei, "Advancing the High-Quality Development of the Manufacturing Industry," April 14, 2021, [https://cset.georgetown.edu/wp-content/uploads/to328\\_Miao\\_Wei\\_manufacturing\\_power\\_EN.pdf](https://cset.georgetown.edu/wp-content/uploads/to328_Miao_Wei_manufacturing_power_EN.pdf).

esteemed companies. The Chinese government identified product quality as the crux of the problem: Chinese and international consumers alike viewed “Made in China” products as low quality, and therefore had little trust in the companies that produced them.

Today, China has developed a number of world-class brands, and its companies dominate global rankings of companies by revenue. However, China has not managed to shed its brand-image problem, due in large part to the aggressive policies of the regime in Beijing. China underperforms in brand quality, even as it overperforms in countless areas of gross production.

The simplest way to rank the strength of a country’s companies is by revenue. The Fortune Global 500 provides this metric each year. It has charted an astonishing rise by China over the past decade. In 2015, 98 Chinese companies appeared on the Fortune Global 500, compared to 128 American companies.<sup>139</sup> The best-performing Chinese companies by revenue were Sinopec Group, China National Petroleum Corp., and State Grid Corporation—all state-owned enterprises. By 2023, the number of Chinese companies on the Fortune Global 500 was higher than the number of American companies, 142 to 136. The top performers were the same: State Grid, China National Petroleum, and Sinopec.

Despite strong earnings, Chinese firms lag behind their international competitors in other metrics. As CSIS has documented, Chinese firms on the 2022 Fortune Global 500 ranked 10<sup>th</sup> by average profit margin and average return on assets.<sup>140</sup> In part, this is due to the industry composition of Chinese firms, which are heavily concentrated in capital-intensive sectors of “traditional” industries. More importantly, it reflects the fact that fully 71 percent of Chinese firms on the Fortune Global 500 are state-owned.<sup>141</sup>

Other metrics of brand competitiveness show that China has made mixed progress. WIPO’s Global Innovation Index measures the “global brand value” of a country’s companies based on the estimated cost those companies would pay to license their own brand if they did not own it. Mainland China ranked 17<sup>th</sup> in this metric when WIPO first incorporated it in 2020.<sup>142</sup> Four years later, it has slid to 20<sup>th</sup> place, although it remains the leader among countries in its income group.<sup>143</sup> China’s most valuable brands are a mix of state-owned and nominally private enterprises. The top 10 by value include state-owned stalwarts like the Industrial and Commercial Bank of China and State, as well as nominally private companies like TikTok/Douyin, WeChat, and Huawei.

WIPO creates this metric in collaboration with Brand Finance, a company dedicated to the study of brand valuation. Brand Finance data indicates that the number of Chinese companies among the world’s most valuable 500 brands grew from 44 in 2015 to 68 in

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<sup>139</sup> *Fortune*, “Fortune Global 500,” accessed June 7, 2024, <https://fortune.com/ranking/global500/>.

<sup>140</sup> Qin (Maya) Mei, “Fortune Favors the State-Owned: Three Years of Chinese Dominance on the Global 500 List,” Center for Strategic and International Studies, October 7, 2022, <https://www.csis.org/blogs/trustee-china-hand/fortune-favors-state-owned-three-years-chinese-dominance-global-500-list>.

<sup>141</sup> Mei, “Fortune Favors the State-Owned.”

<sup>142</sup> World Intellectual Property Organization, “Global Innovation Index 2020.”

<sup>143</sup> World Intellectual Property Index, “China ranking in the Global Innovation Index 2023.”

2024.<sup>144</sup> In both years, state-owned enterprises made up about half of China's entries on the list. However, in 2024, nominally private companies rank much higher on the list than they did a decade before. TikTok/Douyin has topped the list as China's most valuable brand, at seventh place overall, though it remains to be seen how the impending ban on ByteDance in TikTok's most important overseas market, the United States, will affect the app's brand value in the years ahead. Another eight nominally private Chinese companies have cracked the top 100. This is a stark change from 2015, when the most valuable "private" Chinese company to appear on the list, Baidu, ranked 85<sup>th</sup>; it was the only such company to crack the top 100. This phenomenon indicates that China's supposedly private brands are gaining traction relative to state-owned enterprises, although China still relies on the latter far more than comparable nations do, which undoubtedly hurts its brand competitiveness.

China's brands face additional headwinds from negative public opinion about the Chinese government. Ironically, MIC2025's aggressive subsidies and export promotion have led to a backlash that weakens China's brands overseas, even as they have helped many of Chinese companies climb the value chain and improve the quality of their products.

## **Sustainability**

- China leads the world in installation of renewable energy, but remains the world's worst polluter and has hedged its installation of renewables with significant increases in traditional carbon-intensive power.
- When industrial strength and sustainability have come into conflict, Beijing has chosen to prioritize the former.

Another pillar of China's MIC2025 strategy was green manufacturing. This goal had two prongs. First, to dominate the production of renewable energy and green technology, such as solar panels, wind turbines, and EVs. Second, to "green" China's manufacturing sector by lowering its emissions and resource intensity. Beijing claimed that these goals would feed off of each other, creating a virtuous cycle where China's traditional strengths in carbon-intensive inputs like steel and aluminum would give producers of renewables a cost advantage; China could then install home-grown renewables into its electricity grid and industrial base, lowering the emissions of those sectors in turn.

In practice, China has placed much greater stock behind reaching the first goal (manufacturing renewables) than the second (reducing emissions in its manufacturing sector). China's dominant production of green technology was discussed in the Critical Technologies section of this report, so this section focuses on its attempt to "green" its manufacturing sector.

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<sup>144</sup> Brand Finance, "Global 500 2024: The annual report on the world's most valuable and strongest brands," January 2024, <https://brandirectory.com/rankings/global/>.



China is the world's worst polluter and emits the most greenhouse gas of any nation. It rates poorly on a slew of environmental metrics, including air pollutants, heavy metal exposure, and ocean plastics.<sup>145</sup>

The Chinese government has made bold commitments to reduce carbon emissions and increase its use of renewable energy. Xi has announced that China's carbon emissions will peak by 2030, and that China will become carbon neutral by 2060. Xi has further pledged not to build new coal plants overseas (a much-heralded announcement that conveniently serves to strengthen China's domestic manufacturing at the expense of foreign competitors). China has also signed multiple non-binding declarations with the United States pledging to dramatically increase capacity of renewable energy, such as wind and solar.

China's commitment to decarbonization is driven more by worries about energy security than any vaguer environmental commitment. China is the world's largest oil importer, importing 11 million barrels of oil per day. Most of these imports arrive by sea and transit the Strait of Malacca, leaving them vulnerable to blockade. China's overland pipeline capacity is insufficient to make up for a loss of seaborne imports, despite its deepening trade in oil with Russia. China has therefore adopted a number of strategies to mitigate this dependency, including stockpiling and constructing underground oil reservoirs.<sup>146</sup> Transport electrification is another facet of this strategy, allowing Beijing to manage oil demand for strategic reasons while trumpeting the change as a victory for the environment.

China leads the world in renewable energy installations, a boom enabled by its dominant production of solar panels, wind turbines, and nuclear power plants. China installed more solar panels last year than the entire installed capacity of the United States, and has more solar-farm capacity than the rest of the world does combined.<sup>147</sup> China is also ramping up nuclear, with 55 reactors in operation and 26 under construction—although the United States still has a sizeable lead in terms of operating nuclear capacity, due mainly to reactors built decades ago.<sup>148</sup>

Despite this renewable blitz, a host of factors have led China to hedge its installation of renewables with vast increases in carbon-intensive energy and production. Beijing has responded to flagging economic growth and challenges with renewable energy (including intermittency and a record drought that hurt its production of hydropower) with a shift back to reliance on coal-fired power. As a consequence, China's emissions have started to diverge in recent years from its ambitious targets. China's carbon-dioxide emissions increased by 12 percent between 2020 and 2023, in large part due to

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<sup>145</sup> Sebastian Block, John Emerson, Daniel Esty, Alex de Sherbinin, and Zachary Wendling, "2024 Environmental Performance Index," Yale Center for Environmental Law & Policy, 2024, <https://epi.yale.edu/about-epi>.

<sup>146</sup> Gabriel Collins, "China's Energy Import Dependency: Potential Impacts on Sourcing Practices, Infrastructure Decisions, and Military Posture," Rice University Baker Center for Public Policy, March 2022, [https://www.uscc.gov/sites/default/files/2022-03/Gabriel\\_Collins\\_Testimony.pdf](https://www.uscc.gov/sites/default/files/2022-03/Gabriel_Collins_Testimony.pdf).

<sup>147</sup> Isabel Hilton, "How China Became the World's Leader on Renewable Energy," *YaleEnvironment360*, March 13, 2024, <https://e360.yale.edu/features/china-renewable-energy>.

<sup>148</sup> World Nuclear Association, "Nuclear Reactors in China," accessed June 7, 2024, <https://www.world-nuclear.org/nuclear-reactor-database/summary/China>.

increased emissions from the energy and manufacturing sector.<sup>149</sup> Further increases are expected, as China continues to approve and build new coal-fired power plants—permitting the equivalent of two coal plants per week in 2023.<sup>150</sup> Virtually all of the new coal capacity to come online last year was in China. The country has approved enough new coal capacity—218 GW in two years—to supply power to all of Brazil.<sup>151</sup>

Ironically, China’s dominance in clean energy technologies is coming at a high cost to the environment. In parts of China where rare-earth elements are mined and processed, the earth is marred by massive tailings ponds of toxic waste, some miles wide.<sup>152</sup>

Even China’s evident successes, such as dramatic improvements in air quality in major cities in the past decade, are not the tidy stories told by Beijing’s propaganda organs. Much of the improvement in air quality was caused by the relocation of coal-fired power plants and heavy industry from major urban centers to the interior of the country.<sup>153</sup> And last year, levels of particulate matter in most major Chinese cities increased by 7.7 percent, the first worsening of air quality in a decade.<sup>154</sup>

When push comes to shove, Beijing has prioritized industrial strength over sustainability—gambling that it can produce its way out of its problems, including a shrinking population and high levels of debt. This choice reflects the stark reality that manufacturing is, and will be for the foreseeable future, a resource- and emissions-intensive activity. Despite Beijing’s bold climate commitments, it wishes above all to be the world’s dominant manufacturing power. Its actions and energy mix reflect that wish.

## Structural Reform

- Beijing has expressed a commitment to the structural reform of its economy, but has proven unable or unwilling to follow through in practice.
- Some sectors of China’s economy suffer from severe overcapacity, leading to supply gluts and harmful surges in exports.
- Other sectors accused of overcapacity, such as automobiles, do not obviously suffer from the affliction, and may genuinely represent the growing competitiveness of Chinese firms.

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<sup>149</sup> Lauri Myllyvirta, “Analysis: Record drop in China’s CO2 emissions needed to meet 2025 target,” *Carbon Brief*, February 22, 2024, <https://www.carbonbrief.org/analysis-record-drop-in-chinas-co2-emissions-needed-to-meet-2025-target/>.

<sup>150</sup> Julia Simon, “China is building six times more new coal plants than other countries, report finds,” *National Public Radio*, March 2, 2023, <https://www.npr.org/2023/03/02/1160441919/china-is-building-six-times-more-new-coal-plants-than-other-countries-report>.

<sup>151</sup> Colleen Howe and Ella Cao, “In China’s coal country, full steam ahead with new power plants despite climate pledges,” *Reuters*, November 30, 2023, <https://www.reuters.com/sustainability/chinas-coal-country-full-steam-ahead-with-new-power-plants-despite-climate-2023-11-30/>.

<sup>152</sup> Michael Standaert, “China Wrestles with the Toxic Aftermath of Rare Earth Mining,” *YaleEnvironment360*, July 2, 2019, <https://e360.yale.edu/features/china-wrestles-with-the-toxic-aftermath-of-rare-earth-mining>.

<sup>153</sup> Jason Douglas, “China’s Factory Floor Is Moving—But Not to India or Mexico,” *The Wall Street Journal*, October 7, 2023, <https://www.wsj.com/world/china/chinas-factory-floor-is-moving-but-not-to-india-or-mexico-dbd9fd69>.

<sup>154</sup> Christian Shepherd, “China’s air quality worsened this year for the first time in a decade,” *Washington Post*, December 22, 2023, <https://www.washingtonpost.com/world/2023/12/22/china-pollution-worse-coal/>.

One of the more intriguing goals of MIC2025 was structural reform of manufacturing to promote high-value industry, phase out obsolete industry, and resolve what the CCP refers to as “the contradictions of excess capacity.”<sup>155</sup> This goal was closely tied to Beijing’s campaign of “Supply Side Structural Reform,” announced in 2015, which aimed to deleverage China’s heavily indebted corporate sector and reduce capacity in areas such as steel and coal, where industry had grown too large even for China’s vast domestic market. As part of that campaign, China shuttered 290 million tons of coal capacity and 60 million tons of steel capacity, a monumental feat that, as the *Economist* recently noted, meant China had “removed more capacity in these industries than most countries have ever possessed.”<sup>156</sup>

Despite this push for restructuring, China still has excess capacity in many sectors, a problem that has worsened due to the property crisis and cooling of its economy. Excess capacity occurs when a country’s ability to produce certain goods outstrips demand for those goods in its market, leading to cratering prices and spillovers into international markets. The Rhodium Group notes that China’s overall industrial capacity utilization rate has declined the past three years, though it is not at the crisis levels it reached in 2016.<sup>157</sup> Still, in some sectors especially vulnerable to a property downturn, such as cement and glass, China’s capacity utilization is as low as 30 percent, indicating severe excess capacity.<sup>158</sup>

Until very recently, China’s leaders continued to pay lip service to structural reform in official speeches. During the National People’s Congress, Premier Li listed “overcapacity in some industries” as the second problem preventing a sustained economic recovery, after lack of demand.<sup>159</sup>

However, Beijing has proven unwilling—or perhaps unable—to deal with this problem in practice. Its policy choices since the Covid-19 pandemic, in particular, have been the opposite of what it should do if it aims to reduce excess capacity. The Rhodium Group notes that lavish government support to the industrial sector during the pandemic has sharply increased the number and ratio of industrial companies operating at a loss.<sup>160</sup> Xi’s decision to redouble support for manufacturing is a further sign that Beijing is deprioritizing the rightsizing of industry. In effect, China is trying to outrun its troubles through even greater commitment to manufacturing and exports.

In some cases, Beijing’s excess capacity appears to be the product of careful planning more than worsening economic challenges. Excess capacity is evident in many high-tech fields, such as lithium-ion batteries, where China appears to be on track to produce

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<sup>155</sup> State Council of the People’s Republic of China, “Made in China 2025.”

<sup>156</sup> *The Economist*, “What Xi Jinping gets wrong about China’s economy,” May 9, 2024, <https://www.economist.com/finance-and-economics/2024/05/09/what-xi-jinping-gets-wrong-about-chinas-economy>.

<sup>157</sup> Camille Boullenois, Agatha Kratz and Daniel H. Rosen, Overcapacity at the Gate, Rhodium Group, March 26, 2024, <https://rhg.com/research/overcapacity-at-the-gate/>.

<sup>158</sup> Tom Hancock, US-Europe Gripes on China Overcapacity Aren’t All Backed by Data, *Bloomberg*, April 2, 2024, <https://www.bloomberg.com/news/articles/2024-04-02/us-europe-gripes-on-china-overcapacity-aren-t-all-backed-by-data>

<sup>159</sup> Qiang, “Report on the Work of the Government.”

<sup>160</sup> Boullenois, et. al, “Overcapacity at the Gate.”

three times more batteries than the entirety of the world's demand.<sup>161</sup> China retains a similar excess capacity for rare earth magnets—critical inputs in drones, lasers, EVs, and numerous military technologies. Despite signs that global demand for these magnets has begun to flatten, CCP officials have recently ordered state-owned mines to increase processing of rare-earth minerals, while simultaneously issuing regulations aimed at tightening CCP control over rare-earth supply chains.<sup>162</sup>

China's excess capacity is already leading to painful rounds of consolidation in several sectors. And yet, despite that harm to profitability, the CCP may view said capacity as an avenue to gain effective control over strategic supply chains, including those listed above, through export dumping. The ability to flood the global market at any moment with excess magnets, for example, provides Chinese authorities broad discretion to set global prices and strategically undermine competitors abroad.

As international criticism of its trade practices has intensified, China's leaders have angrily denied there is a problem at all. One month after his address at the NPC, Li performed an about-face, stating that the problem of overcapacity should not be attributed solely to China. Xi has taken an even stronger line, stating that “[t]he so-called ‘problem of China’s overcapacity’ does not exist, either from the perspective of comparative advantage or in light of global demand.”<sup>163</sup> China's state media has adopted a typically triumphalist tone, claiming that what Western countries call overcapacity is in fact evidence of China's superior manufacturing, which has triumphed in international competition and can produce more products at lower prices than its competitors.

In some of the sectors that have provoked the loudest protests from Western policymakers, there is some truth to China's protests. The Chinese EV industry, for example, does not have unusually low capacity utilization rates outside of uncompetitive firms that are likely to go bust as part of the ferocious culling underway in that sector. Falling prices and rising production in this sector seem to stem from a combination of heavy state subsidies and genuine competitive advantage. Some analysts have gone so far as to say that China's EV industry is “21<sup>st</sup> Century Fordism” in practice.<sup>164</sup> This is all the more reason to take China's industrial policy seriously as a threat to American, and indeed global, industry.

## **Manufacturing Services**

- China emphasizes producer services, as opposed to consumer services, as a key support for its manufacturing industry.

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<sup>161</sup> *The Economist*, “What Xi Jinping gets wrong about China's economy.”

<sup>162</sup> Enes Marina, “Rare-Earth Prices Are in the Doldrums. China Wants to Keep Them That Way.,” *The Wall Street Journal*, July 15, 2024, <https://www.wsj.com/finance/commodities-futures/rare-earth-prices-are-in-the-doldrums-china-wants-to-keep-them-that-way-bfo477da>.

<sup>163</sup> *The Economist*, “What Xi Jinping gets wrong about China's economy.”

<sup>164</sup> Glenn Luk, X, June 3, 2024, <https://x.com/GlennLuk/status/1797626337919701086>.

- China’s national-security crackdown is leading to an exodus of world-leading foreign firms, accelerating the timeline on which China must rely on its own firms to provide many of the same services.

MIC2025 supplemented its focus on the manufacturing sector with a drive to improve the country’s producer services, which are business-to-business services such as finance, logistics, consulting, and advertising. Beijing emphasizes producer services over consumer services because it is the former that enable Chinese manufacturers to build. In a 2020 speech to the China International Fair for Trade in Services, General Secretary Xi described the services sector as “unique” because it is “asset-light but heavy in soft factors of production.”<sup>165</sup> The lodestar of Beijing’s economic thought is production; its industrial policy is oriented around that goal, including in how it thinks about services.

As China’s manufacturing sector has grown dominant, Beijing has dangled services as an area where foreign firms can participate. However, MIC2025 clearly indicated Beijing’s hope that indigenous Chinese firms should one day take over from foreign firms, just as they have in manufacturing. Beijing’s recent and abrupt crackdown on foreign consulting and finance firms has accelerated this drive for indigeneity.

China’s services sector has experienced growth in the past decade, though services account for a far lower share of its economy than they do for those of its rivals. Services of all types accounted for 53 percent of China’s GDP in 2022, up from 51 percent in 2015.<sup>166</sup> By contrast, services accounted for 78 percent of GDP in the United States, 70 percent in Japan, and 63 percent in Germany. Since 2015, employment growth in producer services in China has been particularly brisk, while the employment share of consumer services (while much higher) has stagnated.<sup>167</sup>

China pays lip service to the importance of liberalizing its services sector to entice new investment from foreign firms. In 2020, Xi declared that the services sector “requires, more than other sectors, an open, transparent, inclusive and non-discriminatory environment.”<sup>168</sup> This declaration was accompanied by a slew of plans to open up targeted services sectors, notably financial services.

However, growing tensions with the United States and other countries have led to an abrupt end to China’s drive for openness. In 2023, the business environment for foreign firms operating in China—particularly firms from the United States and its allies—darkened dramatically. A new “national-security” crackdown began, with 2023 as the watershed year. China broadened its Counter-Espionage Law to cover any “documents,

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<sup>165</sup> Xi Jinping, “Remarks by H.E. Xi Jinping, President of the People’s Republic of China, At the Global Trade in Services Summit of The 2020 China International Fair for Trade in Services,” *China Daily*, September 4, 2020, <https://www.chinadaily.com.cn/a/202009/04/WS5f52502ea310675eafc57a8c.html>.

<sup>166</sup> World Bank Group, “World Development Indicators: Structure of value added,” accessed June 7, 2024, <https://wdi.worldbank.org/table/4.2>.

<sup>167</sup> Xilu Chen, Guangyu Pei, Zheng Song, and Fabrizio Zilibotti, “Is China Becoming a Service Economy?,” *VoxChina*, October 12, 2022, <https://www.voxchina.org/show-3-292.html>.

<sup>168</sup> Xi Jinping, “Remarks by H.E. Xi Jinping, President of the People’s Republic of China, At the Global Trade in Services Summit of The 2020 China International Fair for Trade in Services.”

data, materials, or items related to national security and interests,” not just official state secrets.<sup>169</sup> It also began to investigate and harass foreign firms carrying out due-diligence, audit, and other consulting work in China. Early that year, Beijing instructed state-owned enterprises to phase out their work with the Big Four accounting firms, thus denying Western investors insight into their books and operations. China’s cybersecurity regulator barred Micron products from being included in critical infrastructure.<sup>170</sup> Wind Information, China’s equivalent of Bloomberg Terminal, restricted access to financial data and satellite imagery to users outside mainland China, citing “relevant laws and regulations.”<sup>171</sup> Chinese authorities raided the offices and detained employees of the Mintz Group, an American due-diligence firm allegedly looking into forced labor in the Xinjiang Uyghur Autonomous Region.<sup>172</sup> Other employees of Western firms, including senior executives, were detained or barred from leaving the country for months at a time.

China’s crackdown accelerated a corporate exodus from China. Foreign direct investment in China plummeted 80 percent in 2023 from the year before.<sup>173</sup> FDI was negative in the third quarter for the first time ever recorded. Venture capital and private equity in Chinese companies plummeted, as firms deeply compromised by China scrambled to unwind their investments.<sup>174</sup>

China increasingly must rely on its own firms to provide financial and professional services to other parts of its economy, on a shorter timeline than Beijing perhaps anticipated. It has a slew of companies capable of providing these services. Many of China’s top companies by revenue and market capitalization are banks, insurance companies, and enterprise-technology companies (e.g., Tencent). But the loss of blue-chip Western firms will be hard to replace if the exodus continues. China is paying a heavy price for Xi’s obsession with national security.

## “Going Global”

- China seeks to “go global” by turning its domestic firms into truly globe-spanning enterprises.

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<sup>169</sup> Dennis Kwok, “Xi’s National Security Agenda: How can governments and businesses de-risk?,” China Strategic Risks Institute, June 21, 2023, <https://www.csri.global/research/xis-national-security-agenda-how-can-governments-and-businesses-de-risk>.

<sup>170</sup> Kevin Yao, “China fails Micron’s products in security review, bars some purchases,” *Reuters*, May 22, 2023, <https://www.reuters.com/technology/chinas-regulator-says-finds-serious-security-issues-us-micron-technologies-2023-05-21/>.

<sup>171</sup> Rebecca Feng, “A Chinese Alternative to Bloomberg Terminals Quietly Limits Information Overseas,” *The Wall Street Journal*, May 27, 2023, <https://www.wsj.com/articles/a-chinese-alternative-to-bloomberg-terminals-quietly-limits-information-overseas-bd98cf5e>.

<sup>172</sup> Vishakha Saxena, “US Consultancy Firm in China Worked on Xinjiang Before Raids,” *Asia Financial*, May 19, 2023, <https://www.asiafinancial.com/us-consultancy-firm-in-china-worked-on-xinjiang-before-raids>.

<sup>173</sup> Iori Kawate and Shunsuke Tabeta, “Foreign direct investment in China falls to 30-year lows,” *Nikkei Asia Review*, February 19, 2024, <https://asia.nikkei.com/Economy/Foreign-direct-investment-in-China-falls-to-30-year-low>.

<sup>174</sup> Erin Griffith, “Silicon Valley Venture Capitalists Are Breaking Up With China,” *The New York Times*, February 21, 2024, <https://www.nytimes.com/2024/02/21/technology/silicon-valley-vc-china.html>.

- As trade barriers against China’s products rise in the industrialized world, Chinese firms have targeted the Global South as an export market and overseas manufacturing base.
- The “Sino-forming” of the developing world poses a diplomatic as well as commercial threat to U.S. interests.

Encouraging Chinese companies to “go out” or “go global” has been official policy since at least the mid-1990s. This policy was originally motivated by concern that China’s largely state-owned enterprises would never become internationally competitive if they did not expose their products and people to the rigor of foreign competition. Chinese firms like Lenovo and Sinopec were early participants in this policy, establishing overseas operations and reaping the benefits in terms of technology and talent.

MIC2025 was in many respects an insular strategy, focused on strengthening China’s domestic industry. However, it also inaugurated a new effort to “go global” by encouraging Chinese manufacturing companies to become truly globe-spanning enterprises. The Belt and Road Initiative has provided key support for this goal, facilitating infrastructure projects in the Global South that shift excess construction materials and workers overseas, while paving the way for further exports.

China’s outbound investment is difficult to quantify with any reliability, but it is formidable. Official statistics from China’s Ministry of Commerce claim that outbound investment grew from \$12.3 billion in 2005 to \$183.8 billion in 2023, and has not dipped below \$100 billion in the past decade. Some analysts, notably Derek Scissors of the American Enterprise Institute (AEI), cast doubt on these statistics, noting the absurdity of China’s claim that outbound investment accelerated in 2020-21, when the world was in the depths of the pandemic.<sup>175</sup> AEI’s investment tracker reflects much smaller sums of outbound investment, but records a significant increase in 2023 to \$56 billion.<sup>176</sup>

Whatever the exact figure, it is clear that China’s businesses are eager to expand their international operations. As trade barriers against Chinese products go up, Chinese businesses are “going out” in an attempt to circumvent them, with considerable success. David Goldman notes that while Chinese exports to the United States have plummeted in recent years, they have come in through the back door; China’s exports *to* the Global South have risen in step with the United States’ imports *from* the Global South, indicating massive circumvention of U.S. trade barriers.<sup>177</sup> Goods are being shipped from China to third-party countries, re-flagged, then shipped to their final destination in the United States, a practice referred to as transshipment.

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<sup>175</sup> Derek Scissors, “Better but Not Well: China’s Global Investment Needs More Fuel,” American Enterprise Institute, January 18, 2024, <https://www.aei.org/research-products/report/better-but-not-well-chinas-global-investment-needs-more-fuel/>.

<sup>176</sup> Scissors, “Better but Not Well.”

<sup>177</sup> David Goldman, “2 words explain China export ‘surge’: Global South,” *Asia Times*, May 21, 2024, <https://asiatimes.com/2024/05/2-words-explain-china-export-surge-global-south/>.



Source: UN International Trade Centre, Trade Map, accessed August 28, 2024, <https://www.trademap.org/>.

Note: Trade data representing “Global South” includes the following regions: Association of Southeast Asian Nations (ASEAN), South Asia, Middle East North Africa (MENA), Africa, South America, and Central Asia.

Perhaps a greater long-term concern than transshipment is China’s greenfield investment abroad. Chinese companies are establishing global value chains, which include sophisticated factories that will allow them to enter foreign markets and tamp down criticism about export practices. In 2022, CATL announced a multi-billion-dollar investment in a battery factory in Hungary, Europe’s largest. Chinese automakers, including BYD, have acquired or announced factories in Brazil, hoping to expand their position in the Latin American market. A number of news articles also report China’s interest in building EV factories in Mexico to access the American market through the back door—although Mexican officials appear to have hit the brakes on these plans by denying Chinese automakers access to incentives like low-cost land or tax breaks.<sup>178</sup>

The United States may succeed in preventing China from gaining a toehold in its backyard, but it will face greater challenges farther from home. Countries desperate to

<sup>178</sup> Diego Ore, “Exclusive: Mexico, facing US pressure, will halt incentives to Chinese EV makers,” *Reuters*, April 18, 2024, <https://www.reuters.com/business/autos-transportation/mexico-facing-us-pressure-will-halt-incentives-chinese-ev-makers-2024-04-18/>.



industrialize will be sorely tempted to welcome Chinese manufacturers, who are now best in class in a variety of industries. The way will be paved by China's diplomats and BRI projects to sweeten the deal. These commercial ties will grow into political ties that may be hard to untangle. The Global South risks being "Sino-formed," to use Goldman's phrase, by the newest wave of "going out." The United States will need to offer a substantive alternative, not just strong condemnations and humanitarian aid, to avoid this setback.

## CONCLUSION

Commentary on China's economy swings wildly between extremes. On the one hand, the Chinese economy is often portrayed as deeply troubled, perhaps even on the verge of collapse. Stories in this vein emphasize China's very high debt burden, slowing growth, distressed real-estate sector, and aging population—all real problems. President Joe Biden repeated a version of this argument in an interview with *TIME* magazine in June, where he stated that China's economy is "on the brink":

Name me—Would you trade places with Xi Jinping and any other country? Not a joke, I'm being deadly earnest, a rhetorical question. But would you? You've got a population that's considerably older than the vast majority of the youth in Europe, that is too old to work. And they are xenophobic. Where is it coming from? Where is it going to grow? You've got an economy that's on the brink there. The idea that their economy is booming? Give me a break.<sup>179</sup>

On the other hand, there is growing awareness—and alarm—about China's dominant position in high-tech sectors deemed critical to the future of the world economy. President Biden's attempts to wall off the American auto industry from Chinese competition, while insufficient, show he is aware of this fact.

Can these stories be reconciled? Perhaps. It may be the case that China's export- and manufacturing-oriented development model has been successful enough to propel China to the technology frontier in the short term, but not successful enough to help the country outrun its structural problems in the long term. This is certainly the narrative that many in Washington prefer, as it recalls our victory in the Cold War. Then, an innovative, dynamic, and capitalist United States triumphed over an adversary with a gerontocratic and dysfunctional political class and a communist economic model incapable of managing the transition to the information age. It is tempting to believe that a similar triumph is now assured because our nation has been so successful in the past. We win, they lose.

But an invincible belief in one's own success is a recipe for complacency. And increasingly, this belief is at odds with the evidence in front of our faces. If this report conveys any message, let it be that the United States cannot be complacent about

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<sup>179</sup> *TIME*, "Read the Full Transcript of President Joe Biden's interview With *TIME*," June 5, 2024, <https://time.com/6984968/joe-biden-transcript-2024-interview/>.

Communist China. Think-tank scholars and economists may bank on China's coming collapse. Beijing is taking the other side of that wager. It believes that manufacturing, exports, and "new quality productive forces" are the keys to regime survival and indeed to the "great rejuvenation of the Chinese nation." It believes that technology and production will enable it to preserve its communist system while becoming a rich country. So far, it has succeeded in blazing this alternative development path. But suppose today is the high-water mark of China's power. Even in such an optimistic scenario, the CCP will still present a real, existential threat to American industry and workers for years to come. And Communist China will still be a more formidable adversary than any the United States has faced in living memory. At this point, the burden of proof should be on the critics who insist the CCP's project is doomed to fail.

Instead of being complacent, the United States must act urgently to shield itself from China's predations and reboot its ailing industry. This will require a bold industrial policy to support sectors critical to our national and economic security, paired with an equally bold deregulatory agenda to clear the path for industry to build again.<sup>180</sup> It will require strong trade barriers capable of adapting to China's transshipment and "going out" strategy. It will require greater vigilance against Chinese espionage, propaganda, and technology theft, particularly in sectors like aerospace, agriculture, and biotech, where we retain leads. Adapting to the new reality will require dusting off old history books and playbooks for development.

We should be circumspect enough to realize that, in many areas, the days when China needed to steal from us are past. Now, in sectors as diverse as shipbuilding, EVs, and energy, China leads the rest of the world. Already, Beijing is deploying new resources to lock in its advantages in these sectors, and to use its technology and trade to remake the world according to its interests.

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<sup>180</sup> U.S. Senator Marco Rubio, "Industrial Policy, Right and Wrong," *National Affairs*, Spring 2024, <https://www.nationalaffairs.com/publications/detail/industrial-policy-right-and-wrong>