CHAPTER 9: CHAINED TO CHINA: BEIJING'S WEAPONIZATION OF SUPPLY CHAINS

Executive Summary

China has long made clear its willingness to use its economic heft to advance the Chinese Communist Party's (CCP) strategic interests. In the past five years, however, it has intensified this strategy by prioritizing control over key supply chains. China has already deployed export controls on critical minerals as a coercive tool, including to seek policy concessions in trade negotiations with the United States and to punish other countries. However, critical minerals are just one among several key sectors in which the United States is highly dependent on Chinese sources or could become dependent in the near future.

Other key sectors include active pharmaceutical ingredients (APIs), printed circuit boards (PCBs), and foundational semiconductors—all of which are vital to national security and commercial stability and for which even short-term, partial disruption could cripple critical industries and military readiness. With potentially as much as one quarter of all APIs sourced from China directly—or indirectly through India—U.S. pharmaceutical supply chains face a vulnerability that could have drastic consequences for the American healthcare system. PCBs are critical to all electronics—from the simplest to the most advanced. Though Beijing faces practical barriers to restricting Chinese PCB content to U.S. end users, China has substantial and growing leverage in this important sector, both via direct sales to the United States and much more significantly via made-in-China PCBs embedded in global electronics products. Foundational semiconductors are a likely future vulnerability. China's breakneck expansion in production capacity threatens to flood the market and put competitors out of business if left unaddressed. In that case, the United States may soon depend on access to China's chip industry for producing a wide variety of electronic devices.

As covered in the preceding chapter, an ongoing flood of low-cost Chinese goods is spilling into global markets amid a second China "Shock," threatening to put global competitors out of business in sector after sector and positioning China for dominance over ever more supply chains. Without bold action to strengthen domestic production, de-risk from potential adversaries, and coordinate more closely with allies and partners, the United States will become ever more dependent on Chinese supply chains while Beijing in turn strengthens its ability to exert leverage via those supply chains by imposing either targeted controls or larger-scale embargoes on critical exports to the United States.

Key Findings

- China has held a dominant position in many global supply chains for years, once concentrated in lower-value products and materials but now extending to advanced technologies. In the past few years, the country's economic coercion toolkit has evolved rapidly in sophistication and impact. China now appears poised to accelerate its weaponization of supply chain chokepoints, potentially imposing significant short-term costs on the United States and other trade partners, eroding industrial resilience, and constraining U.S. policy choices.
- China's economic model systematically leads to a concentration of global productive capacity in industries targeted for state support, and establishing such chokepoints has been an explicit CCP policy goal for years. China's supply chain leverage in key sectors will continue to grow over time if unchecked. To date, the United States and other countries have taken only limited measures to mitigate this threat. In the short term, China has already shown an ability and willingness to weaponize its dominant position in critical minerals supply chains, including export restrictions on gallium, germanium, and rare earth magnets in 2023–2025.
- China dominates the supply of APIs and other key starting materials (KSMs)—all of which are essential for U.S. drug supply chains. If Beijing actively restricts U.S. access to these materials, the consequences could be catastrophic for U.S. health security, the broader economy, and potentially military readiness.
- China controls roughly half of global production of PCBs, the essential building blocks of virtually all electronic devices on which integrated circuits and other components are mounted. The United States has lost much of its domestic capacity to produce PCBs and has become heavily reliant on Chinese imports. Losing access to this supply of Chinese PCBs would likely shut down U.S. electronics manufacturing across multiple sectors, including those related to defense, aviation, and critical infrastructure.
- China's coming production surge in foundational semiconductors will pose a serious economic and security threat to the United States and other major semiconductor-producing economies. Foundational semiconductors are workhorse components that, while less advanced than leading-edge chips, are critical to the functionality of most electronic devices. Overcapacity in this sector could drive other producers out of business and make the world heavily reliant on Chinese producers for components that form the backbone of both the modern economy and a modern military.
- Because supply chain vulnerabilities can take years to unwind, it is critical for the United States to immediately de-

velop a more effective risk-mapping tool that identifies where Chinese leverage currently exists as well as the sectors where Beijing's leverage will likely grow in the future. In order to eliminate such critical dependencies and avoid them in the future, the United States must formulate and commit to a long-term strategy of supply chain de-risking—requiring close cooperation with allies and partners—to achieve the conditions necessary for greater safety and resiliency.

Introduction

China's temporary suspension of rare earth exports to Japan in 2010, following a collision between Chinese and Japanese vessels near the disputed Senkaku Islands, demonstrated to the world Beijing's willingness and ability to weaponize supply chain control for geopolitical ends. In the intervening years, China deepened global dependence on its rare earth refineries while concentrating the industry under state control, and it more recently institutionalized a bureaucratic process to impose targeted controls on rare earth exports. Despite a decade and a half of forewarning, the U.S. government failed to develop a policy response sufficient to address this threat, and in 2025, fears were realized as China curbed exports of rare earth elements and permanent magnets to the United States. China's actions threatened U.S. production of a wide range of goods important to economic and national security, including the automobile sector, many critical defense products, medical devices, lasers, and spacecraft.[1] Worse, policy options were constrained by the need to avoid damage from further escalation.

China's supply chain leverage poses a significant threat to both U.S. economic resilience and national security. Beijing's ability to deny access to critical inputs enables it to disrupt production across key industries and stall the U.S. manufacturing sector, or in the case of APIs, deny life-saving drugs to U.S. patients. A sustained disruption could make U.S. firms less competitive on the global stage, compromise defense industrial base resilience, and devastate America's healthcare system. Even short of outright denial, U.S. policymakers may repeatedly find their desired policy responses constrained or stymied because of fear of Chinese retaliation. U.S. firms could also be forced to divert scarce resources toward stockpiling, securing alternative suppliers, or managing higher transaction costs—diverting investment from innovation and growth. Moreover, similar dependencies among U.S. allies can create ripple effects that further undermine U.S. security. Four case studies—critical minerals, pharmaceuticals, PCBs, and foundational semiconductors—demonstrate these risks from China's weaponization of supply chain vulnerabilities.*

*This chapter draws on the Commission's 2025 hearing on "Dominance by Design: China Shock 2.0 and the Supply Chain Chokepoints Eroding U.S. Security," consultations with policy experts, and open source research and analysis.

When Does a Supply Chain Vulnerability Exist?

Different studies offer varying definitions of supply chain vulnerability, some focused on criticality of supply chains to economic and national security and others on measuring degree of exposure to potential manipulation.[2] This chapter considers the following six conditions in evaluating where the United States is vulnerable to Chinese coercive leverage over supply chains. U.S. vulnerability is greatest when:

- There is a high level of dependence on content produced in China—materials, components, or finished goods—for any stage of production or consumption;
- The product is not easily substitutable;
- There is a lack of alternative or immediate suppliers, or China maintains the ability to coerce potential alternative suppliers into restricting sales to the United States;
- The product is a necessary part of an important supply chain, whether essential to the economy (e.g., automobile production), health security (e.g., pharmaceuticals), national defense (e.g., weapons systems), or other vital sectors;
- There is limited surge capacity or long timelines for ramping up alternative sources of production, and
- Stockpiling challenges exist, such as a short inventory shelf-life for medications.

The Imperative to Address China's Leverage over the U.S. Economy

Creating Supply Chain Dependencies Is Now a Feature of China's Economic Model and an Explicit Policy Goal

China's economic model has long used tools of industrial policy to expand its manufacturing dominance across everything from low-end to higher-value goods, all the while capturing market share and thereby increasing its control over key supply chains. In examples ranging from APIs to solar panels to ships, Chinese policies have subsidized production and over-investment, leading to excess supply that then floods global markets at depressed prices, often pushing market-disciplined competitors out of business and leaving the global economy few alternatives but to rely on its production base. While these outcomes have long been at least a byproduct of China's economic model, in the past half-decade Beijing has shifted toward an explicit policy goal of establishing uncontestable dominance across global value chains, eliminating its own vulnerabilities while creating global dependencies on Chinese products. As Xi Jinping proclaimed in a 2020 speech:

> *"We must sustain and enhance our superiority across the entire production chain in sectors such as high-speed rail, electric power equipment, new energy, and communications equipment, and improve industrial quality; and we must*

tighten international production chains' dependence on China, forming a powerful countermeasure and deterrent capability against foreigners who would artificially cut off supply [to China]."[3]

China is Refining its Ability to Weaponize Supply Chains

While China has a history of employing economic coercion through ad hoc import bans against smaller trading partners, its formalization of an export control regime and recent use of these controls against the United States, Europe, and others represents a marked shift in the boldness of its geopolitical agenda.[4] For the United States and other countries, the controls on critical minerals demonstrate that China can wield supply chain leverage not just through brute force embargoes in a conflict scenario—crudely shutting down all exports in a critical supply chain—but also through calibrated controls that impose calculated economic pain to achieve strategic effects. China's effective application of controls on critical minerals owes in part to the consolidation of its domestic industry under state control and institutionalization of internal coordination mechanisms to ensure enforcement. Yet the degree to which Beijing may choose to extend similar controls to other sectors in which it dominates supply chains likely depends on a number of factors, including the effectiveness of its export control regime, the level of U.S. dependence, market conditions, surge capacity, and economic constraints on China.

Modernization of China's Export Controls System

Under Xi Jinping's push for "rule by law," China has formalized its tools for economic coercion by expanding its export control regime.*[5] Future export restrictions will be easier to impose and will likely be used more proactively to assert China's interests, whereas past economic coercion was often retaliatory and frequently aimed at defending what China identifies as its "core interests" like Hong Kong, Xinjiang, or Taiwan.[6]

Lessons Learned from China's 2010 Critical Mineral Restrictions on Japan

In 2010, China informally and temporarily cut off its rare earth element (REE) exports† to Japan following a collision of a Japanese coast guard ship with a Chinese commercial fishing vessel off the disputed Senkaku Islands. At the time, Japan depended on China for more than 90 percent of its rare earth imports.[7] The incident served as a wake-up call not only for Japan but also for the international community, exposing the risks of dependence on a single dominant supplier. Nonetheless, Japan was the only country to take significant steps to reduce its reliance on China. After Japan met China's demands by releasing the Chinese fishing trawler captain to resolve the dispute, it also put together a 100 billion Japanese yen (JPY) ($1.2 billion) package to develop

*For more on China's "rule by law," see U.S.-China Economic and Security Review Commission, Chapter 2, Section 1, "Rule by Law: China's Increasingly Global Legal Reach," in *2023 Annual Report to Congress*, November 2023, 175–206.

†China never officially stated that this action was an export ban.

Lessons Learned from China's 2010 Critical Mineral Restrictions on Japan—*Continued*

and acquire REE mines elsewhere, stockpile REEs, and develop the technology to reduce, recycle, and substitute the use of REEs.[8] Japan also formed partnerships with the United States, Australia, Mongolia, India, Vietnam, and Kazakhstan to secure REE deposits.[9] Today, Japan's dependence on China for REEs has fallen to 60 percent.[10] As dependence remains high, Japan continues its efforts with plans to reduce its reliance to below 50 percent by the end of 2025.[11]

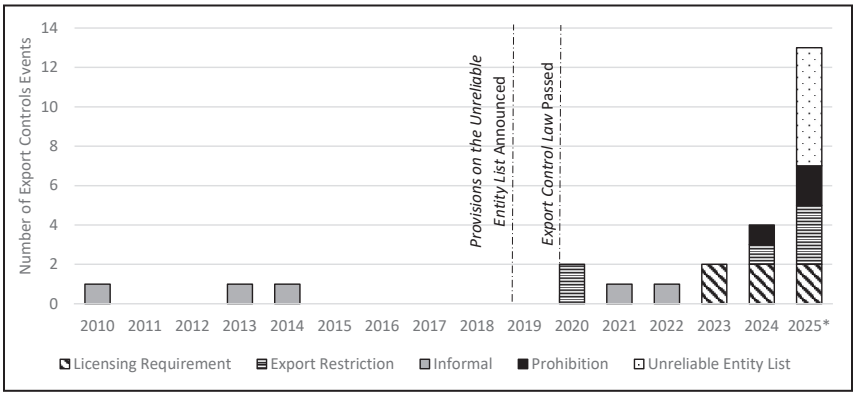
China, in turn, learned that it needs a legal system that allows Beijing to credibly signal its intention, effectively enforce any restriction, and help to minimize international repercussions. Following the 2010 dispute, the United States, Europe, and Japan filed a dispute with the WTO which ruled against China's rare earth export quota system.[12] China dropped the embargo and replaced it with a production quota that kept prices artificially low and stabilized.[13] Additionally, the Chinese government realized that it lacked complete control over REE exports due to smuggling.[14] After Xi Jinping came to power, China's REE export governance evolved into one with much stronger centralized state control and eventually the formalization of its export controls system.[15] The Party-state consolidated the industry and enhanced its ability to exert control over the domestic and global market by reducing the number of REE producers from over 100 to just six by 2016, which then merged to become the China Rare Earth Group in 2021.*[16] The government saw this industry consolidation as an effective strategy to overcome illegal mining and smuggling challenges.[17]

Though the Party-state is mostly unbound by legal constraints in imposing economic restrictions, formalizing its toolkit for implementing export controls can increase the speed and efficacy of its application and provide the appearance of legitimacy under trade rules. While China's export controls system is not new, the 2020 Export Control Law centralized its regime and consolidated various control policies that govern the dual-use catalogue, licensing requirements, extraterritoriality provisions, and end-use and end-users certification.[18] As China gains an edge in technologies that it seeks to prevent others from accessing, Beijing has found it useful to develop a centralized control regime that in many ways mirrors that of the United States. However, unlike the U.S. regime, and those of other countries following the Wassenaar Arrangement, China's sys-

*The Party-state's control over the REE industry stems from a variety of factors and serves a variety of purposes. Industry consolidation is one of the factors to seek control; other policies such as the 2011 Notice on Joint Inspections of the Rare Earth Rectification Campaign strictly targeted illegal mining, production beyond quotas, smuggling, and environmental violations, resulting in closure of small refining and smelting facilities. The Party-state wanted not only to prevent smuggling but also to control pricing and environmental pollution. Guo Fang and Dong Xianping, "江西赣州官员百姓偷采稀土调查:比毒品更上瘾" [Investigation into Officials and Civilians Illegally Mining Rare Earths in Ganzhou, Jiangxi Province], *China Economic Weekly*, April 18, 2012; China's Ministry of Industry and Information Technology, 关于开展稀土专项整治行动联合检查的通知 [Notice on Carrying Out Joint Inspections of Special Rectification Actions for Rare Earths], November 10, 2011.

tem is not grounded in international consensus and is deliberately opaque, enabling deniability and flexibility to navigate geopolitical shifts.[19] Beijing has employed this economic tool more frequently and broadly since late 2023 (see Figure 1). With the proliferation of licensing requirements, Beijing can request supply chain disclosure and foreign end-user verification, enabling it to map out foreign industrial supply chains and identify future leverage.[20]

Figure 1: China's Increasing Use of Export Controls, 2010–2025



Note: *2025 is as of October 10. The number of export control events refers to individual restrictions. Export restriction refers to limits of exports over time (for example, Chinese manufacturers limited sales of drone components to the United States and Europe in December 2024). By contrast, export prohibition refers to a complete ban (for example, of certain materials like gallium, germanium, antimony, and superhard materials to the United States in the same month).
Source: Various.[21]

China's export control regime has evolved from an ad hoc response to foreign policy actions Beijing views as unfavorable to a more potent tool of retaliation and even proactive deterrence aimed at constraining other countries' policy choices. In the past two years, China has developed and employed a more formalized export control regime against the United States (see Table 1). In response to U.S. restrictions on advanced semiconductors and semiconductor manufacturing equipment in October 2022, China introduced a licensing regime for gallium, germanium, and graphite exports, subsequently banning gallium and germanium exports to the United States.[22] Further flexing its leverage over the critical mineral supply chain, China required licensing for seven REEs and other key minerals following U.S. tariffs in February and April, which Beijing used as leverage during trade negotiation with the United States.*[23] In Oc-

*Before placing export licensing requirements on seven REEs and related magnets in retaliation for U.S. tariffs in April 2025, Beijing circulated a draft for public comment in February to improve its REE traceability system. The policy, which went into effect on July 28, attempts to strengthen central oversight of the REE industry and improve Beijing's ability to enforce the export controls on REEs. It may also aim to enhance Beijing's ability to use the controls as a deterrent. China's Ministry of Industry and Information Technology, 稀土开采和稀土冶炼分离总量调控管理暂行办法 [Interim Measures for the Regulation and Management of Rare Earth Mining and Rare Earth Smelting and Separation], July 28, 2025; China's Ministry of Industry and Information Technology, 工业和信息化部公开征求《稀土开采和稀土冶炼分离总量调控管理办法（暂行）（公开征求意见稿）》《稀土产品信息追溯管理办法（暂行）（公开征求意见稿）》的意见 [The Ministry of Industry and Information Technology Is Soliciting Public Opinion on the "Administrative Measures for the Total Amount Control of Rare Earth Mining and Smelting and Separation (Interim) (Draft for Public Comment)" and the "Administrative Measures for the Information Traceability of Rare Earth Products (Interim) (Draft for Public Comment)"], February, 25, 2025.

tober 2025, it expanded controls to encompass five additional REEs, REE processing technologies, and items related to lithium batteries, cathodes, and anodes (see Table 1).[24]

China's use of export controls, however, is not solely retaliatory but can also be proactive.[25] For example, in the summer of 2025, China imposed controls on battery technology and related mineral processing technologies—a move that does not appear to be solely driven by a reaction to any particular U.S. policy (see Table 1). These controls may reflect a desire to retain advantages in these sectors, as well as greater leverage in trade negotiations with the United States.[26]

Table 1: China's Expanded Export Controls and Corresponding Rationale, 2023–2025

Date	Export Control	Reason
Announced Jul. 2023. Effective Aug. 2023.	Required licenses for gallium and germanium exports.	Retaliation for October 2022 U.S. semiconductor controls.
Announced Oct. 2023. Effective Dec. 2023.	Required licenses for graphite exports.	Retaliation for October 2023 U.S. semiconductor controls.
Dec. 2023	Expanded restrictions and bans on exporting REE processing and gallium extraction technology.	Longstanding restrictions on REE processing equipment and to maintain gallium extraction price advantages.
Announced Aug. 2024. Effective Sep. 2024.	Required licenses for antimony exports. Banned antimony processing technology exports.	Likely a response to U.S. efforts in May and June 2024 to enhance global cooperation on semiconductor manufacturing equipment export controls.
Dec. 2024	Banned antimony, gallium, germanium, and "super-hard" exports. Required stricter licensing for graphite exports.	Retaliation for December 2024 U.S. semiconductor controls.
Jan. 2025	Proposed restrictions on battery technology and gallium and lithium processing technologies.	Unknown; either signaling how China could retaliate against trade measures in the future or related to government efforts to keep advanced intellectual property from leaving China.
Effective Feb. 2025	Required licenses for certain bismuth, indium, molybdenum, tellurium, and tungsten products.	Retaliation for February 2025 U.S. tariffs.
Apr. 2025	Required licenses for seven REEs (dysprosium, gadolinium, lutetium, samarium, scandium, terbium, yttrium) and related materials, including magnets.	Retaliation for April 2025 U.S. tariffs.

Table 1: China's Expanded Export Controls and Corresponding Rationale, (2023–2025)—*Continued*

Date	Export Control	Reason
Jul. 2025	Restricted export of battery technology and gallium and lithium processing technologies.	Unknown; either retaliation to enhance Chinese leverage in trade talks with the United States or related to government efforts to keep advanced intellectual property from leaving China.
Oct. 2025	Required licenses for five medium-heavy REEs (holmium, erbium, thulium, europium, and ytterbium) and superhard materials; for related technology for extracting, processing, smelting, manufacturing, and recycling REEs; for Chinese persons to provide substantive assistance related to REEs; for lithium battery-related items; and for cathode and anode materials and related items. License for REE exports used in advanced chips subject to case-by-case review. Prohibited exports for military and related end-uses.	Retaliation for U.S. "50 percent rule" that expanded end-user export controls to organizations at least 50 percent owned by firms on the Entity List as well as strategic leverage in U.S.-China trade negotiations.

Source: Various.[27]

Limitations of China's Economic Toolkit

China faces different degrees of constraint across various sectors in its ability and willingness to leverage its supply chain dominance for economic coercion. The Party-state faces enforcement challenges from coordination between various agencies and levels of government as well as control over Chinese suppliers. China's General Administration of Customs (GAC) has a hands-on role in stopping illegal smuggling, but both GAC and its local customs agencies have long struggled to allocate resources to administer effectively and implement technical guidance from the Ministry of Commerce (MOFCOM) and the Ministry of Public Security.[28]

The Party-state's ability to enforce its export controls effectively depends on the market structure of the industry in question. Chinese officials generally exert greater control in domestic industries, such as the REE industry, that are highly concentrated in a few, state-owned firms. However, their oversight and enforcement capacity may be weaker in more competitive markets with numerous non-state-owned producers.[29] For example, MOFCOM proposed export controls on photovoltaic wafer technology in a 2022 catalogue and opened the proposal for public comments, but it rolled back the proposed controls.[30] Bai Chong'en, a Chinese scholar and member of the Chinese People's Political Consultative Conference raised concerns about growing industry competitiveness in the United States and Europe.[31] Markets with numerous, often smaller producers (including pharmaceuticals and PCBs)

may also make it easier to evade and circumvent export restrictions. Industries in China involving foreign-owned or invested companies, such as PCBs, may face foreign investors' backlash both from impacts to their revenue in China and countervailing pressure from their home governments.

China also faces challenges in enforcing its controls in third countries. Similar to the U.S. export control regime, MOFCOM now asserts jurisdiction over foreign-manufactured items that use or contain China-origin items. For example, in December 2024, China's prohibition of antimony, gallium, germanium, and superhard materials to the United States was the first time China used a provision in its Export Control Law to prohibit the export of products from third countries that contain Chinese-controlled content, similar to the U.S. Foreign Direct Product Rule.*[32] To enforce the control, MOFCOM warned South Korean manufacturers of power transformers, batteries, electric vehicles (EVs), and other electronics that violating China's export controls could lead to major sanctions, including penalties and market access restrictions.[33] Although these South Korean companies are under immense pressure to comply, other firms in other sectors might not.[34] The October 2025 expansion of controls on REEs included far broader extraterritorial provisions, requiring companies in other countries to obtain licenses from Chinese authorities to export products that derive more than 0.1 percent of their value from China-sourced REEs or use of Chinese processing technologies.[35] As more Chinese firms move production abroad, China may need to gain more insights into Chinese and foreign companies' supply chains and assert extraterritorial jurisdiction to enforce its export controls.[36] While Chinese factories, wherever located, are more likely to comply with the Party-state's directives, China is likely to experience resistance from foreign companies and third countries if they are forced to choose between compliance with U.S. or Chinese export controls.[37]

Beijing's weaponization of its supply chain dominance also could create collateral damage to China's economy and reputation. Beijing's economic coercion to date has mostly targeted vulnerabilities that minimize its own economic costs while still achieving its political objective. Restricting exports risks direct economic costs for China, especially when U.S. demand is high and alternative markets are limited. Chinese firms may also face reputational costs worldwide, undermining Xi Jinping's narrative of a "responsible major country."[38] Such reputational costs may vary by sector—for instance, the costs would likely be higher for pharmaceuticals and medicines since they are typically exempt from sanctions because of humanitarian concerns.[39] China could risk being labelled a bully and untrusted trade partner.[40]

*This authority mimics the U.S. Foreign Direct Product Rule, but given that China's authority is still in its infancy, the two countries' ability to enforce extraterritoriality should not be conflated.

China's Capacity to Weaponize Supply Chain Vulnerabilities Threatens U.S. Economic and National Security

The United States' existing and growing dependence on Chinese supply chains heightens its exposure to China's economic coercion in sectors critical to U.S. national security and economic competitiveness. Yet it will be difficult to develop effective risk mitigation strategies in areas vulnerable to Chinese pressure when the U.S. government at this juncture does not even have full transparency into the scope of the problem. Across the four sectors examined in this chapter, U.S. reliance on China for critical minerals presents the most immediate challenge, while the dependence on China's raw pharmaceutical ingredients such as APIs and KSMs indicates a deep though not fully understood vulnerability. In PCBs, China is a leading—if not dominant producer—across most segments in the market, but leveraging this as a chokepoint presents significant challenges for Beijing. Meanwhile, for foundational semiconductors, China's massive state-led overinvestment in the sector signals potential future dominance and underscores the need for a forward-looking, proactive strategy to build resilient supply chains not reliant on Beijing's good graces.

Case Study #1: The Immediate Chokepoint Challenge: Critical Minerals

The United States is dependent on critical minerals for a wide variety of industries and defense needs. The minerals deemed "critical" are not fixed, and their criticality is determined by the U.S. Geological Survey (USGS) under the authority of the Energy Act of 2020, which defined critical minerals as those that are essential to the U.S. economic or national security and vulnerable to disruption.[41] The USGS's 2025 Critical Minerals List includes 54 mineral commodities, used in a range of sectors of the U.S. economy from energy infrastructure, advanced technology manufacturing, and aerospace engineering to medical equipment.[42] For example, REEs discussed earlier contain 17 elements used in various sectors, including health care, transportation, power generation, petroleum refining, and consumer electronics.[43]

The United States is Dependent on China for Key Critical Minerals

The United States' dependency on China for critical minerals is twofold. First, China has a larger volume of commercially viable reserves for a greater number of minerals than the United States. Second, and more importantly, mineral processing and refining is heavily concentrated in China, creating a greater supply chain chokepoint than raw ore mining given that mines controlled by the United States and other third countries continue to send raw materials to China for processing. These points of leverage pose acute risks to the United States: many critical minerals have applications in the defense sector (e.g., yttrium used in lasers) and in essential commercial goods (e.g., gallium and germanium in engine control units in automobiles). While U.S. policymakers have long been aware of the vulnerability caused by heavy reliance on China for

critical minerals, steps to mitigate the risks have been limited, and insufficient to offset deepening dependence on China.

China dominates production and processing of critical minerals, as well as the manufacturing of key components that make use of them. USGS had sufficient information available to make reliable estimates as to the countries that led production of 44 of the critical minerals; in 2024, China was the leading producing country of 30 of them.[44] China is the top source of 15 out of the 32 critical minerals for which the United States is heavily reliant on imports (i.e., for which imports accounted for more than half the minerals the United States consumes; see Figure 2). The country's dominance in processing critical minerals has deepened U.S. dependency, as it controlled 96 percent of global processing for battery grade graphite, 91 percent of magnet REEs, and 70 percent of indium in 2024.*[45] China's control of manufacturing of components that rely on key critical minerals also creates further vulnerabilities for the United States. China controls 90 percent of the global supply of permanent magnets made from REEs, and it leveraged this position to impose export restrictions on these magnets in April 2025.†[46] (For more on the critical mineral supply chain, see Appendix I; for China's dominance in the global EV and lithium battery supply chain, see Chapter 10, "Power Surge: China's Electrification Drive and Push for Global Energy Dominance.")

Even where critical mineral resources are located outside of China, the United States may still be exposed to Chinese leverage, given China's extensive ownership and operation of overseas mines and processing facilities. For instance, although the United States does not rely on direct imports of lithium and cobalt from China, it remains vulnerable to China's leverage, having imported more than half of its lithium from Argentina and Chile where Chinese state-owned enterprises (SOEs) own major stakes in the countries' mining and processing facilities (see Figure 2). These include a 46.7 percent stake in Argentina's Caucharí-Olaroz, one of the world's most productive lithium salt flats, and 22 percent of Chile's Sociedad Quemíca y Minera de Chile S.A., the world's biggest lithium producer, allowing China to account for 72 percent of global lithium processing capacity.[47]

*The International Energy Agency's Executive Director Fatih Birol stated that China's share in the refining of all critical minerals is over 70 percent. Kim Jaewon, "IEA Chief Expresses Concern over China's Dominance in Strategic Minerals," *Nikkei Asia*, August 27, 2025.

†Beijing also told foreign companies not to stockpile rare earths and derived products such as magnets used in electric motors or risk getting cut off. Joe Leahy and Ryan McMorrow, "China Cracks Down on Foreign Companies Stockpiling Rare Earths," *Financial Times*, August 14, 2025.

Figure 2: Critical Minerals with U.S. Net Import Reliance Greater than 50 Percent, China as a Leading Import Source, and Industry Application

Critical mineral	Share from all import sources	China* as a leading import source (2020-2023)	Key Industries		
			Defense	Telecom & Electronics	Energy
CESIUM	100	✓	✓	✓	✓
FLUORSPAR	100	✓		✓	✓
GALLIUM, metal	100	✓	✓	✓	✓
GRAPHITE (NATURAL)	100	✓	✓	✓	✓
INDIUM	100		✓	✓	✓
MANGANESE	100		✓		✓
NIOBIUM (COLUMBIUM)	100		✓		✓
RUBIDIUM	100	✓	✓	✓	✓
SCANDIUM	100	✓	✓	✓	✓
TANTALUM	100	✓	✓	✓	✓
YTTRIUM, compounds	100	✓	✓	✓	✓
TITANIUM, sponge metal	>95		✓	✓	
POTASH	93				✓
BISMUTH, metal, alloys, and scrap	89	✓	✓	✓	✓
TITANIUM MINERAL CONCENTRATES	86			✓	
ANTIMONY, metal and oxide	85	✓	✓	✓	✓
PLATINUM	85			✓	✓
RARE EARTHS, compounds and metals	80	✓	✓	✓	✓
CHROMIUM, all forms	77		✓		✓
COBALT, metal, oxides, and salts	76		✓	✓	✓
BARITE	>75	✓			✓
MAGNESIUM METAL	>75		✓		✓
TIN, refined	73		✓	✓	
ZINC, refined	73		✓	✓	✓
RHENIUM	65			✓	✓
SILVER	64			✓	✓
Alumina	59		✓		✓
MAGNESIUM COMPOUNDS	52	✓	✓		✓
GERMANIUM	>50	✓	✓	✓	✓
LITHIUM	>50		✓	✓	✓
TUNGSTEN	>50	✓	✓	✓	✓
SILICON, metal and ferrosilicon	>50			✓	

Note: *China is one of the top four sources of U.S. critical mineral imports.
Source: Various.[48]

The U.S. Department of Defense (DOD) relies heavily on Chinese critical minerals for components used in its weapon systems. According to a 2025 defense data analytic firm's report, 78 percent of components in DOD's weapons systems contain critical minerals sourced from China.[49] Among the six military services, the U.S. Navy is particularly dependent on China for critical minerals with nearly 92 percent of weapons systems impacted.[50] For instance, Virginia-class submarines use 4,200 kilograms (kg) of REEs, while Arleigh Burke-class destroyers use 2,360 kg of REEs for their radar, munitions, and other technologies.[51] The U.S. Air Force's predator drones and other advanced radar systems all rely on REE magnets for propulsion, targeting, and guidance systems.[52]

U.S. telecommunications and electronics and energy sectors also depend heavily on China for critical minerals (see Figure 2). For the

manufacturing of semiconductors, gallium, germanium, and REEs are essential to the production of wafers, while scandium is used in transistors and diodes, critical for controlling the flow of electronic current.[53] The U.S. energy industry is especially reliant as all of the 15 critical minerals for which the United States depends on China (see Figure 2). New and traditional energy products such as EVs, batteries, and solar panels depend on graphite, gallium, and REEs as well as lithium sourced from China-controlled mines in Chile and Argentina. (For more on how China dominates in the new energy sector, including energy-related critical minerals and products, see Chapter 10, "Power Surge: China's Electrification Drive and Push for Global Energy Dominance.")

Challenges in Reducing U.S. Dependence on Chinese Critical Minerals

Following China's REE export restrictions on Japan in 2010, the United States began examining numerous, fragmented policy options to reduce reliance on REEs from China.[54] These include U.S. Department of Energy-led efforts to find alternative means of obtaining REEs and other critical minerals, including through recycling used electronics and developing domestic mining and processing.[55] Executive orders from 2017, 2020, and 2021 mandated the development of strategies to reduce U.S. reliance on critical minerals.[56] In 2022, the Defense Production Act was used to increase domestic production of minerals, including through investments in graphite projects.[57] In early 2024, DOD's Defense Advanced Research Projects Agency (DARPA) launched the Open Price Exploration for National security research and development (R&D) program to better understand component-based pricing information and supply and demand for a range of critical commodities.[58] In 2025, multiple executive orders targeted the expansion of U.S. critical mineral supplies—including declaring a national energy emergency, establishing a National Energy Dominance Council, and authorizing agencies to use the Defense Production Act to increase domestic production—and a Section 232 investigation has been initiated into the national security risks posed by reliance on critical mineral imports.[59]

However, U.S. reliance on China for critical minerals persists, due to a number of factors. First, there are financial, technical, and operational hurdles the United States would need to overcome to establish sufficient domestic capacity to extract and refine critical minerals, even where it has significant proven reserves. Capital expenditure requirements are substantial, margins are slim, and environmental standards are costly to meet.[60] Even with favorable prospects, most investments would not become profitable for over a decade due to the volatility of global prices—at times due to China's price manipulation—and the long development phases, on average 16.5 years from discovery to production.[61]

As noted above, even if U.S. firms increase their mining capacity, limited processing and refining capability—including difficulty in scaling these operations—means they still may need to send raw materials to China. For example, the Mountain Pass (MP) Rare Earth Mine shipped 98 percent of the extracted REEs to China in 2019 due to the lack of processing capacity.[62] Although the company is working to modernize its ability to process and refine minerals in

the United States, and in April 2025, it halted all of its REE oxide shipments to China, it still can process and refine only about half of its mining output domestically.[63] To support this shift, DOD invested $400 million in MP's shares in July 2025, aiming to help scale up the company's processing and magnet production capacities.*[64] DOD also established a ten-year price floor commitment with MP Materials for neodymium and praseodymium (NdPr), rare earths used in permanent magnets, guaranteeing a $110/kg floor. By comparison, in August 2025, NdPr was selling for $88/kg in China.[65]

In today's mineral markets, U.S. firms struggle to compete as Chinese companies benefit from decades-long policies to dominate in all phases of the supply chain. Chinese industrial policy has long prioritized support for extraction and processing technologies, including through an array of subsidies and other fiscal support.[66] The Chinese government also sets annual quotas on extraction and refining, such as for REEs, to control domestic and international markets and prevent mineral depletion.[67] Notably, China has restricted the export of REE extraction and separation technologies to maintain its monopoly.[68] The government has also focused on cultivating geological talent, having established 38 mineral processing schools and 44 mining programs to train next-generation engineers.[69] These investments appear to have paid off: In 2021, Chinese entities filed for more REE technology patents than the rest of the world combined, and firms such as Huawei are horizontally integrating into advanced mining technology.[70] Moreover, in the long term, Chinese-subsidized operations are taking advantage of Western divestments to rapidly increase production capacity and actual output, suppressing mineral prices.[71] For example, between 2022 and 2023, the price of cobalt fell from $40 to $15 a pound, the result of intense price competition from dominant Chinese producers, which drove the only U.S.-based cobalt mine, Jervois, to close in 2023 and enter into bankruptcy in 2025.[72] China's actions to manipulate global mineral markets—pressuring existing mines to close and deterring investment in new projects—could also exacerbate U.S. vulnerability to China.[73]

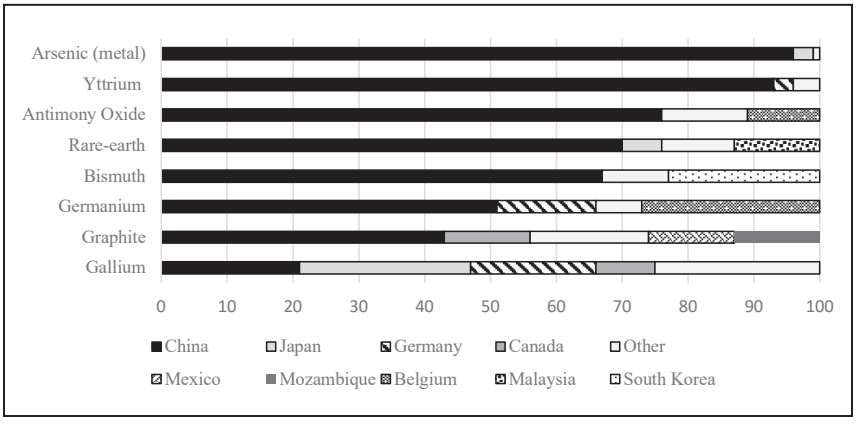
Second, many critical minerals have limited substitutability due to unique chemical and physical properties that make them ideal for specific functions.[74] For example, the Department of Energy designated lithium as not substitutable, and it designated cobalt and copper as minerals with limited substitutability.[75] Researching promising substitutes, like iron nitride magnets as a replacement for rare earth magnets, and determining how to commercialize them also involve long-time horizons, and are risky as many such R&D efforts may never be successful.[76] A 2022 Government Accountability Office (GAO) report found that industry stakeholders lack financial incentives to conduct basic scientific R&D to develop substitutes.[77] While national labs and academia have carried out such research, these institutions are poorly placed to bring initial results to market.[78] Although there have been some recent successful efforts to cultivate alternative supply sources, for instance through Ames Lab-

*In 2024, DOD invested $45 million in MP Materials as part of its "mine-to-magnets" initiative, which aims to build capability at multiple stages of the rare earth supply chain. C. Todd Lopez, "DOD Looks to Establish 'Mine-to-Magnet' Supply Chain for Rare Earth Materials," *Department of Defense Manufacturing Technology Program*, March 11, 2024.

oratory's successful tests in recycling REEs, these projects are far from operating at a commercially viable scale.[79]

Recognizing that some raw materials are not abundant in the United States and that processing here may not be cost competitive, the United States has also turned to allies and partners to diversify sourcing, but they also face similar challenges.[80] Although U.S. allies such as Japan, Germany, and Canada are key exporters of germanium, gallium, and graphite they are often similarly dependent on China across numerous stages of the critical mineral supply chain (see Figure 3).* Other key partners such as Argentina, Brazil, India, Indonesia, Namibia, Saudi Arabia, South Africa, Vietnam, and Zambia are among important mineral-producing countries.[81] These sources form a potential alternative to China in many critical minerals, but their mining and processing operations remain subject to market dynamics while scale and state support position China to retain dominance.

Figure 3: Share of U.S. Imports of Select Critical Minerals by Country



Source: U.S. Department of the Interior, U.S. Geological Survey, *Mineral Commodity Summaries 2025*, March 2025, 34, 36, 46, 74, 80, 84, 144, 198.

China Weaponizes its Dominance in Critical Mineral Supply Chains to Harm U.S. Economic Competitiveness and National Security

China's use of export controls on critical minerals signals broader economic risks to the United States if China chooses to dial up pressure and fully sever U.S. access to key inputs. Should the United States continue to rely on China for critical minerals, conflict scenarios for the United States could involve China: (1) placing all critical minerals on its export control lists to damage the U.S. economy and constrain U.S. policy options and (2) immediately restricting exports during a conflict to impact U.S. warfighting capabilities.†

*For instance, despite over a decade of efforts to reduce its dependence, Japan is still reliant on China for 60 percent of its REE consumption.

†The assessment of potential worst-case scenarios is not a prediction of China's coercive action against the United States as other factors can come into play.

Export Controls on Critical Minerals to Harm U.S. Economy and Constrain U.S. Policy Options

The most immediate economic coercion scenario is one in which China places controls on critical minerals on which the United States depends to try to force concessions or get the United States to back down from its preferred policy choices. The United States already faces this situation. Between April and June 2025, China approved only an estimated 25 percent of license applications, including from U.S. firms.[82] Mineral shortages resulting from Beijing's actions have led to price surges and factory closures, with Ford temporarily shutting down a plant in Chicago due to disruption to the REE supply chain.[83] China has more tools available to ratchet up the pressure. It currently restricts exports of minerals including seven REEs; antimony, gallium, germanium, bismuth, indium, molybdenum, tellurium, and tungsten; and related extracting, processing, smelting, manufacturing, and recycling technologies.[84] It can more strictly enforce existing controls, for instance banning all exports or tightening license requirements. China could also expand controls to an even wider range of minerals and related downstream products.

Immediate and Escalatory Export Bans in a Conflict

A scenario whereby China blocks all critical mineral exports would be highly escalatory and might only become likely during a broader conflict with the United States. Critical mineral shortages from a total export ban by China would shut down large swaths of the U.S. economy. The existing controls on REEs and related products have already resulted in factory shutdowns in the United States, Europe, and Japan that manufacture automobile and defense equipment.[85] A total export ban by China would also severely erode defense industrial base resilience and sustainment across all services, degrading U.S. warfighting capabilities. As noted earlier, the U.S. defense sector heavily relies on China for critical minerals to manufacture components for DOD. Suppliers for the defense sector already delayed their production after China imposed REE export controls because they only hold less than a year's—or sometimes even a few months'—supply of critical minerals in stockpile.[86]

While provocative, leveraging critical mineral dominance during a geopolitical conflict is hardly unprecedented. During World War II, Germany placed export restrictions on copper and sulfate, while Canada banned copper in certain circumstances, creating supply constraints on the U.S. military, even when it had strategic reserves established by the 1939 Strategic and Critical Materials Stock Piling Act.[87] Today, the United States is in a worse position than it was during WWII given the deeper dependence on foreign-sourced critical minerals and the declining stockpile of mineral inventories since the 1950s.[88]

Case Study #2: Prolonged Vulnerability: Generic APIs and KSMs

China's dominance of key chokepoints in the pharmaceutical supply chain has many parallels to U.S. vulnerabilities on critical minerals. Although the United States only imports 3 percent of oral doses and 9 percent of injectables from China, it is substantially more

exposed to Chinese raw pharmaceutical ingredients, including APIs and KSMs—biologically inactive chemical compounds that are purified into APIs. Nearly a quarter of APIs in U.S. generic drugs are potentially sourced from China, with India as a major intermediary, although the poor data visibility makes it difficult to determine the exact proportion. Supply chain visibility into KSMs in U.S. generics is even worse, with anywhere from one-quarter to one-half of U.S. generic drugs containing APIs developed from Chinese KSMs, often in India. While China has not formalized an export control regime for pharmaceuticals as it has for critical minerals, and global reputation costs may constrain it from doing so, the country could increase efforts to restrict pharmaceutical exports, including generic drugs as well as APIs and KSMs to the United States. (For more on the pharmaceutical supply chain, see Appendix I.) Such an action impacting even a small share of drugs used in the United States could have drastic consequences for the U.S. healthcare system, causing supply shocks that would result in loss of lives and force hospitals to make tough choices in allocating insufficient supply.

U.S. Dependency on China for Generic Drugs and Pharmaceutical Ingredients

The United States has become increasingly dependent on China as a source of raw pharmaceutical ingredients for generic drugs. Generic drugs, primarily oral doses, make up 90 percent of prescriptions filled in the United States, with the rest from brand-name drugs.[89] In 2024, the United States manufactured 22 percent of its generic oral dose drugs while importing 60 percent from India and 3 percent from China.[90] India as a major supplier of generic oral dose drugs to the United States also depends heavily on China for pharmaceutical ingredients in the upstream. While the United States is the biggest manufacturer of its injectable generics due to the complexity of production and transportation cost, it still sources 9 percent of injectable generics* from China.[91] The United States also depends heavily on China for pharmaceutical ingredients in the upstream.

Poor Data Transparency in Pharmaceutical Supply Chains and Challenges in Measuring U.S. Reliance on China

Poor data transparency in the pharmaceutical supply chain makes it challenging to accurately measure U.S. reliance on China for pharmaceutical ingredients. Most methodologies to calculate U.S. dependence on APIs from China rely on the Food and Drug Administration's (FDA) list of Drug Master File (DMFs)—applications submitted to the FDA by third-party API or KSM manufacturers for drug production.†[92] DMFs include the manufacturing capacity at facilities making the drug—but

*For the remainder of this subsection, references to "generics" with APIs sourcing from China are intended to refer to generic oral doses and injectables.

†Drug Master Files (DMFs) are confidential submissions to the FDA that detail facilities, processes, or materials used in drug manufacturing, allowing companies to reference the information without disclosure. DMFs include information about chemistry, manufacturing, and controls (CMC) for the API or its KSMs. DMFs indicate manufacturing capacity, not the actual volume used for pharmaceutical manufacturing. U.S. Food and Drug Administration, *Drug Master Files*

Poor Data Transparency in Pharmaceutical Supply Chains and Challenges in Measuring U.S. Reliance on China—*Continued*

not figures on actual volume, meaning methodologies that rely on DMFs to estimate exposure are considering potential rather than actual reliance.[93] As Janet Woodcock, director of the Center for Drug Evaluation and Research at the FDA noted in testimony before the House Committee on Energy and Commerce Health Subcommittee in 2019, the FDA does not have information on the actual volume of API imports from foreign countries or the portion of U.S. drug consumption that is dependent on foreign APIs. This lack of data makes it difficult to assess the true degree of U.S. dependency on China and India—and therefore the ultimate resilience of the U.S. pharmaceutical manufacturing base.[94]

Aside from limitations in using data from DMFs as a proxy for reliance, assessing U.S. dependence on China through India is difficult because of conflicting or inadequate data on India's own reliance on China. A commonly-cited Indian government report states that "India depends on China for around 68 percent of the APIs/Drug intermediates (DI) [or KSMs] that it uses in pharmaceutical manufacturing."[95] However, this statistic came from a 2020 KPMG India report that noted India's import dependency on China, not its overall dependency on Chinese APIs for India's pharmaceutical manufacturing.[96] India is also a large manufacturer of APIs used in its pharmaceutical production, and an Indian credit rating agency affiliated with Moody's reported that imported APIs accounted for 35 percent of its API requirements in 2024.[97] While India manufactures APIs, its KSM manufacturing capacity is limited, and the Indian government reported in 2023 that India heavily relies on China for "most" of the KSMs used in its API and drug manufacturing.[98] It is crucial to not conflate these two distinct phases of the pharmaceutical supply chain.[99] Data on U.S. reliance on China directly and via India for KSMs is even less extensive than data relating to APIs.[100]

Even with sufficient data, alternative approaches to measuring reliance can yield differing assessments of U.S. exposure to China. Calculations based on value will bias the results toward more expensive drugs; conversely, calculations based on volume may overemphasize inexpensive, commonly used drugs.[101] Volume measurements also vary by how a drug is consumed—through oral doses or injections.[102] Among various metrics, daily dose, defined by the World Health Organization as the average adult dose for a drug's main therapeutic use, offers a clearer view of a national healthcare system's consumer reliance on a drug type.[103]

(DMFs); Marta E. Wosińska and Yihan Shi, "U.S. Drug Supply Chain Exposure to China," *Brookings Institution*, July 28, 2025.

Based on daily dosage, an estimated 24.6 percent of the U.S. generic drug supply contains APIs originated from China, including 13 percent directly and 11.6 percent indirectly via India (see Figure 4).* [104] Additionally, there is evidence that the share of U.S. generics with APIs from China is growing, given that Chinese API manufacturers filed 219 DMFs with the FDA in 2023, surging 63 percent from 2021.[105]

The 24.6 percent of U.S. generics with Chinese APIs encompass a wide range of therapeutic categories, and exposure to Chinese APIs varies widely within each category, with some containing exclusively APIs originating from China. An analysis by the Brookings Institution identified 36 drugs where all currently in-use API DMFs are from China (see Appendix II for the list of drugs and their therapeutic uses).[106] These drugs include seven on the FDA's essential medicines list† (e.g., baloxavir marboxil used for pandemic influenza) and four cancer treatment drugs.[107] For a number of anticoagulants and antibiotics, the United States is wholly reliant on APIs from China. For example, dalteparin sodium and heparin sodium crude, used as active ingredients for the production of certain anticoagulants (blood thinners) appear to be solely sourced from China.‡ While there are over 100 antibiotics in use, a few appear to rely solely on APIs manufactured in China; for instance, the antibiotic lincomycin is used to treat serious bacterial infections for patients that have an allergy to penicillin.§ [108]

The high concentration of APIs sourced from China poses significant risks to U.S. consumers that rely on such medications, should disruption occur. For example, a 2016 explosion at a Chinese API factory caused a global shortage of the antibiotic piperacillin, a drug used to treat bacterial infections such as pneumonia, and thus with potential life or death implications.[109] The COVID-19 pandemic also shut down many API and drug intermediate factories in China, halting production of APIs and generic drugs.[110] Even when some sites reopened, ongoing staffing shortages and raw material delays continued to disrupt global pharmaceutical supply chains, caus-

*These estimates are based on calculations of Chinese contents embedded in India's pharmaceutical supply chain. Because India relies on imports to meet 35 percent of its API needs for pharmaceutical manufacturing, and China accounts for 70 percent of India's overall API imports, Chinese APIs then account for 24.5 percent of India's APIs required for drug production. Because India accounts for 47.2 percent of U.S. APIs for generics, U.S. reliance on China via India is 11.6 percent. However, without precise data on the flow of Chinese APIs in India's pharmaceutical production exported to the United States, any estimate assumes an even distribution of Chinese APIs across India's drug manufacturing—even though India's reliance on Chinese APIs likely varies significantly by drug.

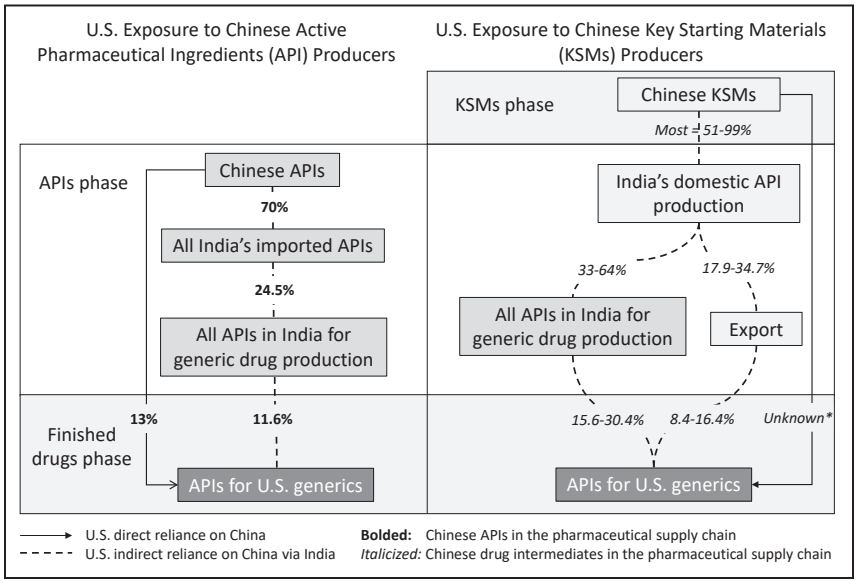
†The FDA's essential medicine list includes 86 drugs that are medically necessary to have available at all times in an amount adequate to serve patient needs and in the appropriate dosage forms, under the directive of the 2020 Executive Order 13944 on "Ensuring Essential Medicines, Medical Countermeasures, and Critical Inputs Are Made in the United States." U.S. Food and Drug Administration, *Executive Order 13944 List of Essential Medicines, Medical Countermeasures, and Critical Inputs*, May 23, 2022.

‡There are many different types of anticoagulants, and research did not establish how many of them were reliant in part on APIs from China.

§Antibiotics shortages could have long run consequences on U.S. and global public health by worsening antimicrobial resistance (AMR)—when pathogens change to become less responsive to medicine—making antibiotics ineffective against treatable diseases. The more patients use low doses of antibiotics or ineffective alternatives, the more antimicrobial organisms grow resistance to drugs. According to a 2016 U.S. Emerging Infections Network survey, the 2011 drug shortages forced 78 percent of the surveyed physicians to use different antimicrobial agents, and more than half of them believed that this action had adverse effects on their patients. World Health Organization, *Antimicrobial Resistance*, November 12, 2023; William G. Powderly, "Letter to Robert Califf Re: Survey Data on Anti-Infective Drug Shortages, Infections Diseases Society of America," November 14, 2016, 1.

ing shortages of antiretroviral drugs for HIV/AIDS and artemisinin-based combination therapy for malaria, among other lifesaving drugs.[111]

Figure 4: U.S. Direct and Indirect Reliance on China in the Pharmaceutical Supply Chain



*No known estimates.
Note: Because the Indian government only reports that it relies on China for "most" of its KSMs, the chart provides the maximum potential range for Chinese dependence at each step. See footnotes on the previous and current page for the discussion of the methodology used to generate this figure.
Source: Various.[112]

India also domestically produces a large portion of the APIs it uses in pharmaceutical manufacturing, but it relies heavily on China for KSMs, including those used in generic drugs and APIs it exports to the United States.[113] Many analyses cited by the Indian government note that China is often a single supplier of many of India's KSMs but provide no comprehensive estimates of such reliance.[114] One government report noted that "raw materials for most of the API intermediates are currently not produced in India [and] key starting materials (KSMs) for most APIs are still sourced from China."[115] Assuming the widest range possible—that anywhere from 51 to 99 percent of India's KSMs originate from China—between 24 and 46.8 percent of generic daily doses distributed in the United States that use APIs from India rely on Chinese content. This figure includes Chinese KSMs in generics from India, which account for anywhere between 15.6 and 30.4 percent of generics distributed in the United States; it also includes APIs from India used to manufacture generics consumed in the United States, which account for anywhere from 8.4 to 16.4 percent of APIs (see Figure 4).*[116] There

*Given the lack of precise information on India's reliance on China for KSMs, the estimates in this chapter assume 51 percent for the minimum likely reliance and 99 percent for maximum likely reliance. These estimates are based on calculations of Chinese contents embedded in In-

is evidence that India's reliance on China for KSMs is significantly higher for certain drugs; for example the Indian government reported that India's production of dexamethasone, used to treat inflammatory and autoimmune conditions, relies on key chemicals such as diosgenin, which is no longer available in India and has to be imported, presumably from China.[117]

In addition to its generics imports, the United States imports brand-name drugs from Europe, which sources more than half of its APIs from China.[118] Both the Indian government and the EU are aware of their dependency on China for APIs and KSMs and claim to be working to reduce such dependency, but as noted by both governments, progress remains glacial.[119]

Foreign pharmaceutical manufacturers struggle to compete with Chinese firms, as China's industry has benefited from financial subsidies that have driven down costs of API and KSM production, decades of market entry barriers, intellectual property theft, and lax environment regulation. Industrial policy support for pharmaceutical industry development dates back to at least 2005 with the Medium and Long-Term Plan for Science and Technology Development (2006–2020), and it continued under Made in China 2025 with support for more advanced biopharmaceuticals—drugs developed from living organisms rather than chemical synthesis.[120] Aside from long review times and a complex regulatory approval process for foreign drug makers seeking to sell into China, the Chinese government has also required foreign businesses to disclose sensitive technical information in drug formulations, which would later get leaked to local competitors.[121]

As the industry moves to more complex biopharmaceuticals, Chinese API manufacturers have further reduced production costs through extensive buildout of Chinese contract development manufacturing organizations offering critical intermediate steps in biopharmaceutical production supply chains. For example, Wuxi AppTec and other related companies reportedly have been involved in the development of one-fourth of all drugs in the United States.[122] As discussed extensively in Chapter 6, China is also a global leader in fermentation capacity used to cultivate genetically engineered cells for synthetic biology (for more see Chapter 6, "Interlocking Innovation Flywheels: China's Manufacturing and Innovation Engine").[123]

If China Leverages its Dominance in the API and KSM Supply Chains, It Could Cause Severe Harm to the United States

As noted above, global reputational constraints may limit China's willingness to exercise leverage over pharmaceutical APIs and KSMs. Having worked for years to expand its role in global pharmaceutical supply chains, however, China is increasingly in a position to use its dominance as leverage against the United States. Although China has not yet taken steps to weaponize its control over

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dia's pharmaceutical supply chain. Because India's domestic production of APIs accounts for 65 percent of its APIs needed for drug production, Chinese KSMs then account for 33–64 percent. Because India accounts for 47.2 percent of U.S. APIs for generics, U.S. reliance on Chinese KSMs via India is 15.6–30.4 percent. Given that India exports 35 percent of its domestically produced APIs, Chinese KSMs embedded in exported APIs then account for 17.9–34.7 percent, resulting in 8.4–16.4 percent of U.S. reliance on Chinese KSMs via India.

As noted in the previous textbox, DMFs indicate manufacturing capacity, not the actual volume used for pharmaceutical manufacturing.

pharmaceutical supply chains, some Chinese policy commentary has signaled awareness of China's leverage and interest in potentially employing it coercively. A few Chinese scholars have publicly suggested using China's control of APIs to retaliate against the United States, although the degree to which these scholars have direct policy influence is unclear. Several Chinese state media outlets reprinted a 2020 editorial noting if China places "strategic control of pharmaceutical products and prohibit exports to the United States, then the country would be trapped in the vast ocean of COVID-19."[124] A Chinese economist at Tsinghua University also urged the use of export restrictions on vitamins and antibiotic raw materials to halt global medical systems.[125] In spring 2025, some Chinese commentary on bilateral trade negotiations with the United States included a suggestion to restrict API exports as leverage.[126] Should Beijing succeed in effectively imposing export restrictions, U.S. dependence on China for many generic drugs would present a direct threat to its economic competitiveness, national security, and public health.

Findings from the Commission's 2019 Annual Report to Congress on U.S. API Supply Chain Vulnerability to China Prior to the COVID-19 Pandemic

The Commission first raised the issue of U.S. dependence on China in API supply chains in its hearing and 2019 Annual Report, before the world faced a severe global health crisis and disruption in the pharmaceutical supply chains during the COVID-19 pandemic.[127] The 2019 Annual Report chapter found the United States is heavily dependent on drugs sourced from China or drugs that include APIs sourced from China. The lack of regulation and oversight on the pharmaceutical industry in China exposes the United States to potential drug shortages and contamination. The Commission recommended a series of legislative actions to Congress, including requiring the FDA to compile a list of drugs and corresponding APIs that are foreign-sourced, critical to health and safety, and exclusively produced in China.

Since then, Congress has introduced a number of bills to address this concern. The Senate introduced the Medical Supply Chain Security Act in 2020 to give the FDA the authority to require manufacturers to notify the agency when they become aware of potential shortages.[128] The House introduced similar legislation in 2022.[129] Earlier this year, the Senate also introduced the Medical Supply Chain Resiliency Act to strengthen U.S. medical supply chains through strategic trade agreements with trusted trade partners.[130] However, none of these bills have been signed into law, and the risks from U.S. dependency on China's drugs and pharmaceutical ingredients persist. Additionally, after Congress passed the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) in 2020, the FDA established the Office of Supply Chain Resilience to encourage manufacturers to create a contingency plan to mitigate disruption. However, the legislation established reporting requirements but did not create binding obligations for manufacturers or grant FDA authority to ensure full industry compliance.[131]

Conflict Scenario: API and KSM Supplies Could Be Cut Off

In a conflict scenario, China could cut off exports of generics, APIs, and KSMs directly and/or indirectly to the United States. First, Beijing could cut off direct exports to the United States of its generic drugs, APIs, and KSMs. This would result in the United States losing access to 3 percent of generic drugs consumed through oral doses and 9 percent through injection, as well as 13 percent of the APIs used to make generic drugs domestically.

Second, Beijing could further escalate by attempting to restrict exports of APIs used to make drugs shipped to the United States from India—essentially introducing a "foreign direct product rule" on Chinese content in pharmaceuticals. Such a restriction could potentially cut off an additional 11.6 percent of U.S. generic drugs, but even a more targeted application—such as to the 36 drugs which appear to have no known alternative API sources—could cause severe disruptions to healthcare provision.

China could further devastate the U.S. healthcare system by seeking to control access to KSMs used in APIs and generics production for the United States, both directly and through India, threatening nearly one-quarter to one-half of U.S. generics. Whether China would be able to pressure India to comply with extraterritorial restrictions on its re-export of Chinese content is an open question, but China could attempt to employ tactics like limiting exports to India to only meet domestic demand or demand for a limited volume of exports, forcing the country to decide whether or not to sell to the United States. Such a threat could be costly to India as the country exports $15 billion of generic drugs to more than 200 countries, with the industry contributing nearly 2 percent of the country's gross domestic product (GDP).[132]

Generic drug shortages in the United States pose significant public security and economic harms to the country. An immediate drug shortage would severely undermine the U.S. public health system. Christopher Priest, then–Acting Deputy Assistant Director for Health Care Operations and Tricare for the Defense Health Agency, testified before the Commission in 2019, "Should China decide to limit or restrict the delivery of APIs to the U.S. it would have a debilitating effect on U.S. domestic production and could result in severe shortages of pharmaceuticals for both domestic and military uses."[133] A 2014 GAO report found that the 2011 record-high drug shortage caused serious health consequences or death as providers had to cancel or delay procedures because of high costs, difficulties finding alternative drugs, and reduced time for patient care.[134] For example, the U.S. norepinephrine shortage in that year correlated with increased mortality rate in septic shock patients by 3.7 percent.[135] Even a small disruption can lead to devastating shortages due to unavailability of one API source and long delays from the FDA having to approve new source of raw materials.[136] Additionally, the U.S. generic drug industry has a projected market size of $143.1 billion in 2025, and the outright lack of raw materials as well as other market disruptions caused by any Chinese export controls could halt production and/or sale of many generic drugs, potentially causing significant economic harm.[137]

U.S. Defense Sector Is at Risk of China's Weaponization of the API and KSM Supply Chain

DOD is vulnerable to disruptions in its API and KSM supply chains with China. In its 2023 *Report on the Department of Defense Pharmaceutical Supply Chain Risks*, DOD conducted a supply chain analysis by examining the 211 pharmaceuticals on the FDA's Essential Medicines and Medical Countermeasure list.[138] Based on that analysis, DOD designated 27 percent of the analyzed drugs as very high risk, including 5 percent of essential drugs made with an API sourced from China and 22 percent sourced from an unknown country, which could include China.*[139] The unknown country of origin in this analysis further highlights the challenges in tracking DOD pharmaceutical supply chains critical for the health and safety of service members.[140] An additional 26 percent of the pharmaceuticals had an API sourced from India.[141] In total, DOD has identified that 54 percent of the DOD pharmaceutical supply chain is considered either high or very high risk, with dependency on non-Trade Agreement Act (TAA) compliant suppliers, sourcing from China and India, or unknown countries.[142]

Drug shortages could pose significant risks to DOD operations and military readiness.[143] If the United States were to be cut off from access to pharmaceuticals with APIs sourced from China, DOD would see access to certain critical medicines curtailed.† DOD identified 46 drugs it used that relied upon Chinese APIs for certain specific formulations or dosages, accounting for 684 National Drug Codes (NDCs), seven of these (accounting for 20 NDCs, including certain formulations and dosages of insulin and doxycycline) relied on China entirely for their APIs.‡[144] DOD did not characterize the impact of losing access to the drugs identified as being reliant upon China, nor did it examine the viability of alternative suppliers. In a conflict scenario, losing access to even a small volume of critical drugs could affect combat readiness.

DOD has contingency plans in-place for the disruption of medications during military operations.[145] For example, DOD's Administration for Strategic Preparedness and Response manages the Strategic Active Pharmaceutical Ingredient Reserve, which is supposed to maintain two years' worth of supply, but as of March 2024, it only maintained reserves at 1 percent of that level.[146] DOD also administers the Shelf-Life Extension Program to evaluate and extend shelf life of certain federally stockpiled medical

*While DOD used the word "drugs" in its November 2023 *Report on the Department of Defense Pharmaceutical Supply Chain Risks*, its analysis is focused on National Drug Codes (NDCs), which list drugs based on dosage and delivery mechanism. Therefore, a single "drug" could have multiple NDCs. In fact, the Department identified 211 drugs, which accounted for 12,917 separate NDCs. U.S. Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report on the Department of Defense Pharmaceutical Supply Chain Risks*, November 2023, 8.

†Although advances in biomanufacturing may ultimately enable the U.S. military to produce APIs and precursors on site, the technology remains nascent, with its effectiveness and scalability still under testing.

‡The 684 drugs based on NDC the Department identified as reliant on Chinese APIs amounted to about 5 percent of the NDCs (formulations/dosages) in the DOD report; the 20 drugs entirely reliant on Chinese APIs amounted to 0.15 percent. U.S. Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report on the Department of Defense Pharmaceutical Supply Chain Risks*, November 2023, 8.

U.S. Defense Sector is at Risk of China's Weaponization of the API and Chemical Precursors Supply Chain—*Continued*

materials.[147] However, stockpiling is reserved for certain operations. For routine operations, DOD relies on the "just-in-time" ordering concept and does not keep or store additional generic drug products.[148] Therefore, if there are supply disruptions, including transportation delays or intentional adversarial actions, drug shortages might impact operations.[149]

Case Study #3: Latent Vulnerability: China's Control over Printed Circuit Board Manufacturing

U.S. electronics supply chains hinge on access to PCBs, a majority of which are produced in China. Although PCBs may appear to be a simple technology, they are in fact precision-manufactured components that constitute the infrastructure for other electronic parts. PCBs serve as both the bedrock that holds componentry in place and the electrical highways that link them together to form a functional device. Most electronics cannot be manufactured without one, if not multiple, PCBs (for more on the PCB supply chain, see Appendix I).

China produces more than half of the world's PCBs and leads a market estimated to be worth around $90 billion in 2025.[150] China accounted for 51 to 55 percent of global PCB production in 2023.[151] Its share exceeded 60 percent in specialized segments of the PCB market, including a 67 percent share in high-density interconnect (HDI) PCBs, which are complex, multi-layer boards that allow components to be stacked closer to meet the performance needs of advanced electronics ranging from artificial intelligence (AI) chips to electronic wearables such as fitness watches.[152] By comparison, the United States has only a handful of firms with the technology to produce HDI PCBs.[153] To further consolidate its lead, China has targeted the development of high-end electronic components, with a 2021 action plan channeling support into high-density and high-frequency PCB production.[154]

China may be able to exert significant leverage by targeting export restrictions to disrupt U.S. high-tech sectors, including AI and data center infrastructure. Targeted export controls on HDI PCBs may provide China such an option given its significant share in global production and the technology's importance to advanced computing applications.[155] If China prevented U.S. companies operating anywhere from accessing its HDI PCB production—for example, prohibiting sales to a company like Nvidia,* which reportedly sources PCBs from Chinese producers—it could slow the expansion of AI data centers and other high-performance computing infrastructure using U.S. technology both in the United States and overseas.[156] This in turn could make reliance on non-U.S. alternatives more attractive. Over time, U.S. companies may be able to switch to non-

*Nvidia has not reported details on its suppliers, and it is unclear which Nvidia graphics processing units used in AI applications are made using PCBs from Chinese firms.

China-based suppliers, but this switch could take some time due to the uniqueness and highly customized nature of each PCB.*[157]

China, however, would face challenges wielding its PCB manufacturing capacity to inflict broad-based harm to the United States. While a large share of PCBs is imported directly into the United States from China, this trade flow does not provide Beijing meaningful leverage over the United States as the level of domestic production that depends on unassembled PCBs is miniscule. China remains the largest single source of direct U.S. PCB imports used as inputs in domestic production, though its share has declined since 2018, when Section 301 tariffs were imposed on most PCB products from China. In 2024, the United States directly imported $786 million in PCBs from China, accounting for 30.3 percent of total imports—down from 46 percent in 2018.†[158] However, domestic U.S. production that depends on PCBs is limited; the value of PCB inputs used by U.S. producers amounted to 0.1 percent of GDP.‡[159] This volume of PCBs could likely be met through non-Chinese PCB suppliers, such that even if China implemented restrictions on direct PCB sales to the United States, the disruption would be localized and short-lived.

Most Chinese PCBs enter the U.S. market preassembled or embedded in electronic devices, posing immense challenges and costs for Beijing in trying to weaponize this dependence. While there are not readily available estimates of the percentage of U.S. electronics imports that contain Chinese PCBs, China is the United States' largest source of electronic product imports, accounting for $140.5 billion in imports in 2024, or 20.9 percent of the total.[160] Given China's over 50 percent share in global PCB production, a substantial portion of U.S. electronics likely contain made-in-China PCBs. Although this share likely exceeds a threshold that could damage the U.S. economy if Beijing restricted Chinese PCB content to U.S. end users, practical barriers limit its ability to impose a broad embargo. Since many Chinese PCBs are processed and assembled inside China, an effective ban would necessitate end-use checks across China's diverse electronics manufacturing sector, exponentially increasing the enforcement and monitoring challenge. Moreover, instituting a ban that severs China's electronics exports to the United States would pose high economic costs to China, given the importance of the U.S. market as a source of demand.

Case Study #4: The Future Chokepoint: Foundational Chips

China is seeking to replicate its supply chain dominance strategy in foundational semiconductors, which underpin almost all of modern technology. While the AI boom has sent the market value of leading-edge semiconductor companies soaring, AI chips account for less than 1 percent of nearly one trillion chips sold globally.[161]

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*PCBs are typically purpose-built for every electronics application, making each board unique. For more, see Appendix I.

†After China, the next five largest sources of U.S. bare PCB imports in 2024 were Taiwan (29.2 percent), Japan (6.5 percent), South Korea (5.5 percent), Canada (5.3 percent), and Thailand (4.1 percent).

‡This refers to the total value of output in 2017 from the printed circuit assembly industry—including fabrication, assembly, and other activities—that was used as an input in other U.S. production.

The vast majority of semiconductors are lower-cost components that are nonetheless crucial to virtually all electrically powered devices, including as key components embedded in AI processors themselves.[162] Foundational chips (sometimes misleadingly called legacy chips, see textbox) are typically defined as chips manufactured on a 28-nanometer (nm) or larger process node,* and the classification encompasses an array of different chips with distinct functions and utility (for an overview of the foundational chip industry, see Appendix I). Foundational chip fabs—highly specialized manufacturing facilities that produce the semiconductors—are largely concentrated in Taiwan, Japan, Europe, and the United States, meaning that U.S. exposure to Chinese production of these vital inputs is currently limited. However, Beijing has made establishing domestic semiconductor capabilities a top industrial policy priority for more than a decade, including within its Made in China 2025 plan, which called for achieving international competitiveness in both foundational and cutting-edge chips. Fueled by massive government support, China's production capacity in this market is expanding at breakneck pace, threatening global incumbents. Left unaddressed, the United States may soon depend on access to China's chip industry for producing even the most mundane electronic devices, creating a new point of strategic leverage for the CCP.†

Foundational Chips Are the Core of the Modern Economy, Not Legacy Technology

As foundational chips are often produced on long-established process nodes and with older-generation equipment, they are sometimes called "legacy" or "mature" chips, but these terms can be misleading, downplaying their importance and obscuring ongoing technological advances.[163] As Sarah Stewart, chief executive officer and executive director at Silverado Policy Accelerator, testified before the Commission, "These are chips that, in many cases, are quite innovative, and they are fit for a purpose, whether it is heat tolerance or moisture tolerance. They are not necessarily outdated or legacy."[164] Practically every electronic device contains anywhere from one to hundreds of foundational chips; the average vehicle contains over 1,700 foundational chips.[165] Even AI processors, which are powered by advanced semiconductors, rely on numerous foundational chips in order to operate properly.

*The process node generally refers to the feature size of transistors etched on the semiconductor. Node size does not necessary reflect how advanced or state of the art a foundational chip is, since the optimal feature size varies depending on the application and use case. This contrasts with advanced logic chips below the 28-nm threshold, where node shrinkage generally yields faster and more efficient chips but requires more complex manufacturing processes. Today's cutting-edge chips used in AI and other compute-intensive applications are made using 3-nm and 5-nm process nodes. Bryan Moyer, "Legacy Process Nodes Going Strong," *Semiconductor Engineering*, July 23, 2024.

†The United States launched two trade investigations into imports of Chinese-made foundational chips in the past year, including one under Section 301 of the Trade Act of 1974 initiated in December 2024 and the other under Section 232 of the Trade Expansion Act of 1962 in April 2025. Both investigations are still ongoing as of October 10, 2025. U.S. Department of Commerce, Bureau of Industry and Security, "Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Semiconductors and Semiconductor Manufacturing Equipment," 90 Fed. Reg. 15950 (April 16, 2025); U.S. Trade Representative, "Initiation of Section 301 Investigation; Hearing; and Request for Public Comments: China's Acts, Policies, and Practices Related to Targeting of the Semiconductor Industry for Dominance," 89 Fed. Reg. 106725 (December 30, 2024).

Foundational Chips Are the Core of the Modern Economy, Not Legacy Technology—*Continued*

According to the Semiconductor Industry Association's estimates, foundational chips enabled $10.8 trillion in economic activity in the United States in 2023.[166] Because foundational chips are ubiquitous across sectors such as automotive, industrial machinery, consumer electronics, military equipment, and medical devices, disruptions in their supply could cascade rapidly through the broader economy.[167]

The technology underlying some foundational chips is still advancing. Emerging foundational chip technologies include compound semiconductors—which are made by combining multiple elements, whereas most chips today are made primarily from a single element, silicon. For instance, silicon carbide (SiC) semiconductors have enabled EV manufacturers to adopt higher-voltage battery systems, increasing range and reducing charging times.[168] Gallium nitride (GaN) semiconductors have higher speed and lower resistance, offering reduced power consumption and smaller device sizes than traditional silicon-based semiconductors.[169]

Foundational chips are critical to the economy. The downstream products they enable—such as vehicles, industrial machinery, and medical devices—cannot function without them. The foundational chip shortage that began during the COVID-19 pandemic in 2020 exposed how an inability to source these components can halt entire production lines and cascade into a widespread economic disruption. The shortage stemmed from a sharp supply-demand imbalance driven by multiple factors, including fab slowdowns due to pandemic controls and automakers canceling orders in anticipation of weaker demand than actually materialized.[170] In addition, the global shift to work-from-home drove demand for consumer electronics, which contributed to demand for chips reaching historic highs—128 percent of available foundational wafer fabrication capacity in 2022.[171] The impact of the shortage was most visible in the auto sector.[172] Though many of the chips needed by the auto industry only cost a few dollars, those chips were necessary for producing systems throughout a car. North American automakers were forced to delay delivery of entire vehicles and cut production by over 4.3 million vehicles in 2021 and 2022 due to foundational chip shortages.[173] According to one estimate, the chip shortage led to over $210 billion in lost revenue for the global auto industry in 2021.[174] In addition to autos, the shortage disrupted production and created inflationary pressures across virtually every chip-using industry, which collectively account for roughly 40 percent of U.S. manufacturing output.[175]

U.S. Position in Foundational Chip Supply Chains

The United States has a substantial domestic foundational chip manufacturing sector that accounts for a large share of the global market, but it still relies heavily on overseas foundries. In 2023, the United States was home to 12 percent of global foundational chip production. Major companies include Texas Instruments, Global Foundries,* and onsemi.[176] U.S.-based production only makes up a portion of total domestic sales of foundational chips, estimated at $72 billion in 2023, and the United States therefore relies heavily on imports from other economies.†[177] The United States has awarded over $1.7 billion in funding under the CHIPS Act to support investment in domestic foundational chip capacity.[178]

U.S. producers earn significant revenue in other markets.[179] Chinese customers made up 19 percent and 25 percent of Texas Instruments' and onsemi's revenues, respectively, in 2024.‡[180] These customers include not only Chinese original equipment manufacturers (OEMs) serving the domestic market but also its export manufacturing sector.§

U.S. semiconductor firms not only operate sizable domestic fabs but also are major users of overseas capacity. In the key 20–45 nm process nodes,¶ U.S. "fabless" chip firms—companies that specialize in chip design and outsource production to other facilities—are heavily reliant on contract manufacturing with foreign facilities, including those located in Taiwan and, to a more limited degree, China.[181] However, U.S. (and global) manufacturers have significant reliance on Chinese facilities for the final stages of chip production—assembly, testing, and packaging (ATP)—where the United States held just 4 percent of global capacity compared to China's 30 percent in 2022.[182]

The United States Risks Deepening Reliance on Chinese Chips

The United States currently has a relatively low level of *direct* exposure to Chinese foundational chip production. The globalized nature of semiconductor supply chains makes it difficult to track the origin of chips entering the U.S. market, but most available metrics suggest that Chinese chips make up only a small share of direct imports. In the first half of 2025, the United States sourced 9.4 percent of its total integrated circuit imports from China on a volume

*Global Foundries is majority owned by a United Arab Emirates sovereign wealth fund.

†No comparable number is publicly available on the value of U.S.-made foundational chips used domestically, but available data suggest U.S.-based production is substantially smaller than total U.S. chip demand. The 2022 U.S. Economic Census reports that sales in the semiconductor manufacturing industry, including all types of chips, totaled $48.2 billion that year. U.S. Census Bureau, "*Economic Census: EC2200NAPCSPRDIND | Selected Sectors: Products by Industry for the U.S.: 2022*," 2025.

‡onsemi reports this revenue as coming from Hong Kong.

§In 2023, Kurt Sievers, CEO of Dutch foundational chip firm NXP Semiconductor, estimated that, of the 38 percent of revenue attributed to Chinese customers, roughly half was tied to chips that were processed and re-exported as part of assembled electronics. Conor Humphries, "NXP CEO Applauds EU Chips Act, Seeks Clarity on China Restrictions," *Reuters*, April 19, 2023.

¶The 20–45 nm process nodes are widely used for microcontrollers, which are versatile mini-computers that perform specific tasks in a wide range of electronics and industrial applications.

basis.* Similarly, U.S. fabless chip firms use Chinese manufacturers for only a portion of their fabrication needs. According to a survey conducted by the Department of Commerce's Bureau of Industry and Security (BIS) in January 2024, U.S. semiconductor firms outsourced just 1.5 percent of their total chip output to China-based foundries, which provide contract manufacturing services for other companies.[183] Semiconductor Manufacturing International Corporation (SMIC) and Hua Hong Group, China's two largest foundries, accounted for a majority of chip production outsourced to China by U.S. companies.†[184] One of the primary reasons respondents cited for sourcing from China was a lack of alternative suppliers that were willing to produce those chips at the same cost, underlining how non-Chinese foundries are particularly vulnerable to losing market share in lower-value market segments to state-supported Chinese competitors.[185]

Despite the limited direct sourcing of Chinese foundational chips, Chinese-made chips are present in most products sold by U.S. companies, although the number of such chips in each product is frequently unknown. While China-fabricated chips account for a small share of overall chip usage, they are used consistently across many products. According to the January 2024 BIS survey, just 2.8 percent of the number of foundational chips used by surveyed manufacturers come from Chinese-owned foundries, and most of these chips are sourced from U.S. or European-based chip designers.[186] At the same time, over two-thirds of respondents' products contained at least one chip from a China-based foundry, indicating that U.S. manufacturers' use of Chinese chips is pervasive but typically limited in scale.[187] Alarmingly, the true level of Chinese chips in U.S. products is unclear, with more than 44 percent of U.S. companies indicating that they lacked sufficient visibility to determine whether semiconductors from China-based foundries were present in their products.[188] Similarly, the full number of Chinese foundational chips entering the U.S. market embedded in finished goods is unknown, but this trend is almost certain to accelerate as Chinese chip production surges.

Chinese-made chips are present in U.S. defense supply chains, creating a vulnerability that exposes critical military systems to po-

*Import data largely reflect where chips are finalized, which can differ from where the fab is located due to outsourcing of assembly, testing, and packaging (ATP) to specialized firms. In other words, chips fabricated in China but finished in offshore facilities would not be recorded as China-origin in U.S. trade data. Additionally, U.S. data on imports from China capture non-Chinese chips finalized inside China, which is home to roughly one-third of global ATP capacity. Notably, alongside Taiwan's share of U.S. chip imports (21.8 percent), other major U.S. sources were Malaysia (21.9 percent) and Thailand (9.7 percent), which account for a large share of global ATP capacity but have limited chip manufacturing capabilities. U.S. Census Bureau, *USA Trade Online*, August 19, 2025; Raja Varadarajan et al., "Emerging Resilience in the Semiconductor Supply Chain," *Boston Consulting Group and Semiconductor Industry Association*, May 2024, 10, 21.

†Chinese companies have continued to have access to many types of semiconductor manufacturing equipment used for foundational chips. While SMIC was placed on the Entity List in 2020, subjecting exports to license requirements, the rules exempted mature-node production. Hua Hong is not on the Entity List. Hua Hong had been listed as a Validated End-User, which meant exports of controlled items were allowed under a general authorization. However, its designation was removed in December 2024, meaning exports now require individual license reviews, though not under a presumption of denial as with many Entity List companies. Reva Goujon and Ben Reynolds, "Slaying Self-Reliance: US Chip Controls in Biden's Final Stretch," *Rhodium Group*, December 9, 2024; U.S. Department of Commerce, Bureau of Industry and Security, "Additions and Modifications to the Entity List; Removals from the Validated End-User (VEU) Program," 89 Fed. Reg. 96830 (December 5, 2024); Reva Goujon and Jan-Peter Kleinhans, "All In: U.S. Places a Big Bet with October 17 Controls," *Rhodium Group*, November 6, 2023.

tential disruption, compromise, or strategic leverage by Beijing. The BIS survey found that, while products with known use in defense production contained lower levels of known China-origin chips, a majority of those products likely still contained at least one chip that was manufactured in Chinese facilities.[189] However, the agency reports that "most companies providing defense products had no visibility into the location of fabrication," and the actual extent of Chinese semiconductors could be higher.[190] Other studies point to greater upstream exposure to Chinese companies. A 2024 report by AI supply chain analytics company Govini estimated that more than 40 percent of the chips used in U.S. military systems are produced by chipmakers that source components, equipment, or services from Chinese companies.[191] It found that Chinese companies were present in supply chains for over 6,500 chips in Ford-class aircraft carriers, underscoring the exposure of even the most advanced military systems to Chinese suppliers. In addition to raising the risk of a supply disruption that stalls U.S. defense production, foundational chips sourced from Chinese foundries may provide Beijing the opportunity to tamper with and introduce vulnerabilities into U.S. critical systems. Although the United States has restricted government and defense procurement of Chinese chips,* the presence of Chinese chips in the broader U.S. market is projected to grow.

China Positioning for Dominance in Foundational Chip Production

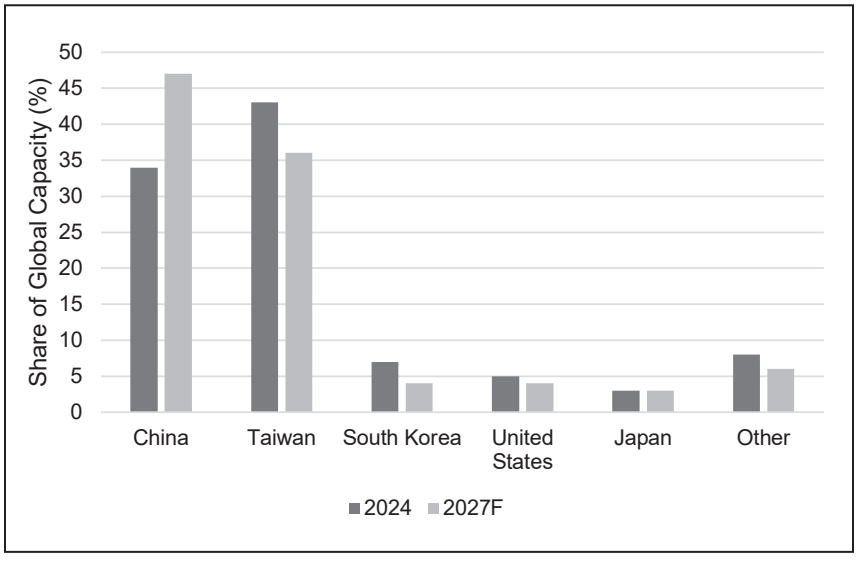
While China's current position in semiconductors does not at first blush suggest impending dominance, China is making massive investments in new capacity completely divorced from market dynamics, a trend likely to create significant supply distortions that could upend profitability for existing companies, undercutting their ability to compete and substantially strengthening China's market position. China's investments in the foundational chip sector are outpacing the rest of the world and will likely lead to overcapacity. In 2024, China's planned investments in new foundational wafer capacity exceeded the rest of the world combined, making up 55 percent of planned investments.[192] If all this production comes online,† China's share of global production is projected to rise from 34 percent in 2024 to 47 percent by 2027 (see Figure 5). Its share may even exceed 50 percent by 2030.[193] Although Chinese foundational chipmakers do not currently exhibit signs of overcapacity—in its simplest form defined as high levels of unused production capacity—this massive

*To combat Chinese foundational chip usage in defense supply chains, the FY23 National Defense Authorization Act § 5949 prohibits the U.S. government from sourcing chips made by SMIC as well as memory companies ChangXin Memory Technologies (CXMT) and Yangtze Memory Technologies Corp (YMTC)—as well as any product that contains such chips—starting in 2027. However, ensuring compliance with Section 5949 may prove challenging given defense suppliers' limited visibility. Tina D. Reynolds, "Key Takeaways from the Federal Government's Proposed Rule Banning Certain Chinese-Origin Semiconductor Technology," *Morrison Foerster*, May 16, 2024.

†These projections are based on announced investments, but semiconductor companies may adjust the pace of supply expansion based on various factors. For instance, SMIC stated in November 2024 that it is avoiding initiating new investment projects due to projected softness in chip demand. In addition, the performance of China's existing facilities varies widely, and it is possible new fabs fail to achieve their projected productivity levels. Andreas Schumacher, "China's Mature Semiconductor Overcapacity: Does It Exist and Does It Matter?" *Center for Strategic and International Studies*, November 19, 2024; "SMIC Sees Prolonged Chip Glut, Signals Cautious Expansion Outlook," *Reuters*, November 7, 2024.

influx of new production capacity driven by China's industrial policy rather than market forces will likely lead to high levels of excess capacity in the near future.*

Figure 5: Foundational Foundry Capacity by Location, 2024 and 2027 (Forecast)



Source: Analysis of TrendForce data by Lin Yu-Jou, "紅鏈逼近! 中國殺價拚擴產, 台灣成熟製程晶圓廠如何突圍?" [The Red Supply Chain Closes In! As China Slashes Prices to Expand Capacity, How Can Taiwan's Mature-Node Foundries Break Through?], *TechNews*, February 11, 2025.

As an initial step, China's chip buildout threatens to displace foreign chipmakers in its domestic market. A majority of China's planned capacity expansion is occurring in foundational nodes for low-power Internet of Things chips and microcontrollers.† [194] These components are widely used by China's immense electronics manufacturing sector, which purchases nearly a quarter of the world's foundational semiconductors.[195] Domestic OEMs already account for a majority of Chinese chipmakers' revenue—up to 85 percent in 2024 in SMIC's case—and the domestic manufacturing sector will likely absorb most of China's capacity expansion, at the expense of sales by non-Chinese firms.[196]

To ensure demand for its chip companies, China is implementing import substitution policies, including discriminatory procurement policies and explicit and implicit guidance to SOEs to purchase indigenously made chips.[197] In line with these efforts, a group of Chinese industry associations urged companies to exercise caution in purchasing U.S. chips in December 2024, warning that U.S. chip supplies can no longer be considered "safe and reliable" due to risks from U.S. export control policies.[198] Amid U.S.-China trade tensions, China's MOFCOM announced

*SMIC and Hua Hong have largely maintained capacity utilization rates that exceed the global average up through 2023. Reva Goujon, Jan-Peter Kleinhans, and Laura Gormley, "Thin Ice: US Pathways to Regulating China-Sourced Legacy Chips," *Rhodium Group*, May 7, 2024, 5.

†Specifically, China is investing heavily in production capacity at the 20–40-nm process nodes.

on September 13, 2025, an anti-dumping investigation into U.S. shipments of certain analog chips, which could impact the sales of U.S. chip companies.[199] Combined with looming overcapacity, these policy actions may make it increasingly challenging for non-Chinese firms to retain market share inside China, enabling Chinese firms to capture the domestic market.* This could allow them to attain greater scale and grow globally competitive, further placing foreign firms at a disadvantage. As ST Microelectronics' CEO Jean-Marc Chery highlighted, ceding market share in China means "the Chinese players [will] dominate their market… and their domestic market is so huge, it will be a fantastic platform for them to compete in other countries."[200]

Chinese capacity expansion is already pushing down prices and forcing competitors to exit from segments of China's market, as Chinese foundries win customers away from non-Chinese manufacturers.[201] Taiwan Semiconductor Manufacturing Company (TSMC) is reportedly terminating its gallium nitride (GaN) chip production due to a price war (see textbox below).[202] Similarly, Taiwan's Powerchip Semiconductor Manufacturing Corporation announced that it was pivoting into new, AI-related product lines due to competition from Chinese chipmakers.[203] As below-cost Chinese chips flood both domestic and global markets, price pressures are expected to persist, with even SMIC's co-CEO Zhao Haijun cautioning that growing production capacity in China could trigger price wars among foundries competing over limited orders.[204] The surge in production capacity in excess of expected market demand is likely to weigh further on prices, cutting into the profitability and financial performance of non-Chinese chip companies.

Loss of market share in China may force further global consolidation in the industry. According to Global Foundries, "China's decision to build capacity for China, to be sourced primarily from indigenous suppliers, will likely have the dual effect of limiting the Chinese market for other global suppliers like us and significantly increasing the competition we face globally."[205] Western semiconductor companies are unlikely to be squeezed out uniformly or all at once, and some market segments are more vulnerable to nonmarket competition. For instance, in the automotive industry where automotive chips must meet exacting operational specifications, carmakers tend to establish relationships with chip suppliers that span decades, rather than years, making it highly costly to switch to a new supplier.[206] In contrast, many chips used in consumer electronics are sold as commercial off-the-shelf products that are interoperable and interchangeable. For example, when certain microcontrollers were in short supply during the COVID-19 pandemic, the Chinese chipmaker GigaDevice introduced a "pin-compatible clone" of a microcontroller made by ST Microelectronics, rapidly gaining market share and tripling its revenue.[207]

*Chinese officials are increasingly employing similar tactics to curb purchases of leading-edge foreign chips. In September 2025, the Cyberspace Administration of China effectively blocked several Chinese companies from buying Nvidia RTX Pro 6000D graphics cards. For more, see Chapter 1, "U.S.-China Economics and Trade Relations (Year in Review)." Mackenzie Hawkins and Luz Ding, "China Tells Companies to Stop Buying Nvidia Chip with AI Uses," *Bloomberg*, September 17, 2025.

To date, the massive increase in spending on foundational chip manufacturing equipment has not been accompanied by public commentary in China explicitly identifying the strategic benefits that dominance in foundational chipmaking could provide as a tool of influence.[208] An article published in February 2025 by Peking University scholar He Pengyu is among the first to articulate the strategic advantages of China's chip buildout. He argued that "establishing a competitive edge in traditional chips is not only a strategic countermeasure against the U.S. 'stranglehold' over advanced chips, but also a critical step toward building domestic industrial chains and developing indigenous technologies."[209] He argued that China should consider restricting market access to U.S. chip companies to further erode their role within China's market.[210]

China Invests in Overlooked Chip Segments with Significant Military Value

China is seeking to leapfrog the United States by gaining a first-mover advantage in emerging compound semiconductor technologies, particularly in wide band-gap semiconductors.* This class of semiconductors include gallium nitride (GaN) and silicon carbide (SiC), which have wide-ranging applications from efficient power chips for EVs to chips with higher power density used in the next generation of military radar systems that are able to track targets at farther distances with higher resolution.[211] China set a goal of leading technological breakthroughs in wide band-gap chips within its 14th Five-Year Plan released in 2021.[212] China refers to these as "third-generation semiconductors," intentionally implying that wide band-gap chips represent a step change in semiconductor technology.[213] Strong state support, combined with dominance in upstream raw materials for compound semiconductor wafers, has fueled the rapid expansion of its domestic industry and helped Chinese firms undercut foreign competitors. These efforts enabled Chinese suppliers to offer unfabricated SiC wafers for as low as $500 a piece, relative to the $1,500 cost of wafers from the global leader in SiC technology, U.S.-based Wolfspeed.†[214] Increased competition from China contributed to a decline in Wolfspeed's global market share, which fell from 62 percent in 2021 to 33 percent in 2023.[215] In GaN chips, China's Innoscience has already established a market-leading position.[216] China has placed export controls on gallium and related materials since mid-2023 (see Table 1), creating barriers to U.S. production of military systems that rely on gallium and GaN chips.[217]

*Wide band-gap refers to a special class of compound semiconductors whose properties enable devices to operate at higher voltages, temperatures, and frequencies. "Wide Bandgap Semiconductors (SiC/GaN)," *Infineon*.

†In June 2025, Wolfspeed filed for Chapter 11 bankruptcy. A U.S. court approved its restructuring plan in early September, and it exited Chapter 11 bankruptcy on September 30. "Wolfspeed Shares Rally after Chipmaker Exits Chapter 11 Bankruptcy," *Reuters*, September 30, 2025; "Wolfspeed's Shares Surge as US Bankruptcy Court Approves Restructuring Plan," *Reuters*, September 9, 2025.

Consequences of China Establishing and Leveraging Dominance over Foundational Chip Supply Chains

In the absence of a response by the United States and like-minded countries, the current surge of Chinese chipmaking capacity risks a scenario where an increasing share of foundational chips used in U.S. production—which the Semiconductor Industry Association estimated at $72 billion in 2023—are sourced from China-based fabs.[218] As non-Chinese competitors are forced out of market segments by heavily subsidized Chinese competitors, this could force U.S. manufacturers to rely on Chinese suppliers for essential components, exposing them to potential disruption or coercion in times of geopolitical tension. Given the ubiquitous nature of foundational semiconductors in all electronics, the economic damage would be profound; a wide swath of U.S. manufacturing could be ground to a halt, including manufacturing necessary for defense needs, critical infrastructure, healthcare, and more. As illustrated by the COVID-19-era chip shortage, China may need to exercise effective control over only a portion of the United States' chip imports to inflict multiple years of economic pain. Because they are complex, multi-billion-dollar facilities, establishing new fabs to replace embargoed capacity would likely take years, giving Beijing a chokepoint it could exploit to inflict prolonged costs on the United States.

The United States Needs a Coherent Long-Term Commitment to Reduce China's Supply Chain Leverage

The status quo of U.S. supply chain exposure to China presents unacceptable risks to U.S. economic and national security. This strategic failure persists in large part because U.S. policymakers still lack transparency around the scope of these vulnerabilities as well as a broader appreciation of what could happen if Beijing ever chose to weaponize these economic dependencies in a conflict scenario. Without a coherent long-term strategy supported by consistent implementation with necessary resources, and likely requiring cooperation with allies, these vulnerabilities will deepen as China expands its dominance in additional sectors.

Any effective strategy to insulate the U.S. economy from Chinese economic coercion requires adaptive, forward-looking prioritization of which supply chain vulnerabilities to address. Moving to zero reliance on Chinese production is neither a realistic nor necessary objective. Rather, the United States must focus its efforts on supply chain dependencies based on a full estimate of the risks and dynamics in the sector. Analysis must identify supply chains where the United States has a high degree of dependence on Chinese production (or could develop a dependence based on clear trends); focus on products or inputs critical to U.S. economic and/or national security; and evaluate constraints on China's ability to weaponize the supply chain, including practical enforcement challenges, economic costs to China, and risks from reputational impact and escalation. China's control over critical minerals poses a significant economic threat to the United States without parallel costs on China, which

has enhanced its enforcement capacity, but other sectors will have different profiles that must be carefully assessed.

Addressing Gaps in the Current Approach to Supply Chain Resiliency

Several critical gaps must be addressed to align U.S. government and private-sector efforts toward the goal of resiliency against Chinese economic coercion, including: limited data on supply chain vulnerabilities, a misaligned incentive structure that leads to underinvestment by the private sector in resiliency, insufficient surge production capacity, and coordination problems with U.S. allies and partners.

- *Challenges to supply chain analytics and data:* The U.S. government's ability to identify supply chain vulnerabilities has improved in recent years, but insufficient data and analytic capabilities means it continues to lack a complete and dynamic picture of dependencies on China. While the U.S. government has made greater use of commercially available supply chain datasets and analytic software, these are often insufficient to map key supply chains because many critical pieces of information needed by decision-makers, such as a supplier's production capabilities or upstream sourcing vulnerabilities, are not captured.[219]

  Prior to 2020, supply chain assessments were largely focused on identifying risks to defense supply chains and were often undertaken on an ad hoc basis. These included industrial base assessments conducted by the U.S. Department of Commerce under Section 705 of the Defense Production Act and annual reports by DOD on risks to the defense industrial base.*[220] In recent years, in-depth supply chain reviews prompted by COVID-19-related disruptions, as well as the recently established Supply Chain Center in the Commerce Department (see textbox below), have provided policymakers with much more detailed insight into supply chain risks. Nonetheless, visibility remains inadequate to provide up-to-date analysis of many critical sectors.

  As Monica Gorman, former Special Assistant to the President for manufacturing and industrial policy and now managing director at Crowell Global Advisors, assessed in testimony before the Commission, the U.S. government "lacks a systemic view of the U.S. industries and products most at risk" because it lacks detailed-enough data to analyze specific dependencies.[221] Supply chain analytics is hampered by two key challenges: insufficient data collection—whether due to the government's difficulties gathering it or the absence of viable proprietary providers—and institutional barriers that hinder sharing and using data in analysis.[222]

  The U.S. government's visibility into pharma supply chains exemplifies these challenges. The U.S. Department of Health and

*Efforts to monitor risks in manufacturing supply chains without a direct defense nexus also existed, such as the USGS's annual Mineral Commodity Summaries, the U.S. Department of Energy-funded Clean Energy Manufacturing Analysis Center, established in 2015, and a 2017 executive order mandating a review of U.S. manufacturing capabilities essential to national security.

Human Services assessed in the White House's 2021 100-Day Supply Chain Review that "the data currently available to FDA are not sufficient to build a system that allows for optimal, timely predictions or action."[223] The FDA does not collect data on KSMs, which, as discussed earlier, makes it extremely difficult to assess U.S. reliance on Chinese inputs in API production.[224] It also lacks data that may contribute to assessment of supply chain risks, such as whether a drug manufacturer is fully reliant on a single upstream supplier for a specific input or how much time it takes manufacturers to scale production to meet demand surges.[225] Further, much of the data the FDA collects is siloed or otherwise unavailable for use by other agencies to support supply chain mapping efforts.* Similar challenges are present throughout the U.S. government.[226] Moreover, many agencies, including the FDA, lack legal authority to compel firms to share critical data; by contrast, Executive Order 13603 delegated Defense Production Act authorities to the Department of Commerce that enable it to require firms within its jurisdiction to provide data on U.S. defense industrial capabilities.†[227]

Supply Chain Dependencies Identified by the Commerce Department's Novel SCALE Tool

In 2023, the Commerce Department established the Supply Chain Center with the aim of integrating industry expertise and data analytics to monitor and identify supply chain vulnerabilities. The center developed a novel tool called SCALE, which aims to provide the U.S. government a whole-of-economy analysis of U.S. supply chains and promises to create a "heat map of risk and assess industries from highest to lowest risk."[228] Since 2024, SCALE analysis revealed that more than 38 percent of U.S. industries source over half their imports from two adversarial nations, China and Russia, and 71 different industries are at least 70 percent reliant on these nations for most of their imports. Moreover, nearly 38 percent of industries are reliant on single-country-sourced products.[229] The center has used this analytical tool

*Statutory limitations, such as Section 311(j) of the Food, Drug, and Cosmetic Act, restrict the FDA from providing data collected for regulatory purposes to other U.S. agencies to conduct supply chain analytics. The FDA's approach to data collection and storage may pose additional challenges, as data gathered primarily for regulatory purposes may not be organized for analytical use. Stephen Schondelmeyer, a professor of pharmaceutical management and economics at the University of Minnesota, testified before the Commsision that the data the FDA collects on drug products are "generally not structured to permit systematic, market-wide assessment of the drug supply chain within a given agency, let alone across agencies." Stephen W. Schondelmeyer, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on Dominance by Design: China Shock 2.0 and the Supply Chain Chokepoints Eroding U.S. Security*, June 5, 2025, 7; U.S. Senate Committee on Homeland Security and Government Affairs Majority, *Short Supply: The Health and National Security Risks of Drug Shortages*, March 2023, 38; National Academics of Sciences, Engineering, and Medicine, *Building Resilience into the Nation's Medical Product Supply Chains* (National Academies Press, 2022), 166.

†The Defense Production Act of 1950 grants the President broad authority to obtain information "as may be necessary or appropriate, in his discretion, to the enforcement of the administration" of the act, including to conduct assessments of the U.S. defense industrial base. Executive Order 13603 delegated this authority to the Commerce Department, in cooperation with the Departments of Defense and Homeland Security. Alexandra G. Neenan, "The Defense Production Act of 1950: History, Authorities, and Considerations for Congress," *Congressional Research Service* (Report No. R43767), October 6, 2023, 15; White House, "Executive Order 13603 of March 16, 2012: National Defense Resources Preparedness," 77 Fed. Reg 16651 (March 22, 2012); Defense Production Act of 1950 § 705, codified at 50 U.S.C. § 4555.

Supply Chain Dependencies Identified by the Commerce Department's Novel SCALE Tool—*Continued*

to perform feasibility assessments. For instance, SCALE analysis found that the buildout of AI data centers is highly vulnerable to disruptions in the supply of backup generators, PCBs, cooling technologies, networking equipment, and semiconductors.[230] However, experts have noted that the tool is limited by the data available to the U.S. government. For instance, trade data used in the analysis are limited by the product grouping under the Harmonized Tariff Schedule, which is not granular enough to track the origin of specific inputs or components.[231] Lacking such micro-level data, the tool itself is unable to reveal dependencies on suppliers vital to U.S. production. The center continues to rely on qualitative analysis to compensate for the limitations of SCALE's quantitative findings, with the tool acting as part of a three-legged stool, alongside the agency's in-house industry expertise and engagement with business and subject matter experts.[232] Improved data could enhance the type of insights it can provide.*

- *Lack of incentives for U.S. industry to invest in supply chain resiliency:* Various market-based factors and policy changes incentivized U.S. industry to offshore production, contributing to supply chain vulnerabilities. The market continues to underprice the risks of supply chain fragility. Dr. Gorman noted in testimony that "companies do not routinely 'stress-test' supply chains against various risk scenarios, even though the frequency and severity of supply chain disruptions has been increasing over time."[233] Addressing supply chain risks will require U.S. policy to create market signals that incentivize firms to de-risk and enhance resiliency.
- *Limited surge capacity and stockpiling:* The United States lacks the manufacturing industrial base to surge many critical needs to meet demand in a crisis. Numerous recent crises have demonstrated the consequences of insufficient surge production, including U.S. vulnerability to China's critical minerals controls; bottlenecks in producing munitions used by Ukraine; the 2021 and 2022 semiconductor shortage; and the supply of ventilators during the COVID-19 pandemic, which ramped up only after the peak had passed.[234] Stockpiling critical inputs and goods provides greater time and flexibility to respond to supply disruptions, but current U.S. strategic stockpiles are insufficient for a prolonged supply disruption and would be rapidly depleted in a high-intensity conflict.[235] A series of wargames run by the Center for Strategic and International Studies found that "the United States would likely run out of some munitions—such as long-range, precision-guided munitions—in less than one week in a Taiwan Strait conflict."[236] The limitations of stockpiling, in-

*In June 2025, the Senate passed the Promoting Resilient Supply Chains Act of 2025. If passed by the House and signed into law, the Act would create new reporting requirements on supply chain risks, which would likely be completed by the Supply Chain Center. Promoting Resilient Supply Chains Act of 2025, S.275, introduced January 27, 2025.

cluding the difficulty of accurately predicting crisis-time needs, mean it is only viable as part of a larger strategy to prepare for demand surges and supply disruptions.[237] A more comprehensive approach requires the U.S. government to view surge production capacity as a collective good and ensure a level of domestic manufacturing capacity beyond what the market ordinarily supports.

- *Challenges in coordinating with allies and partners:* China's dominance in a supply chain will often create parallel risks for U.S. allies and partners. Building enduring supply chain resilience requires cooperation with like-minded and similarly vulnerable countries to secure access, diversify sources, ensure scale for alternative suppliers, and stabilize global markets. The United States and its allies and partners will need to overcome challenges in information sharing and coordinating policy responses.[238] Without international collaboration, the United States may risk implementing fragmented, costly, and ultimately ineffective efforts in countering China's weaponization of supply chain vulnerabilities.

Implications for the United States

China's drive to control strategic chokepoints across numerous key industries threatens to expand the scope of U.S. supply chain insecurity. **Despite the risks of reliance on China for inputs like critical minerals and APIs being long acknowledged, U.S. policy has not meaningfully moved at scale to fortify against potential coercion.** The status quo approach is also failing to prepare for China's emerging dominance in foundational chips and other critical sectors.

Whether it is critical minerals, APIs and other critical inputs in the pharmaceutical supply chain, or PCBs, the vulnerabilities of the American economy in both peacetime and wartime are staggering. New vulnerabilities, like potential dependence on Chinese foundational chips, will make the problem worse. **Without a deliberate U.S. strategy—either unilateral or coordinated with allies and partners such as Europe, Japan, South Korea, and India—the United States is on track to face an enduring strategic vulnerability that China can exploit for decades to come.** The implications go beyond physical supply disruptions.

Deep economic dependence creates not only the risk of supply disruption but also the risk of decision paralysis—where U.S. policymakers avoid necessary action for fear of Chinese retaliation. This chilling effect on U.S. decision-making can weaken deterrence in both economic and security domains, undermining the credibility of U.S. commitments to allies and partners.

Addressing persistent supply chain vulnerabilities requires a sustained and comprehensive effort across the U.S. government. These vulnerabilities are the direct result of decades of market decisions that were allowed to be shaped by China's nonmarket practices. Undoing these networks will require the U.S. government to create alternative market signals and reshape the incentives facing U.S. firms through carefully coordinated and targeted use of tariffs, subsidies, procurement, and other industrial

policy instruments. Identifying where the United States needs to deploy these policy tools is key. However, the U.S. government lacks sufficient information on supply chains to act, largely because it lacks the necessary legal authorities, has underutilized the authorities it does have, or keeps key datasets trapped behind bureaucratic siloes.

Supply chain security does not entail zero reliance on Chinese producers. Rather, it involves an end state where, if China severs supply chain access to U.S. companies, the economy can continue to meet its critical needs. **However, the United States has yet to define the contours of this end state, let alone propose an economic strategy to realize it.** Any such approach will require a blend of policies, such as implementing industrial policies that expand U.S. domestic production, providing U.S. businesses incentives or support to diversify supply relationships away from sole reliance on China, investing in capabilities like surge production capacity to mitigate the damage from supply disruptions, and pursuing other measures targeted at critical supply chain vulnerabilities.

Building and maintaining this resilience will be an ongoing process. U.S. efforts have at best focused on today's vulnerabilities, not tomorrow's chokepoints. The emergence of new technologies and China's perpetual pursuit of manufacturing dominance will create new vulnerabilities. Beijing is already positioning itself to control supply chains of the future, including synthetic biology (for more, see Chapter 6, "Interlocking Innovation Flywheels: China's Manufacturing and Innovation Engine"). **Without proactive monitoring and effective interventions, the United States may repeat the pattern of reacting too passively and too late while allowing China to maintain critical leverage over key U.S. supply chains.**

Recommendations

The Commission recommends:

- Congress build U.S. pharmaceutical supply chain resilience by increasing visibility into the supply chain, as well as tracking and reducing U.S. direct and indirect dependence on Chinese active pharmaceutical ingredients (APIs) and related key starting materials (KSMs), through legislation that:
  - Amends section 3112(e) of the Coronavirus Aid, Relief, and Economic Security (CARES) Act to expand the authority of the U.S. Food and Drug Administration (FDA) to require drug manufacturers to report volume and ultimate origin of APIs and KSMs used in drugs consumed in the United States, including sourcing of Chinese content through third countries. Based on this information, the FDA should:
    - Produce a confidential report analyzing U.S. vulnerabilities to Chinese APIs and KSMs. The report should identify the proportion of U.S. drug consumption that is dependent on foreign APIs and KSMs, determine vulnerabilities, and track trends over time, including anonymized aggregates of increases or decreases in U.S. dependency on China.

- Directs the FDA to identify regulatory authorities and deficiencies to support or incentivize the use of APIs and KSMs from sources with no China origin.
- Directs the Centers for Medicare and Medicaid Services (CMS) to explore the use of procurement and reimbursement authorities to protect the U.S. and allies' API and KSM markets, which could include price floor commitments in support of U.S. industry to protect investments against nonmarket practices and price manipulation.

- To support the U.S. Department of Commerce's Supply Chain Center in addressing the lack of sufficiently fine-grained, real-time data on U.S. dependence on China for materials and intermediate goods, the relevant committees of Congress should hold hearings on the activities of the Center, the adequacy of its funding, and the ways in which its work might be improved through the incorporation of data and techniques being developed in the private sector. The Supply Chain Center should then be required to provide an annual report identifying a set of goods and materials deemed critical to national defense and/or the functioning of the civilian economy, detailing trends in U.S. dependence on China for those goods and materials, and reporting on the status of policies and programs intended to limit that dependence.
- Congress expand and modernize applicable lending, investing, and grantmaking authorities for the U.S. International Development Finance Corporation, Export-Import Bank of the United States (EXIM), and other strategic financing vehicles established by the U.S. government to ensure these financing entities are adequately positioned to utilize significant portions of their funding to prioritize critical U.S. needs in geostrategically relevant sectors ("strategic projects"), including:
  - Supply chains for critical and emerging technologies and related enabling inputs (e.g., critical minerals, critical minerals processing, semiconductors, artificial intelligence, biotechnology, quantum information sciences, digital technology, etc.);
  - In sectors where reliance on supply chains based in China poses serious economic or national security risk to the United States, as determined by the President, in consultation with Congress; and
  - In countries of geostrategic importance to U.S.-China competition as determined by the President, in consultation with Congress, for projects relevant to such competition.

  Congress should also ensure that current limits applicable to each of these entities, including EXIM's 2 percent default cap, content requirements, and limits on types of recipients, do not unduly constrain U.S. entities from funding or advancing strategic projects.

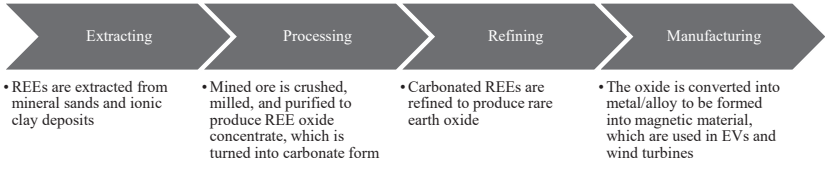
Appendix I: Understanding the Supply Chains of Select Sectors

Background on the Critical Mineral Supply Chain

Many critical mineral supply chains require capital and time-intensive processes and use specialized equipment to go from extraction to the use of refined minerals in manufacturing (see Figure 6).

- *Exploration:* Critical mineral supply chains start with mineral exploration for commercially viable reserves.[239]
- *Extraction*: For some minerals, ore is primarily found underground, and extraction requires mining; in other cases, such as for REEs, ores are often on the earth's surface but require chemical separation from other elements.
- *Processing and refining:* After extraction, ore is refined into oxides and processed into metals. For REEs, processing involves multiple steps of cracking and leaching to break down the REEs into individual elements and separate them from other impurities and each other.[240] Then, the processed elements are refined to produce rare earth oxide and smelted with other raw materials.
- *Manufacturing:* Finally, in the downstream, processed metals are used to manufacture components, and those components are integrated into a finished good. For instance, REE oxides are smelted into metals or alloys used in permanent magnets found in EV batteries and wind turbines.

Figure 6: Rare Earth Elements Supply Chain



Source: Adapted from Jared Cohen, "Resource Realism: The Geopolitics of Critical Mineral Supply Chains," *Goldman Sachs*, September 13, 2023.

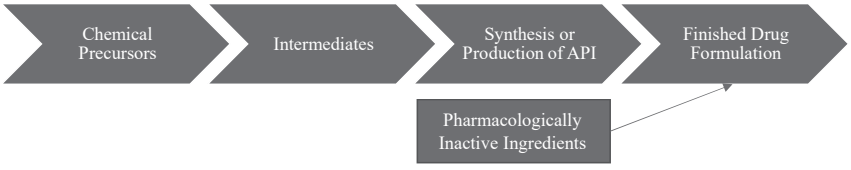
Background on the Pharmaceutical Supply Chain

The pharmaceutical manufacturing process* is complex, often crossing several borders as chemical precursors are synthesized into APIs—the part of the drug that provides the intended therapeutic effect—and combined with inactive substances into a final dosage (see Figure 7). APIs are initially developed from chemical precursors, often simple commodity petrochemicals. Precursors are then refined into more complex but still biologically inactive compounds through complex chemistry processes, for instance to make compounds more stable or reactive in later steps. In synthesis, the resulting intermediaries are further purified into active compounds with pharmacological effects—APIs. The APIs are then combined

*The full pharmaceutical value chain also encompasses drug discovery, trials, regulatory approval, manufacturing, and distribution, as well as in the downstream where the finished drugs are transported and distributed to patients.

with inactive substances called excipients that act as carriers of the API into the finished drug formulation, such as a tablet or a capsule.[241] Excipients have a number of functions to support a medication's effectiveness, ranging from preserving the drug's chemical stability and shelf life to improving the patient's ability to absorb the drug or making it easier to administer.[242]

Figure 7: Simplified Graphic Representation of the Pharmaceutical Manufacturing Supply Chain



Source: Patrícia Véras Marrone et al., "Decision Criteria for Partial Nationalization of Pharmaceutical Supply Chain: A Scoping Review," *Economies* 11, no. 25 (2023): 1–21.

Background on PCB Supply Chains

PCBs form the digital backbone upon which all electronic devices are built. Every electronics device requires at least one PCB, from the humble toaster to the most advanced AI processor. PCBs are also vital to U.S. critical infrastructure and virtually all defense systems. PCBs are sheets of resin or other non-conductive material onto which copper lines or traces are etched. These boards hold but also electrically connect integrated circuits and other electrical components that are mounted on them. They function as maps that route signals and power to electronic devices and back out into external systems. PCB fabrication refers to the process of layering and etching copper traces onto the board itself. In the PCB assembly stage, electrical components—ranging from packaged semiconductors* to basic hardware like capacitors—are mounted on the fabricated board. Every PCB is designed to hold a set of components and to serve a particular purpose. PCB manufacturers produce boards according to design files submitted by the customer placing the order, such as an OEM. The complexity of the PCB depends on its application. The growth in small form-factor electronics (i.e., wearable devices and Internet of Things devices), as well as the high-speed performance requirements of leading-edge chips, are driving demand for advanced PCB technologies like flexible PCBs and high-density interconnect (HDI)—complex, multi-layered PCBs that enable higher component density and faster signal transmission needed in advanced computing applications.[243]

The United States relies heavily on overseas production in PCBs. Over the past three decades, U.S. manufacturing capabilities in PCB production have been offshored to East Asia, and today China is the world's leading PCB manufacturer. The number of U.S. PCB

*Although semiconductor supply chains also contain an "assembly" stage, this is an unrelated process. Within chip fabrication, the assembly and packaging stages of ATP involve cutting individual chips from a wafer, mounting them onto a substrate, and encasing the dies within protective packaging that contains connectors for interfacing with the rest of the device. Abiola Ayodele, "OSAT Semiconductor Services: The Backbone of Outsourced Chip Assembly & Testing," *Wevolver*, March 17, 2025.

manufacturers declined from over 2,000 in the 1990s to just 145 today.[244] The United States produces 4 percent of global PCBs, falling from 30 percent 25 years ago.[245] U.S. producers mainly focus on low-volume specialty boards used in industrial, medical, defense, and aerospace products, with many heavily dependent on defense contracts for continued operations.[246] According to David Schild, executive director of the Printed Circuit Board Association of America, the defense industry accounts for around 40 percent of demand for domestic PCB production.[247]

Foreign offshoring helped establish China's prominence in PCB supply chains, and foreign-owned facilities still account for a significant share of the country's PCB output. Cost-cutting pressure combined with Chinese government subsidies for plant construction and equipment, low labor costs, and proximity to material inputs drove offshoring and outsourcing of production to China.[248] Consequently, despite China's large share of the market, many of the top PCB manufacturers are non-Chinese; only two of the top ten PCB manufacturers by revenue were Chinese in 2023.*[249] According to estimates by the Taiwan Printed Circuit Association and the Industrial Technology Research Institute, two-fifths of China's PCB production came from foreign-invested firms in 2023, meaning that Chinese-funded companies alone accounted for 30.5 percent of the global market.†[250] Outside of China, Taiwan is the largest PCB manufacturing hub. Southeast Asia, and particularly Thailand, is emerging as a new production center as U.S. tariffs since 2018—as well as competitive pressures to co-locate with Southeast Asia's growing electronics manufacturing base—are driving manufacturers to relocate to the region.[251] Though Chinese companies are also establishing facilities in Thailand, its share of PCB manufacturing remains small and appears unlikely to substantially challenge China for market share.[252]

Upstream, China is one of the largest suppliers of inputs for PCB manufacturing. China produces over 75 percent of the world's copper-clad laminate, a material that accounts for roughly 30 percent of PCB production costs.[253] However, China's production is concentrated in lower-value copper-clad laminates, whereas China holds only 7 percent of the market for high-speed and high-frequency variants needed by more advanced computing applications.[254]

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*China's two largest PCB firms are DSBJ, with 2023 revenues of $3.3 billion, and Shennan Circuits at $1.9 billion. Compared to $23.0 billion in revenue for Chinese-owned PCB manufacturers in 2023, these two companies made up over one-fifth of Chinese-owned production. The remainder of China's industry is divided between dozens of smaller players. Out of the 134 companies that earned over $100 million in 2023, 59 firms were Chinese. "AI伺服器和車用電子助攻, 預估2024年陸資PCB將成長至267.9億美元" [Boosted by AI Servers and Automotive Electronics, Mainland Chinese-Funded PCBs Are Projected to Grow to $26.79 Billion in 2024], *Taiwan Printed Circuit Association*, November 18, 2024; Hayao Nakahara, "Can Thailand Pad Its PCB Gains?" *Printed Circuit Engineering Association*, October 2024.

†After Chinese firms, Taiwan-owned facilities are the largest contributors to China's PCB output. Industry analyst Hayao Nakahara estimated that Chinese firms accounted for 60 percent of output in 2021, Taiwan-owned firms were 29 percent, and the remaining 11 percent came mainly from Austria's AT&S, the United States' TTM International, and other firms headquartered in Japan or Southeast Asia. Hayao Nakahara, "NTI: The Unsinkable, Unstoppable PCB Market," *Printed Circuit Design & Fab*, July 28, 2022.

U.S. Government Demand Signals May Be Insufficient to Revive Domestic Industry

Recent U.S. government actions have expanded the market for domestic PCB production. In March 2023, the Biden Administration authorized the use of the Defense Production Act to support the U.S. PCB industry.[255] Also, as of 2023, DOD is prohibited from procuring PCBs manufactured in China, Russia, North Korea, or Iran, in accordance with the FY 2021 National Defense Authorization Act.[256] At the same time, however, U.S. industry may face challenges in scaling production. Mr. Schild stated that "zero new facilities for defense [PCB] manufacturing have been established in the past twenty plus years in the United States."[257] The economics of PCB manufacturing require scaling production to achieve profitability; the defense industrial base, with its small market size relative to the wider electronics industry, cannot provide sufficient demand on its own.[258] Many U.S. firms struggle to match overseas competitors on cost, and industry advocates state that a lack of capital to invest in new manufacturing equipment has left them lagging in technological advancements in PCB production.[259]

Background on Foundational Semiconductor Supply Chains

Foundational chips are the workhorse components that drive the modern economy and a modern military. As a category, foundational chips encompass a vast set of devices that are manufactured on a 28-nm or larger process node, which generally refers to the feature size of transistors etched on the semiconductor. They are ubiquitous in any product with electronics and are critical to wide swaths of economic activity. While often discussed as a single market, the foundational chip industry includes a wide range of components, including microcontrollers, power chips, and Internet of Things sensors that each have distinct technologies, applications, and market dynamics.

The semiconductor supply chain—both for foundational and leading-edge chips—is highly globalized, involving hundreds if not thousands of different production steps.[260] Despite the diversity within the foundational chip industry, production follows three broad stages:

- *Design:* Chip designers utilize electronic design automation tools and work closely with a specific fab to develop, verify, and simulate chip designs tailored to particular use cases. Chips are designed according to the fabrication process of a given chip manufacturer, meaning that switching to another manufacturer may require redesigning the chip.[261]
- *Fabrication:* Fabrication, also known as front-end manufacturing, is the core production step for chips—transferring chip designs onto wafers inside fabrication plants (also called "fabs") through various processes, including deposition, photoresist coating, photolithography, and etching.[262] Fabrication depends on upstream inputs that are typically sourced externally, in-

cluding dozens of specialty chemicals and the high-purity crystals used to make raw wafers.

- *Assembly, test, and packaging (ATP):* Also known as back-end manufacturing, ATP is where individual chips are cut from finished wafers, tested, and packaged in preparation for placement on a PCB and final assembly.

In addition, the semiconductor industry operates under two main business models. The integrated device manufacturer (IDM) model entails a single company vertically integrating all three stages of production—design, fabrication, and ATP. In contrast, the fabless-foundry model separates these functions, with fabless firms focusing on chip design and outsourcing fabrication to pure-play manufacturing companies called foundries. Foundries are fabs that typically source production contracts from several fabless companies, providing greater flexibility in maintaining sufficient levels of end demand.[263]

Semiconductor production is a business that relies heavily on scale for profitability. Chip design and fabrication involve massive upfront costs—particularly fabs, which can cost billions of dollars to construct.[264] These costs remain constant regardless of the production volume. Typically, the first few years of production occur at a net loss and profits are only earned in later stages of production.[265] Maintaining a high-production volume is crucial to recouping the substantial fixed costs of building a fab and justifying investments in new fabs.[266] When capacity is underutilized, these high fixed costs are spread across fewer unit sales, increasing the per-unit cost and reducing profitability. The industry is, consequently, highly demand driven, with profit-oriented firms aiming to avoid underutilized fab capacity.

Compared to the high concentration of leading-edge chip fabrication in Taiwan, foundational chip production is more geographically dispersed and involves a broader set of market players. Whereas Taiwan held nearly 70 percent of global production capacity for chips in advanced nodes in 2023, it accounted for only 44 percent for nodes at 28 nm and above.[267] The United States, Europe, Japan, Korea, and China each maintain a sizeable share of production capacity for foundational chips.[268] Because foundational chip manufacturing relies on mature processes and does not require continual investment in cutting-edge machinery, many established foundries have fully depreciated their assets, allowing them to operate at lower cost and remain profitable, even in low-margin segments.[269]

Backed by heavy state support, China has emerged as a global hub for foundational chip fabrication over the past decade, driving much of the world's capacity growth at mature process nodes. Since 2014, and with specific targets set in Made in China 2025, Chinese industrial policy accelerated efforts to position China as a leader in the chip industry and establish self-sufficiency in these critical components. Extensive state support has driven the expansion of China's chipmaking capabilities, with likely over $150 billion in state-led investment since 2014, including from the China Integrated Circuit Industry Investment Fund, a government-led investment

vehicle that is also known as the Big Fund.*[270] China's foundational chip production capacity rose 250 percent from 1.2 million wafers per month in 2015† to 3.0 million in 2023, driving 72 percent of global capacity growth during that time.[271] In 2024, 34 percent of global wafer fabrication capacity for foundational chips was located in China, according to Taiwan market research firm TrendForce.[272] Moreover, while some of this production reflects the China-based operations of foreign firms,‡ most of China's foundational production capacity is concentrated in three state-supported firms: SMIC,§ Hua Hong Group, and Nexchip. These companies now rank in the top ten global foundries.[273] Combined, they earned 9 percent of global foundry revenue in Q4 2024.[274]

*In May 2024, the Big Fund closed its third funding round, raising another $47.5 billion in capital. If fully invested in the chip industry, this new funding could bring total state-led investment since 2014 to nearly $200 billion, including central and provincial government support. Ryan McMorrow and Cheng Leng, "China Raises $47bn for Chip Industry in Drive for Self-Sufficiency," *Financial Times*, May 27, 2024; "China Boosts State-Led Chip Investment," *Economist Intelligence Unit*, March 13, 2024.

†This refers to wafer starts per month, or the number of wafers that enter production in a fab. It takes on average 12 weeks to produce a finished semiconductor wafer. "Chipmakers Are Ramping Up Production to Address Semiconductor Shortage. Here's Why that Takes Time," *Semiconductor Industry Association*, February 26, 2021.

‡According to one study of China's share in the foundational logic chip segment, China-headquartered firms accounted for 83 percent of China's capacity. Will Kirkman, Graham Newell, and Dan Brown, "Current- and Future-State Legacy Semiconductor Manufacturing Capacity," *MITRE*, May 2024.

§SMIC also manufactures leading-edge chips. Notably, it produces the Kirin line of system-on-chips for Huawei's flagship phones on a 7-nm process node. However, leading-edge chips account for only a portion of SMIC's sales, and industry experts estimate that 75 percent of its production capacity is dedicated to foundational nodes, although the company does not disclose revenue by node size. "SMIC's U.S. Revenue Share Climbs to Nearly 13% in Q1; Warns of 4–6% Q2 Sales Dip," *TrendForce*, May 9, 2025.

Appendix II: U.S. Pharmaceutical Drugs with Potential Sole Reliance on China's APIs

Drug Name	Therapeutic Category	FDA Essential Drug List
Abemaciclib	Cancer Treatment	
Acarbose	Diabetes treatment	
Acetylcysteine	Acetaminophen overdose	X
Baloxavir marboxil	Pandemic influenza	X
Cefoperazone sodium	Antibiotics	
Chlortetracycline hydrochloride	Antibiotics	
Colistimethate sodium	Antibiotics	
Dalteparin sodium	Anticoagulant/blood thinner	
Dirithromycin	Antibiotics	
Dobutamine hydrochloride	Cardiac	X
Famciclovir	Antiviral	
Gentamicin sulfate	Antibiotics	
Glucosamine sulfate potassium chloride	Symptomatic slow-acting drugs	
Heparin sodium crude	Anticoagulant/blood thinner	X
Iodixanol	Cardiac; radiology	
Iopamidol	Radiology	
Ipratropium bromide	Pulmonary	X
Isoflurane	Anesthetic	X
Kanamycin sulfate	Antibiotics	
Lincomycin hydrochloride	Antibiotics	
Miglitol	Diabetes treatment	
Mitotane	Cancer Treatment	
Nesiritide citrate	Cardiac	
Niraparib tosylate monohydrate	Cancer Treatment	
Nitrofurazone	Antibiotics	
Paroxetine mesylate	Anxiolytics	
Pilocarpine hydrochloride	Oral and eye care	
Polidocanol	Dermatological agent; venous disease	

Drug Name	Therapeutic Category	FDA Essential Drug List
Streptomycin sulfate	Antibiotics	
Tazobactam sodium	Antibiotics	X
Telavancin hydrochloride	Antibiotics	
Tobramycin	Antibiotics	X (ophthalmic solution only)
Tobramycin sulfate	Antibiotics	
Vinorelbine tartrate	Cancer Treatment	
Ziconotide acetate	Analgesic	
Zidovudine	HIV-1 Treatment	

Note: The list only includes currently active DMFs submitted between 2013 and 2024.

Source: Derived from underlying data supplied by Marta Wosińska and used in Marta E. Wosińska and Yihan Shi, "U.S. Drug Supply Chain Exposure to China," *Brookings Institution*, July 28, 2025; U.S. Food and Drug Administration, *Drug and Biologic Essential Medicines, Medical Countermeasures, and Critical Inputs for the List Described in Section 3(c) of the Executive Order 13944*, October 30, 2020.

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