SECTION 4: U.S. SUPPLY CHAIN VULNERABILITIES AND RESILIENCE

Abstract

The United States is vulnerable to a number of threats stemming from the concentration of critical supply chain segments in China, including active pharmaceutical ingredients (APIs), rare earth elements, castings and forgings, and many others. Chinese leaders are aware of their supply chain strengths, as well as their weaknesses, and they are taking active measures to limit their own vulnerabilities and sustain and enhance their leverage over certain U.S. supply chains.

Key Findings

- The concentration of production within China for certain critical global supply chains leaves the United States and other countries vulnerable to disruption and potential strategic trade interdictions by the Chinese Communist Party (CCP). Beijing seeks further consolidation and domination of global supply chains to create influence and leverage. The CCP has demonstrated its willingness to wield the resulting trade dependencies as tools of strategic and political competition.
- CCP leaders' assessments of their own supply chains have led them to a combustible mix of confidence and anxiety. While CCP leaders plan to bolster and leverage China's strong position in manufacturing, they are extremely concerned about technological dependencies and vulnerabilities. Recent U.S. actions against Chinese telecommunications companies, as well as the coordinated multilateral response to Russia's unprovoked invasion of Ukraine, have led Beijing to hasten longstanding plans for achieving technology self-reliance.
- A continuing lack of visibility into critical U.S. supply chains masks significant vulnerabilities to disruptions and compromise by Chinese state actors. The lack of a coordinated U.S. supply chain mapping and mitigation strategy, as illustrated in recent reports by various U.S. government agencies, continues to hinder supply chain diversification and resiliency across a number of key national security and critical industries, including active pharmaceutical ingredients (APIs) and rare earth elements that are crucial for U.S. infrastructure, health, and security.
- While numerous supply chain risk management and mapping initiatives are underway, further action in the public domain is needed for standardizing, collecting, and analyzing necessary data, particularly in supply chains reliant upon sole- or single-source suppliers, as in many renewable and alternative

energy supply chains. Greater due diligence and verification are needed to protect defense and critical infrastructure supply chains from Chinese counterfeit or corrupted components and to prevent investments by Chinese companies that may compromise suppliers' intellectual property (IP) or limit their ability to participate in federal acquisition programs.

- The U.S. government's inconsistent spending trends and irregular, outdated procurement practices have accelerated contraction of the defense industrial base, leading to reduced manufacturing capacity, fewer alternative suppliers, and ultimately greater dependence on Chinese suppliers for some critical materials and components. Federal funding practices discourage much of industry, particularly small businesses, from competing for contracts with the U.S. Department of Defense and does not incentivize resilience measures like excess manufacturing capacity and material stockpiles that would mitigate supply chain disruptions and allow the defense industrial base to meet surge capacity requirements if needed.

Recommendations

The Commission recommends:

- Congress direct the Administration to create an Economic and Security Preparedness and Resilience Office within the executive branch to oversee, coordinate, and set priorities for cross-agency efforts to ensure resilient U.S. supply chains and robust domestic capabilities, in the context of the ongoing geopolitical rivalry and possible conflict with China. This Office would be tasked with:
  - Establishing a dedicated Supply Chain Mapping Unit to determine requirements, set priorities, and coordinate efforts to continuously map, monitor, and analyze the most critical supply chains, including but not limited to semiconductors, rare earths, life-saving and life-sustaining medications and their active pharmaceutical ingredients, and castings and forgings.
    - The unit would be tasked with developing interoperable performance measures to monitor and assess current U.S. supply chain resiliency and risk mitigation efforts, including data collection on U.S. supply chain dependencies on direct and indirect Chinese suppliers, prioritizing defense-critical supply chains.
  - Establishing a Defense Mobilization Unit responsible for coordinating and setting priorities for:
    - Assessment of the requirements for weapons, munitions, supplies, and other equipment necessary to equip and support U.S. forces and to assist friends and partners in the Indo-Pacific region in a potential conflict with the People's Republic of China, including conflicts of varying duration;
    - Determination of the adequacy of existing stocks and available productive capacity to meet those needs;

- Identification of potential shortfalls or bottlenecks that might impede production and resupply in some scenarios; and
- Recommendation of corrective measures to address these problems.
- Including in its assessments the effects of potential disruptions in U.S.-China trade on defense mobilization and domestic availability of critical materials, products, and supplies. Where it identifies likely requirements for additional capacity, the unit shall determine funding and support mechanisms to ensure the timely development of such capabilities and capacity.
- Consulting with other departments and agencies to identify shortfalls in current defense industrial base and supporting industrial capabilities and what additional measures might be needed to address them.

- In enacting legislation subsidizing reshoring or existing production in the United States, Congress should evaluate whether the subsidies may lead to additional dependence on supply chains running through or relying on China to serve that production.
- Congress enact legislation requiring suppliers to the U.S. government in "critical" sectors, as defined by Congress, to confidentially disclose all tiers of their contractors for the purpose of identifying U.S. supply chain dependencies on China. If suppliers are unable to do this within three years and each year thereafter, they are ineligible to receive government contracts.
- Congress direct the Administration as part of the Indo-Pacific Economic Framework (IPEF) to negotiate a prohibition on the utilization of China's National Transportation and Logistics Public Information Platform (LOGINK) or similar systems provided by Chinese state-affiliated entities within IPEF member ports. A two-year transition period shall be provided for existing users of LOGINK or similar Chinese-controlled or -affiliated systems to terminate use of such systems and transition to secure logistics systems with no Chinese control or affiliation.
- Congress direct each federal agency administering Small Business Innovation Research (SBIR) or Small Business Technology Transfer (STTR) programs to develop a due diligence program to ensure the supply chain integrity of participating U.S. small businesses and decrease their dependencies on Chinese suppliers. The program should also include resources for participating businesses to prevent investments from Chinese firms, particularly those involved in China's Military-Civil Fusion program, that target emerging technologies and innovations valuable to the U.S. Department of Defense and other SBIR or STTR sponsoring agencies.
  - The due diligence program of each SBIR or STTR administering agency should provide financial and technical assistance to U.S. small businesses for up to three years for the purposes of supporting sustained procurement opportunities for the

government and improving small businesses' internal capacity for federal engagement. Technical assistance may include establishing procedures for identifying foreign entities of concern within small businesses supply chains.

- Congress direct the U.S. Food and Drug Administration in cooperation with other federal agencies, within one year and on an ongoing basis thereafter, to identify pharmaceutical products that utilize active pharmaceutical ingredients (APIs) and other ingredients and inputs that are sourced directly or indirectly from the People's Republic of China and develop alternative sourcing arrangements through available tools and resources, including Defense Production Act authorities. The United States should maximize the production of such goods domestically or, as appropriate, from trusted countries.
- Congress direct the U.S. Department of the Treasury to require U.S. corporations and U.S.-registered subsidiaries of foreign corporations to publicly disclose, on an annual basis, all holdings in firms linked to China's military, including those that maintain any production permit, qualification, or certification issued by the People's Liberation Army or China's State Administration for Science, Technology, and Industry for National Defense.
- Congress direct the Administration to release a comprehensive public report on the utilization of commercial-off-the-shelf (COTS) procurement of inputs, components, and products from China:
  - By the U.S. Department of Defense and contractors in major weapons systems; in Munitions List items; and in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) items;
  - In critical infrastructure as identified by the U.S. Department of Homeland Security; and
  - In critical supply chains and sectors as identified in U.S. government agency reports submitted per section 4 of Executive Order 14017 on "America's Supply Chains." Such a report shall identify the specific items that were purchased, overall quantities, and, where applicable, the value of the contracts in aggregate by item.
- Congress direct the Administration to provide a public semiannual report on the volume of products detained, excluded, or seized for violations of the Uyghur Forced Labor Prevention Act and related enforcement activities. This report should detail product sector, product quantity, and whether the shipment was stopped directly or indirectly containing any production linked to Uyghur forced labor. This report shall also detail any and all existing loopholes in U.S. trade law and trade enforcement mechanisms that inhibit the ability of relevant U.S. government agencies to trace mined, manufactured, or procured goods made using Uyghur forced labor.
- To ensure the U.S. government is able to assess its reliance on foreign sources, Congress direct the U.S. Department of Com-

merce to calculate U.S. import dependence at the product level across all industries, combining domestic production data (North American Industry Classification System [NAICS] codes) with U.S. export and import data (HTS [Harmonized Tariff Schedule] codes) in order to obtain a clearer picture of the United States' import dependence and provide the results in a publicly accessible database. This database should be consistently updated and should for each industry and product category tabulate dependence on China or any major source location that is known to use components and materials from China.

Introduction

The movement of U.S. and global industrial capacity to China since the 1980s has led to a concentration of supply chains in that country, posing risks to U.S. economic and national security. These risks have become more acute under CCP General Secretary Xi Jinping, as China's government has adopted a strategy of reducing economic reliance on other nations while more deeply embedding China in a central and indispensable position in numerous supply chains. To execute this strategy, Chinese industrial policy has become increasingly targeted toward indigenizing production across multiple sectors and obtaining dominant global market share for extracting and processing key materials not found within China's borders. At the same time, China's government is increasing its use of economic coercion and continues to engage in predatory trade practices.

This section examines China's rise and current strategy in global supply chains, the increasing U.S. risks from supply chain exposure to China, and strategies for mitigating dependence on Chinese sources. It begins with a brief recounting of China's emergence as the world's workshop, focusing on key manufacturing industries that moved to China. From there, it describes Chinese leaders' current supply chain objectives and motivations. It also examines threats to U.S. economic and security interests posed by supply chain dependence on China, first looking at risks from China-centric supply chains and then considering the gaps in U.S. supply chain security and information that exacerbate these risks. Finally, it explores various approaches for bolstering U.S. supply chain resilience, including reshoring, nearshoring, and friendshoring.

This section draws on the Commission's June 2022 hearing on "U.S.-China Competition in Global Supply Chains," the Commission's staff and contracted research, consultations with policy experts, and open source research and analysis.

China's Rise and Current Position in Global Supply Chains

The CCP's supply chain efforts are characterized by a dual strategy to bolster its relative advantages and protect its economy against vulnerabilities. At the core of this effort is a commitment to redouble China's strength in material extraction and processing and component manufacturing at the beginning and intermediate supply chain stages, as well as a state-centric drive to move up the value and production process by any and all means, with a prominent focus on indigenizing key technology supply chains within China and produc-

ing integrated systems. These dual efforts, encapsulated in Beijing's "dual circulation" strategy, aim to make China more self-reliant while at the same time rendering others more dependent than ever on China.[1] Beijing seeks immunity from the type of coercive influence it views the United States as capable of wielding and, moreover, envisions wielding itself.[2] While the CCP's broad objectives have remained stable over time, its strategic approach has evolved in lockstep with its changing assessments of the country's capabilities and vulnerabilities. In brief, contemporary CCP assessments of Chinese strengths and foreign threats have combined into a combustible mix of confidence and anxiety, leading to a more pronounced push to acquire or augment advantageous positions throughout key global supply chains.

China's Prominence in Global Supply Chains

Developments before Xi: Foreign Direct Investment, Technology Diffusion, and Outsourcing

Central government direction, local government experimentation and competition, and structural features of China's economy all converged to give rise to China's strong position in global supply chains.[3] China's central and local government industrial and regulatory policies have aimed to induce foreign corporations to engage in joint ventures (JVs) with local partners and locate supply lines, factories, and research and development facilities throughout China. This has led to licit and illicit knowledge transfers, enhanced China's manufacturing capabilities, and bolstered key aspects of China's developmental and great power ambitions.* The pursuit of low-cost goods by U.S. consumers and producers coincided with China's central and local government subsidies, developmental policies, and fierce competition for foreign direct investment (FDI), contributing greatly to an ongoing process of U.S. deindustrialization.[4] Outsourcing of capital-intensive, lower-margin processes—as occurred in the metal casting, forgings, and rare earth mining and refining industries—lowered costs for consumers and improved financial performance for shareholders, but it also contributed to a sustained loss of manufacturing capacity and employment within the United States and resulted in overconcentration of production within China, entrenching China's position in global supply chains.[5] In a permissive global environment that encouraged engagement with China, FDI, outsourcing, and technological diffusion from more advanced economies greatly contributed to China's rise into global supply chains.

Central Industrial Policy under Xi Is De Facto Supply Chain Security Policy

Xi has hastened a shift that began around 2006 from decentralization in economic policy back toward centralization, particularly in

*Central and local governments deploy subsidies, offer discounted land, and provide tax breaks to entice localization. They also enact export quotas and restrictions on upstream inputs to companies not located in China. Increasingly, regulatory levers such as antitrust investigations are also used to force compliance with policy ambitions, leading companies to form JVs that "often generate Chinese companies' most technologically advanced and innovative procedures and products, acquired through technology transfer from their foreign JV partner." Sean O'Connor, "How Chinese Companies Facilitate Technology Transfer from the United States," *U.S.-China Economic and Security Review Commission*, May 6, 2019, 7.

the realm of technology industrial policy (for more on the centralization of economic policymaking under Xi, see Chapter 1, "CCP Decision-Making and Xi Jinping's Centralization of Authority"). Under Xi's predecessor Hu Jintao, China launched the Medium- and Long-Term Plan* in 2006 and the Strategic Emerging Industries Plan† in 2010, both of which relied upon increasingly interventionist, top-down guidance to hasten technological catchup and rapidly move China into strategically important and higher-value-added parts of supply chains.[6] Xi has increased the scale and prominence of industrial policy in China's economic policymaking, launching well-known initiatives such as Made in China 2025 (2015) and the Next Generation Artificial Intelligence Development Plan (2017). In testimony before the Commission, Mark Dallas, international affairs fellow at the Council on Foreign Relations, noted that Beijing's plans are now increasingly characterized by "(1) more resource allocations for industrial policies, (2) greater precision in their industrial targeting, and (3) a greater focus on upstream or infrastructural information communications technology (ICT) sectors (5G, internet, AI, semiconductors, data) which are perceived to allow China to 'leapfrog' into the technological frontier."[7] Furthermore, as Dr. Dallas noted, while "Chinese policies generally do not explicitly declare a policy to be for 'supply chain security,' many of their stated goals for 'self-reliance,' 'self-strengthening,' or 'indigenous innovation,' all have important supply chain implications, particularly industrial policies with specific targets. Thus, many Chinese policies are de facto supply chain policies, without naming them as such."[8] The challenges to U.S. supply chains stemming from the CCP's shift away from its previously more decentralized economic model and toward centralized industrial policy are significant, as the systematic penetration and consolidation of control over China's economy allows Beijing greater leverage over U.S. supply chains concentrated in China.

China's Industrial and Economic Development Bolstered by U.S. Multinational Participation

U.S. multinationals have historically invested in ways that supported and benefited from the CCP's developmental programs, as a 2013 assessment of China's Strategic Emerging Industries Plan by the U.S.-China Business Council made clear when it sought to provide "[r]ecommendations to ensure full participation for foreign-invested companies in China's industrial modernization."[9]

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*The Medium- and Long-Term Plan articulated a four-step approach to execute the absorption, refinement, and redeployment of foreign technologies through government and industry collaboration. Expert on China's industrial policy Tai Ming Cheung translates the strategy as one to Introduce, Digest, Absorb, and Re-Innovate. "Introduce" refers to the targeting and importation of foreign technologies and knowledge through licit and illicit means, such as research partnerships, JVs, or cyber espionage. "Digest" refers to the study of foreign technology and knowledge acquired from abroad. "Absorb" refers to assimilation of digested foreign technologies into China's domestic industrial ecosystem by reverse-engineering them or producing alternative copies of them. "Re-innovate" refers to Chinese companies improving upon foreign technologies and developing home-grown products that are internationally competitive. Tai Ming Cheung et al., "Planning for Innovation: Understanding China's Plans for Technological, Energy, Industrial, and Defense Development," *University of California Institute on Global Conflict and Cooperation* (prepared for the U.S.-China Economic and Security Review Commission), July 28, 2016, 118–119.

†The Strategic Emerging Industries plan is a techno-industrial policy that builds on the Medium- and Long-Term Plan in targeting specific sectors and is often referred to by the Party as an effort to "seize the commanding heights" or take the lead in new and emerging high-value-added technologies. Ling Chen and Barry Naughton, "An Institutionalized Policy-Making Mechanism: China's Return to Techno-Industrial Policy," *Research Policy* 45:10 (December 2016): 2138–2152.

However, as Alan F. Estevez, head of the U.S. Department of Commerce's Bureau of Industry and Security, noted in July 2022, a key goal of U.S. policy is to "ensure that the U.S. retains technological overmatch" and that "China cannot build capabilities that they will then use against us, or against their neighbors for that matter, in any kind of conflict."[10] U.S. multinational participation in China's manufacturing, technological,* and financial ambitions may conflict with this policy aim.†[11] Analysts at the Mercator Institute for China Studies warn that the CCP seeks "to systematically acquire cutting-edge technology and generate large-scale technology transfer" so as "to obtain control over the most profitable segments of global supply chains and production networks."[12] As precedent in the solar panel, telecommunications, and high-speed rail industries suggests, the facilitation of China's statist drive to the manufacturing technology frontier is likely to harm U.S. innovation and industrial capacity.[13]

The Case of "Smart Manufacturing"

One pronounced example of ongoing multinational facilitation of China's ambitions occurs in so-called "smart manufacturing," a term that refers to boosting manufacturing productivity through the incorporation of data analytics, automation, and industrial robotics. With the broad scale transfer and outsourcing of lower-end manufacturing from the United States to China having peaked, CCP leaders including Xi now have their eyes set on higher-end smart manufacturing value chains.‡[14] According to conservative estimates from public filings, robotics-related government subsidies increased from $687 million (renminbi [RMB] 4.6 billion) in 2015 to $2.3 billion (RMB 15.4 billion) in 2019.§[15] Most recently, several of China's most important ministries jointly promulgated Beijing's 14th Five-Year Plan for Smart Manufacturing, sending a strong signal that government support is intensifying.¶[16] In line with these programs, a number of major multinational firms

*U.S. investors and semiconductor firms continue to invest in and partner with Chinese semiconductor firms, a longstanding target of central government policy support, hastening Beijing's advances in that industry.

†Capital markets, for example, are particularly warped by the CCP's increasing control of its financial machinery and integration into industrial policy objectives. For more, see U.S.-China Economic and Security Review Commission, Chapter 2, Section 4, "U.S.-China Financial Connectivity and Risks to U.S. National Security," in *2021 Annual Report to Congress*, December 2021.

‡Xi, in a 2018 speech titled "Strive to Become the World's Primary Center for Science and High Ground for Innovation," noted the importance of smart manufacturing to his broader economic agenda, stating that "[i]t is necessary to focus on intelligent manufacturing to promote industrial technological transformation and optimization and upgrading, to promote the fundamental transformation of manufacturing industry models and corporate models … propelling China's industries toward the high-end of global value chains." Ben Murphy, et al., "Xi Jinping: 'Strive to Become the World's Primary Center for Science and High Ground for Innovation,'" *DigiChina*, March 18, 2021.

§Unless noted otherwise, this Report uses the following exchange rate from June 30, 2022 throughout: 1 U.S. dollar = 6.70 RMB.

¶An interpretive account of the plan offered by the Ministry of Industry and Information Technology evinces a clear strategic intent, recognizing that "[t]he international environment is becoming more and more complex, the global science and technology and industrial competition is becoming more intense as the strategic game of great powers further focuses on the manufacturing industry. Developed countries such as the United States, Germany, and Japan regard intelligent manufacturing as an important starting point to seize the commanding height of a new round of competition in the global manufacturing industry." China Ministry of Industry and Information Technology, *Interpretation of the "14th Five-Year Plan for the Development of Intelligent Manufacturing*," December 28, 2021 (《"十四五"智能制造发展规划》解读). Translation.

The Case of "Smart Manufacturing"—*Continued*

from the United States, Germany, and Japan have been "actively supporting Chinese manufacturers in their respective journeys to smart manufacturing," including through numerous JV agreements with Chinese state-owned enterprises (SOEs).[17] Many prominent and lesser-known industrial robotics firms have similarly established JVs in the country.*[18] At least in the short term, participation in China's smart manufacturing programs appears to make financial sense for these firms, as Beijing lavishes attention on the industry and businesses receive advice to invest in accordance with China's five-year plans to capitalize on government largesse.[19] Over the longer term, however, these firms are likely to see their positions eroded as Chinese companies indigenize their technology, squeeze them out of the domestic market, and compete with them for global market share.[20] More broadly, such multinational participation in the CCP's nonmarket manufacturing upgrading ambitions could accelerate the erosion of the United States' advanced manufacturing capacity and increase reliance on Chinese supply chains.

CCP Supply Chain Objectives in the Xi Era

Supply Chain Ambitions under Xi

CCP leaders today are keenly aware of their strategic advantages and vulnerabilities in global supply chains. The result is a dual offensive and defensive approach to China's supply chain position. On the one hand, officials recognize the strategic leverage they have acquired through China's rise to prominence in many key global supply chains–from rare earths to APIs to manufactured ICT products like phones and computers–and are seeking to protect, strengthen, and exploit their control in those areas. At the same time, however, they continue to recognize and worry gravely about their technological reliance on other countries, particularly the United States and its allies, in more advanced areas such as semiconductors (for more on China's capabilities in semiconductors, see "The Challenges of China-Centered Supply Chains" and the Appendix I: U.S.-China Supply Chain Competition in Semiconductors below). This paradoxical mix of confidence and anxiety appears to be driving a more aggressive approach to supply chains.

The offensive and defensive approach underpinning CCP supply chain strategies was clearly displayed in an important speech Xi gave at the seventh meeting of the Central Financial and Economic Affairs Commission in April 2020.[21] In the speech, Xi noted that China must "sustain and enhance [its] superiority" in key sectors while "mak[ing] up for [its] shortcomings" in others.[22] The broad-

*Among the many firms that have created JVs to participate in China's smart manufacturing sector, there are General Electric's (United States) 2016 partnership with China's Huawei, Siemens' (Germany) 2020 partnership with China's Boasteel, Fanuc's (Japan) 2021 partnership with China's Shanghai Electric Group, and ABB Robotics' (Switzerland) 2022 partnership with China's HASCO. Emily Jin, "Smart Manufacturing: A Linchpin in China's Industrial Policy," *Lawfare*, September 6, 2022.

er quote strikingly illuminates Beijing's contemporary approach to supply chain competition:

> *First, we must build on our advantages, solidify and increase the leading international positions of strong industries, and forge some "assassin's mace" technologies. 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]. Second, we must make up for our shortcomings. That is, in sectors and segments related to national security, we must build a domestic supply system that is independently controllable and secure and reliable, so that self-circulation can be accomplished at critical moments, and ensure that the economy operates normally in extreme situations.*[23]

A month later, at a May 2020 Politburo Standing Committee meeting, Xi's dual assessments of strengths to be bolstered and vulnerabilities to be mitigated were consolidated into a deliberate supply chain strategy termed "dual circulation." Dual circulation seeks to strengthen China's economic resilience by boosting domestic production while maintaining strategic links with global markets to secure access to technology essential to China's development. An article published in the CCP's leading theory journal *Qiushi* explains the logic, saying China possesses "the most complete industrial manufacturing system in the world and occupies an important position in the global industrial chain, but it is still at the middle and low end of the value chain."[24] In the future of international competition, the article goes on, China needs to "consolidate the advantages of traditional industries, lay out strategic emerging industries in advance, promote the rationalization and upgrading of industries, and take advantage of [its] complete industrial support system and the unique advantages of super-large markets to advance [its] continuous position in the global value chain system."[25] The dual circulation strategy is the latest encapsulation of an increasingly centralized economic security strategy that Chinese leaders hope will consolidate their advantages in global production networks while protecting access to the global technological and financial knowhow necessary to move up the value chain, ultimately aiming for asymmetric leverage across the full spectrum of design, manufacturing, and distribution in global supply chains.[26]

Dual Circulation Prioritizes Production and Import Substitution over Household Consumption

The dual circulation strategy, first articulated at a Politburo meeting in May 2020, intends to promote production via "import substitution across the board" while increasing domestic consumption.[27] In practice, however, it is clear that boosting household consumption remains limited to rhetoric, while overcoming production gaps is an immediate and action-oriented imperative.[28] Government policy remains disproportionately, or even solely, aimed at stimulating production and import substitution, particularly in industries identified as strategic priorities. China's response to the novel coronavirus (COVID-19) pandemic has made this priority of government policies particularly clear. Chinese government support for households and workers has remained extremely limited in contrast to most other major economies, which extended substantial support to households and workers. Producers, however, received a bevy of tax breaks, subsidized loans, and surreptitious People's Bank of China support via currency intervention.[29] Producers in priority industries, such as semiconductors and electric vehicles, were also encouraged to operate during lockdowns via closed-loop systems, while labor rights obligations were often explicitly waived.[30]

A variety of factors undergird dual circulation's prioritization of production over consumption, but the core motive is an increasing drive toward self-reliance and the localization within China's borders of productive capacity across strategic parts of various value chains.*[31] Whereas the CCP considers its reliance on others for high-value inputs a clear strategic weakness that could be exposed as a chokepoint at a moment's notice, its views on its export dependence are far more ambiguous. While CCP leaders recognize an increasingly unstable external demand environment and have long discussed the need for promoting household consumption, they also express a view that concentration of production capacity and external dependence on sourcing from China are sources of security and economic leverage.[32] In the long run, meanwhile, CCP planners may hope that exports to the developing world will help reduce China's current dependence on the markets of the advanced industrial democracies.[33] Therefore, for Xi and the CCP, ensuring that domestic demand is met by domestic production is a nonnegotiable first-order priority, while ensuring that domestic production is increasingly met by domestic consumption is, for now, a distant secondary priority.[34]

The CCP Aims to Bolster Its Comparative Advantages

When it comes to "enhancing superiority," Chinese policymakers look first and foremost to manufacturing. CCP leaders consider the concentration of manufacturing capacity within China an important

*Three partial explanations aside from self-reliance could be: (1) the role of entrenched interests that benefit from state largesse; (2) the statist orientation of policy informed by both Marxist-Leninist and neomercantilist economic theories that prioritize developing factors and means of production domestically; and (3) normative views on promoting employment rather than "welfare."

source of leverage and fundamental to broader developmental and great power ambitions. High-level economic planning documents point to the importance of bolstering and protecting China's comparative advantage in manufacturing. For example, in a reversal from the 13th Five-Year Plan's* focus on cultivating service industries, the Chinese government's 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives through 2035 recognizes and prioritizes the protection of China's manufacturing centrality in global supply chains.[35] The plan aims to protect China's strong supply chain position by doing away with targets for the services sector's growth and instead calling for the share of manufacturing in the economy to remain "basically stable."[36]

Top policymakers also routinely cite China's manufacturing position as a source of strategic superiority and leverage in global supply chains that must be maintained. In a speech in November 2021, Liu He, China's top economic advisor, stated that Xi believes "the manufacturing industry is the core of building a country and the foundation of strengthening the country."[37] In a speech in 2020, Xi noted that in the context of "optimizing and upgrading industrial and supply chains," manufacturing "serves as the foundation of all our efforts to strengthen the country" and emphasized that the manufacturing sector plays a "crucial role" in the "development and security of a country, especially a large country."[38] Former Minister of Industry and Information Technology Xiao Yaqing, for example, wrote in *Qiushi* in December 2021 that China's manufacturing prowess underpins the country's economic competitiveness and called for improved quality and resilience of China's manufacturing capabilities.[39] Separately, Deputy Director of the CCP's Central Financial and Economic Affairs Commission† Han Wenxiu wrote in the same publication that the CCP must "continue to enhance industrial advantages" and "tighten the interdependence of domestic and international industrial chains."[40]

The CCP Seeks to Mitigate Technological Vulnerabilities

While manufacturing is broadly viewed by policymakers in China as a source of strength and leverage to be enhanced, technology is often assessed to be a domain characterized by vulnerability and shortcomings. Analysis by the Center for Security and Emerging Technology of 35 articles in *Science and Technology Daily*, a newspaper published by China's Ministry of Science and Technology,

*Five-year plans are economic policy blueprints that enumerate the Party's objectives and priorities during the ascribed time period. They historically have centered on production targets or other numerical targets rooted in the command economy of the Soviet Union and inherited by other Communist regimes. The Party's 14th Five-Year Plan is notable, however, in shelving mandated annual growth targets during the plan's term (2021—2025), indicating instead that growth targets will be addressed each year based on economic conditions. *Xinhua*, "(Two Sessions Authorized Release) The 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives through 2035" ([两会受权发布] 中华人民共和国国民经济和社会发展第十四个五年规划和 2035 年远景目标纲要), March 12, 2021. Translation; *Economist*, "What Is China's Five-Year Plan?" March 4, 2021.

†The CCP's Central Financial and Economic Affairs Commission is responsible for information collection and drafting proposals and outlines for pivotal economic policies, including five-year plans, the annual Central Economic Work Conference, and quarterly Politburo meetings. For more, see Alex He, Statement for the Record for the U.S.-China Economic and Security Review Commission, *Hearing on CCP Decision-Making and the 20th Party Congress*, January 27, 2022, 2–3, 8.

shows that Beijing judges 35 technologies* to serve as key "choke points."[41] While contemporary Chinese industrial policy has focused on developing China's capabilities in cutting-edge technologies such as microelectronics, artificial intelligence, biotechnology, and quantum computing, the *Science and Technology Daily* articles point to concerns about reliance on foreign suppliers across an even broader array of more niche technological inputs.[42] For instance, one article points to radio frequency components, which it assesses the United States as having monopolized.[43] As Dr. Dallas testified before the Commission, China is often heavily dependent on foreign firms in these more specialized layers and links in the supply chain.[44]

CCP concerns over China's technology supply chain vulnerabilities have accelerated markedly since 2018, when the United States stepped up efforts to counter the adverse and often illicit actions of China's technology companies. From 2018 to 2020, the Trump Administration advanced a series of measures to prevent the flow of U.S. technology to Chinese military end users, entities engaged in human rights abuses, and companies supporting China's extraterritorial land reclamation efforts.† The drastic impact of U.S. sanctions on Chinese telecommunications giants Huawei and ZTE shocked CCP leaders, leading them to attach increased urgency to ensuring technological supply chain security.[45] Since then, Xi has called for self-reliance in "core technologies," described China's limited technological and innovative capacity as an "Achilles' heel," and identified semiconductors and new materials as "extruding chokepoints."[46] Dr. Dallas testified that these "recent events have tapped into China's long-standing insecurities and Xi has given greater voice to them (for instance concerning technological dependency and information security), thereby empowering security-oriented voices in China."‡[47] The CCP's increasingly anxious dash toward technological self-reliance has brought this long-lurking ambition, pursued largely below

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*The 35 chokepoint technologies are: photolithography machines, microchips, operating systems, aircraft engine nacelles, touch sensors (for industrial robots), vacuum evaporators, high-end frequency components, primers and reagents used for iCLIP technology (for gene editing), heavy-duty gas turbines, LiDAR (light detection and ranging), airworthiness standards, high-end capacitors and resistors, electronic design automation software, high-end indium tin oxide sputtering targets (for panel displays), core algorithms (for robotics), aviation-grade steel (for landing gear), milling cutters, high-end bearing steel, high-pressure piston pumps (for hydraulic machinery), aviation design software, high-end photoresists, high-pressure common rail direct fuel injection systems (for low-emission diesel engines), transmission electron microscopes, main bearings for tunnel boring machines, microspheres, underwater connectors, key materials for fuel cells, high-end welding power sources (for underwater welding robots), lithium battery separators, components for medical imaging equipment, ultra-precision polishing techniques, epoxy (for high-end carbon fiber), high-strength stainless steel (for rocket engines), database management systems, and scanning electron microscopes. Ben Murphy, "Appendix: Key Details of the 35 'Chokepoint' Technologies," *Center for Security and Emerging Technologies*, May 2022.

†For a thorough overview of Trump Administration actions targeting China, see U.S.-China Economic and Security Review Commission, *Timeline of Executive Actions on China (2017—2021)*, April 1, 2021.

‡Nazim Uras Demir and Etel Solingen distill three stylized views among CCP leaders regarding the future of global supply chains. A first group of global supply chain "preservers" believes China should not seek to disintegrate from global supply chains and instead should continue to encourage investment from multinational enterprises in China to extract technology and knowledge from them. A second group of global supply chain "reformers" view Trump Administration actions against Huawei and ZTE as more durable threats that necessitate alternative supply lines, though not complete economic decoupling. A third group of global supply chain "replacers" favors the complete substitution of Western-led supply chains and technological self-sufficiency. Nazim Uras Demir and Etel Solingen, "Are Global Supply Chains Vital to China's Leaders?" in Etel Solingen, ed., *Geopolitics, Supply Chains, and International Relations in East Asia*, Cambridge University Press, 2021, 135–152.

the surface in myriad licit and illicit manners, more forcefully to the fore.

Already on high alert, in 2022 the CCP's technology insecurities grew even more pronounced following Russia's unprovoked invasion of Ukraine. Beijing has observed how coordinated sanctions and export restrictions by the United States and U.S. allies and partners have compromised Russia's technology supply chains, gravely undermining its ability to manufacture materiel. Reportedly, Russia has resorted to cannibalizing existing machinery, vehicles, and goods, such as airplanes, just to keep some portion of its military functional.[48] Zongyuan Zoe Liu, a fellow for international political economy at the Council on Foreign Relations, argues that in light of these geopolitical developments, China is "hardening itself for economic war" and preparing to withstand a forced decoupling.[49] The U.S.-China Business Council, in its September 2021 analysis of China's government and SOE procurement, noted a decisive increase in import substitution efforts for the 2020–2022 period. Council members reportedly "discovered detailed, nonpublic plans to replace foreign products with domestic alternatives in the ICT sector," with the central government having "issued instructions to local government entities and SOEs in sectors related to national security, including aerospace, healthcare, and energy, requiring them to gradually devote a higher share of their procurement budget to ICT products from domestic brands."[50] These plans are also "particularly troubling, as they suggest that domestic preferences, unequal treatment, and support for Chinese brands have moved behind the scenes."[51] These surreptitious and detailed import substitution plans are the flip side of the vague yet increasingly pervasive central and local government announcements on increasing the "independent controllability of the supply chain."[52]

Inadequate Implementation of U.S. Export Controls Aids China

Mistakes and oversights in the implementation of U.S. export control policy may be advancing China's technology capabilities. When Congress enacted the Export Control Reform Act in 2018, section 1758 of the act intended for the Commerce Department to develop lists of "emerging" and "foundational" technologies to augment the U.S. government's capacity to respond to national security issues stemming from countries of concern, particularly China, acquiring and using U.S. technologies to bolster their own innovation in these critical dual-use areas.[53] In May 2022, the Commerce Department's Bureau of Industry and Security released a notice of proposed rulemaking noting its intention to forego creating lists of "emerging" and "foundational" technologies and rather create a singular list termed "section 1758 technologies."[54] Without a definition of "foundational," the Export Administration Regulations (EAR) may not include technology export controls on capabilities that it is in the U.S. national security interest to prevent China from obtaining. In addition, the Committee on Foreign Investment in the United States (CFIUS) relies on an enumerated list of technologies in order to trigger

Inadequate Implementation of U.S. Export Controls Aid China—*Continued*

mandatory filings for inbound investment review.[55] Without an adequately detailed list, many transactions of consequence might go unnoticed, potentially allowing China to invest and extract knowledge from U.S. companies to build up its own capacity. The Commerce Department's ongoing failure to enumerate technologies may thus be enabling the development of frontier industries in China that could scale up rapidly and undermine pivotal parts of U.S. supply chains.

Lax enforcement of the foreign direct product rule under the EAR is also a cause for concern. The rule prohibits foreign countries from exporting or reexporting controlled items produced outside the United States using controlled technology to restricted countries unless the exporter receives a license or license exception.*[56] The foreign direct product rule was revised and expanded in 2020 to increase restrictions on exports that supported Huawei's purchase of advanced semiconductors made using U.S. technology. Despite the revision, the Commerce Department has brought limited regulatory actions against companies for violating the expanded foreign direct product rule.†[57] This stands in contrast to other export control regulations–such as those on Iran, which have led to numerous investigations and substantial penalties–and in spite of evidence suggesting exporters have violated the rule.[58] An October 2021 report by the Senate Committee on Commerce, Science, and Transportation's Minority staff found that Seagate Technology, a California-based producer of hard disk drives, had continued to ship drives to Huawei without a license after the rule went into effect in September 2020.[59] Without more committed U.S. government export control enforcement action, exporters may continue to assess that they face little downside risk from failing to adhere to export restrictions on Chinese firms.[60]

The Challenges of China-Centered Supply Chains

A simple taxonomy for determining U.S. supply chain risks from China is the combination of exposure and consequence along stages of the supply chain. Exposure is simply U.S. dependence on inputs sourced from China at each stage. Consequence is the degree of harm that the lack or compromise of essential inputs or components sourced from China would cause the United States.‡ The latter dis-

*De minimis rules establish that items produced outside the United States incorporating certain controlled U.S. goods that do not exceed a certain de minimis threshold (10 percent or 25 percent depending on the technology) are not subject to the EAR. Some controlled technologies, including certain software, are ineligible for de minimis rules and some restricted countries are excluded. 15 C.F.R. § 734.4 - De Minimis U.S. Content, 1996.

†An exception is possible enforcement against Synopysis Inc., the largest U.S. supplier of electronic design software, a critical chokepoint for designing semiconductors. In April 2022, Bloomberg reported that Synopysis Inc. was under investigation by the Commerce Department for potentially exporting restricted technology to Huawei's semiconductor design subsidiary HiSilicon without a license (for more on semiconductor chokepoints, see the Appendix I: U.S.-China Supply Chain Competition in Semiconductors). Ian King and Jenny Leonard, "Synopsys Probed on Allegations It Gave Tech to Huawei, SMIC," *Bloomberg*, April 13, 2022.

‡A number of more elaborate taxonomies of supply chain risks are employed by some U.S. government agencies. A leading example is the Cybersecurity and Infrastructure Security Agency's

tinction is significant: severe consequences can result from Chinese entities cutting off, drastically limiting, or sharply increasing the price of an essential good, such as personal protective equipment (PPE); they can also result from a Chinese entity intentionally compromising an import, such as installing a backdoor in ICT used in U.S. critical infrastructure; and they can result from negligence or poor safety standards rather than deliberate compromise, such as Chinese pharmaceutical producers selling blood pressure medication with 200 times the acceptable interim limit for carcinogens per pill.

The passage that follows highlights the exposure to China at each supply chain stage and assesses the potential consequences that such exposure may carry. This report focuses on supply chain risks with the most acute consequences for U.S. security.* For this analysis, supply chain stages are broken down into five pieces: materials, components, final products, transportation, and research and design (R&D). This approach indicates that the United States faces several risks from China at every stage of the production and distribution process.

Exposure and Consequence: Materials Stage

The production process begins with mining, refining, and processing the raw material inputs that are constitutive elements necessary for later-stage production processes. Base material inputs can include a variety of metals and chemicals, such as iron ore, copper, aluminum, antimony, cobalt, nickel, lithium, graphite, silicon, rare earth elements, and active pharmaceutical ingredients, to name a few.†[61] China has consolidated control over numerous nodes of this production stage, including through developing extensive domestic mining and refining capacity in key materials as well as through strategic investments abroad.‡[62]

- *Active pharmaceutical ingredients (APIs)* are key components in over-the-counter and prescription drugs undergirding common pain relief medication, antibiotics, high blood pressure medication, and many other lifesaving and life-sustaining medications on which U.S. residents rely.[63] According to data from the U.S. Census Bureau, the United States imported 16.2 percent of its overall organic chemicals from China in 2021 and 24.9 percent of its antibiotics, including 41.6 percent of its penicillin, 64.5 percent of its streptomycin, 72.2 percent of its tetracycline, and

work on ICT supply chains. Cybersecurity and Infrastructure Security Agency, *ICT Supply Chain Resource Library.*

*A granular assessment of U.S. sectoral supply chain dependence is beyond the scope of this report, but a number of other U.S. government agencies have compiled such reports in the last two years. See for example the U.S. Department of Energy's numerous deep dive assessments, including of the rare earth permanent magnet supply chain, the solar photovoltaic supply chain, and others. However, these reports focus on U.S. supply chain risks overall, not with specific focus on China. U.S. Department of Energy, *Securing America's Clean Energy Supply Chain*, February 2022.

†According to the U.S. Geological Survey, of the 47 materials for which the U.S. net import reliance is greater than 50 percent, China is either the—or one of the—leading import sources in 25, including: tungsten, germanium, magnesium, barite, antimony, most rare earths, indium, graphite, gallium, and arsenic. U.S. Geological Survey, *Mineral Commodity Summaries* 2022, 5.

‡For an overview of critical materials, see the 2020 USGS investigation into the United States' foreign reliance on critical minerals, which, in part, found that "the most notable global shift [since the 1990s] has been the increasing production of mineral commodities in China." Nedal T. Nassar, Elisa Alonso, and Jamie L. Brainard, "Investigation of U.S. Foreign Reliance on Critical Minerals—U.S. Geological Survey Technical Input Document in Response to Executive Order No. 13953 Signed September 30, 2020," *U.S. Geological Survey*, December 7, 2020, 2.

86.4 percent of its chloramphenicol.[64] The extent of U.S. dependence evidenced by U.S. Census data, however, is incomplete and leads to underestimations, as China is the key supplier of APIs to most other countries. Most prominently, China supplies India, the world's largest producer of generic drugs, with 80 percent of its APIs, resulting in a concealed and embedded trade dependence on China that is far higher than U.S. trade data indicate.[65]

- *Rare earth elements* are small but crucial material inputs in national security-related products, including aircraft engines, fiberoptic cables, TV and computer displays, electric vehicle motors, and medical devices.[66] China has a commanding position in the rare earth element supply chain.[67] In 2021, according to the U.S. Geological Survey (USGS), China accounted for 60 percent of the world's mined output of rare earth elements.[68] China also commanded 85 percent of the world's rare earth processing in 2021.[69] From 2017 to 2020, China supplied approximately 78 percent of U.S. imports of rare earth compounds and metals.[70] In 2021, over 94 percent of U.S. imports of neodymium, a critical input into permanent magnets for electric vehicles, were sourced from China.[71]

Rare Earth Elements Case Study

Rare earth elements are not actually rare but rather are rarely found in isolation, are costly to separate, and are costlier to refine.[72] Most rare earth element applications require at least 99.9 percent purity and therefore must undergo several rounds of processing and refining to separate the elements from the extracted deposits.[73] China's dominance in rare earth elements, however, is attributable less to its geographic proximity to a disproportionate share of global rare earth element reserves and more to policy choices pursued by the Chinese government.[74] Beginning in the early 1980s, the Chinese government began to subsidize its own mining industry aggressively and invested heavily in human capital and technical refining knowledge. This contributed to the erosion of the U.S. rare earth industry: Mountain Pass mine in California was once the largest source of rare earth elements until it ceased production in 2002, unable to compete with subsidized output from China.[75] Similarly, Chinese state support and lax environmental regulation pulled global mining and refining of rare earth elements out of the United States and other countries and into China.[76] Chinese firms made critical inroads into the rare earth element industry via overseas acquisitions, as occurred in 1995 when Magnequench, a General Motors subsidiary, was sold to a consortium whose ultimate beneficiaries were two state-linked Chinese entities.* Prior to the acquisition,

*The consortium was comprised of three entities, a U.S. investment company the Sextant Group, which served as the lead firm in the transaction, and two state-linked Chinese companies, San Huan New Material High-Tech Inc. and China National Nonferrous Metals. The Chinese entities sought to acquire the technology and transplant it to China. Both Chinese entities were partly owned by the Chinese state, and the heads of both companies were, respectively, the hus-

Rare Earth Elements Case Study—*Continued*

Magnequench was the main supplier of permanent magnets for precision-guided munitions for the United States.[77] CFIUS reviewed the transaction and allowed the merger to go forward, despite Magnequench's key role in defense supply chains.* CFIUS' approval was reportedly conditioned on a mitigation agreement requiring Magnequench's operations to remain in the United States for a period of time.† Over a period of 12 years, however, Magnequench's technology and operations were transferred piecemeal to China and the company eventually closed its Indiana-based plants.[78]

The decline of U.S. rare earth element mine production and downstream rare earth element refining capability has magnified the difficulties of restarting the domestic rare earth element industry. In testimony before the Commission, associate professor of political science at the University of Maine Kristin Vekasi argued that U.S. challenges in restoring rare earth element supply chain resilience result from "(1) Willingness to bear high environmental externalities; (2) Technological expertise in separation and refinement; [and] (3) Market risks introduced by information failure."[79] For example, U.S. mining company Molycorp attempted to reopen Mountain Pass mine but was beset by cost overruns. Facing bankruptcy, the Mountain Pass mine was acquired by MP Materials, which has continued operations at the mine, focusing primarily on mining neodymium and praseodymium. MP Materials currently lacks domestic facilities to process rare earth elements,‡ however, and it sells its rare earth concentrate under contract to China's Shenghe Resources, which also owns 7.7 percent of MP Materials' share equity.[80] CCP leaders continue to make strategic control over rare earth element production a policy priority.[81] China's stranglehold on rare earth element mining and refining presents serious vulnerabilities to the United States. As a result of China's dominance in the supply chain, 16 out of the 17 rare earth elements are now considered "critical minerals" by USGS. This means these metals, while "essential to

bands of the first and second daughters of Deng Xiaoping. Andrew Leonard, "How G.M. Helped China to World Magnet Domination," *Salon*, August 31, 2010.

*For an assessment of CFIUS' shortcomings in the 1990s and early 2000s, including with regard to the Magnequench transaction, see U.S. Senate Committee on Banking, Housing, and Urban Affairs, *Hearing on a Review of the CFIUS Process for Implementing the Exon-Florio Amendment*, October 2005.

†CFIUS mitigation agreements are not public. A United Auto Workers negotiator representing workers at Magnequench in the agreement indicated that the Chinese consortium that purchased Magnequench duplicated the production line in China before shutting down its U.S. plant. John Tkacik, "Magnequech: CFIUS and China's Thirst of U.S. Defense Technology," *Heritage Foundation*, May 2, 2008; Scott L. Wheeler, "Missile Technology Sent to China," *Insight on the News*, January 31, 2003.

‡In February 2022, the U.S. Department of Defense awarded MP Materials a $35 million contract to fund construction of processing facilities based in Mountain Pass, California. DOD indicated the award aims to fulfill some of the initiatives outlined in Executive Order (EO) 14017 on America's Supply Chains (for more on EO 14017, see "Appendix II: The U.S. Government's Recent Supply Chain Actions"). MP Materials is also constructing a facility to produce permanent magnets in Fort Worth, Texas using output from California's Mountain Pass mine. MP Materials Corp., "MP Materials Begins Construction on Texas Rare Earth Magnetics Factory to Restore Full U.S. Supply Chain," April 21, 2022; U.S. Department of Defense, *DoD Awards $35 Million to MP Materials to Build U.S. Heavy Rare Earth Separation Capacity*, February 22, 2022.

Rare Earth Elements Case Study—*Continued*

the economic or national security" of the United States, also suffer from supply chains that are highly "vulnerable to disruption."[82] In the event of geopolitical friction with the United States, the Chinese government could choose to stifle the flow of rare earth elements for innovations essential to military preparedness and competitiveness of domestic industry.[83] CCP leaders have appeared willing to do this in the past, restricting exports of rare earth elements to Japan amid a territorial dispute concerning the Senkaku Islands in 2010.[84] Chinese state-backed firms are also investing in the mining and processing of other USGS-identified critical minerals abroad, such as cobalt in the Democratic Republic of the Congo; lithium in Bolivia, Argentina, and Chile; and nickel in Indonesia.[85]

A major vulnerability stemming from China's control over key materials is its ability to restrict U.S. access. Such a disruption could halt later-stage commercial production processes, deny U.S. citizens access to key healthcare products, and limit critical defense supply chain inputs.* A March 2020 editorial in state media outlet *Xinhua* acknowledged China's stranglehold on global pharmaceutical production and suggested China could assume "strategic control" over supplies and limit exports.[86] Similarly, despite intense diplomatic backlash to the CCP's decision to effectively weaponize rare earth exports during a 2010 dispute with Japan, CCP leaders have continued to explore limiting the export of rare earth elements.† In January 2021, China's Ministry of Industry and Information Technology proposed draft controls on the production and export of rare earth elements.[87] Industry executives consulted by the ministry observed that the Chinese government appeared interested in understanding how severely U.S. and European defense contractors could be affected by such controls.[88]

China itself faces a number of severe material input dependencies, some of which U.S. allies control that could deter weaponization. China is highly dependent on others for many base material inputs, with oil and iron ore constituting its largest import categories.[89] Although China produces more steel than the rest of the world combined, it is also the world's largest importer of iron ore, the base material needed to produce steel, relying on imports for roughly 80 percent of its iron ore requirements and relying on U.S. treaty ally Australia for roughly 60 percent of those imports in 2020.[90] China's

*In testimony before the Commission, Rosemary Gibson, senior advisor at the Hastings Center, stated that "if China shut the door on exports of medicines and their key ingredients and raw materials, U.S. hospitals and military hospitals and clinics would cease to function within months, if not days." Rosemary Gibson, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on Exploring the Growing U.S. Reliance on China's Biotech and Pharmaceutical Products,* July 31, 2019, 2.

†Daniel Drezner, professor of international politics at Tufts University, argues that China's exploitation of leverage even in this instance has not been particularly successful: "Even in the rare instances in which China appears to have successfully exploited its leverage—as when it withheld rare-earth exports to coerce Japan in a 2010 dispute—the long-term effect was to weaken China's coercive capabilities." More broadly, he argues that "[a]ctors run the risk of abusing their role as central hubs, putting their network centrality at risk for the future." Daniel Drezner, "The Uses and Abuses of Weaponized Interdependence," *Brookings Institution Press*, March 2021, 5–6.

Ministry of Industry and Information Technology, Ministry of Science and Technology, and Ministry of Natural Resources allude to this dependency in the context of "security risks to industrial and supply chains that have become clear and obvious" as a result of a "deglobalization tide."[91] The ministries jointly released as part of their 14th Five-Year Plan (2021–2025) a report that for the first time targets the entire raw material industry at once, including inputs for petrochemical, steel, and nonferrous metals production, in contrast to the previous pattern of developing plans for each sector separately.[92]

U.S. vulnerability at the material stage is exacerbated by lack of visibility, incomplete public data, and lack of research into the supply and demand balance for critical inputs. Raw material suppliers are often located at the lowest tiers in a firm's supply chain, and firms have generally not acquired such depth of visibility.[93] At an aggregate level, and in part as a result of limited firm-level supply chain visibility, USGS assesses that the actual extent of the United States' net import reliance in critical minerals is greatly obscured and likely underestimated.*[94] To address challenges related to unknown supply and demand balance, the European Commission in 2020 undertook a foresight study, Critical Raw Materials for Strategic Technologies and Sectors in the EU, to assess future supply and demand balance of raw materials needed for future-oriented industries (e.g., robotics, drones, and 3D printing), but the U.S. government has not conducted a comparable publicly available forecasting study.†[95] These limitations may enable unexpected U.S. supply chain dependencies upon China to arise and disrupt U.S. economic and national security.

Exposure and Consequence: Component Stage

The component stage of the production process transforms processed raw materials into usable intermediate inputs that constitute key parts of finished products. The component supply chain stage includes a number of production and manufacturing categories, many of which China has assumed a commanding position within, leading to high U.S. reliance on imports from China. Many of these industries, such as castings and forgings, represent traditional but still crucial manufacturing industries, while others undergird future-oriented industries, such as electric vehicles, green energy technology, and digital electronics.

- *Batteries* are a core component for a number of industries, including the telecommunications, energy, and automotive industries (for more on China's capacity in batteries and clean energy technologies, see Chapter 2, Section 3: "China's

*According to USGS, factors which complicate assessing the extent of net reliance include: indirect trade reliance, embedded trade reliance, and foreign ownership of mineral assets. Nedal T. Nassar, Elisa Alonso, and Jamie L. Brainard, "Investigation of U.S. Foreign Reliance on Critical Minerals—U.S. Geological Survey Technical Input Document in Response to Executive Order No. 13953 Signed September 30, 2020," *U.S. Geological Survey*, December 7, 2020, 7–8.

†The closest effort may be the 2020 USGS report issued in response to the Trump Administration's Executive Order 13953, which calculates U.S. net import dependence for a number of critical inputs and provides a composite estimation of future reliance under certain scenarios. Nedal T. Nassar, Elisa Alonso, and Jamie L. Brainard, "Investigation of U.S. Foreign Reliance on Critical Minerals—U.S. Geological Survey Technical Input Document in Response to Executive Order No. 13953 Signed September 30, 2020," *U.S. Geological Survey*, December 7, 2020.

Energy Plans and Practices"). China dominates battery production, with 76 percent of global battery cell manufacturing capacity located within its borders as of 2020.* [96] According to U.S. Census data, China represented 32 percent of all U.S. battery imports in 2021. At a more granular level, however, reliance on China in 2021 was even higher, accounting for 51.7 percent of lithium-ion batteries for electric vehicles and 54.5 percent of total U.S. lithium-ion battery imports.[97] This dependence has only grown in 2022, with China accounting for 64.2 percent of the total U.S. lithium-ion battery imports through July.† [98]

- *Permanent magnets* are critical components of electric motors and widely used in electric vehicles, wind turbines, and other domains. The United States now imports the vast majority of these inputs from China. In 2021, according to U.S. Census data, 73.6 percent of U.S. permanent magnets made from metal were imported from China, while 74.9 percent of those most widely used in electric vehicles, sintered neodymium-iron-boron permanent magnets, were imported from China.‡ [99]
- *Castings and forgings* are the processes through which metal, typically iron, steel, or aluminum, is set and forged into highly engineered molds. Castings form key parts of roughly 90 percent of all durable goods, from automobiles and ships to aerospace and defense equipment.[100] From 2000 to 2020, China's production of castings increased by 374 percent, while the United States' production fell by 26 percent.[101] As a result, China went from producing 17 percent of all castings globally in 2000 to producing 49 percent in 2020, while the United States went from producing 20 percent in 2000 to producing just 9 percent in 2020 (see Figure 1).[102] DOD relies on China for a variety of large cast and forged products employed in the production of defense systems and machine tools.[103]

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*As John VerWey, East Asia National Security Advisor at Pacific Northwest National Laboratory, noted in testimony before the Commission, China's lead in battery manufacturing extends down into base materials as well: "Lithium-ion batteries rely on cobalt, iron, nickel (C1), manganese, lithium, and graphite. China leads the world in raw material mining of graphite, accounting for 82% of the global production. The DOE recently found 'China has near absolute dominance of today's refining capacity for metals necessary for lithium-ion batteries,' which includes cobalt sulfate (62%), high-purity manganese sulfate (95%), and lithium hydroxide carbonate (61%). Similarly, for subcomponents, China's has dominance in the worldwide production of cathodes (63%), anode materials (84%), separators (66%), and electrolytes (69%)." John VerWey, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on U.S.-China Competition in Supply Chains*, June 9, 2022, 5.

†China's Ganfeng Lithium Co. Ltd in early 2022 acquired a major lithium concession in Mexico, just months prior to President Andrés Manuel López Obrador's decision in April to nationalize the Mexican lithium industry. The fate of Ganfeng's lithium mine concession remains uncertain, despite López Obrador's assertion in June that existing projects would be respected. Guo Yingzhe and Lu Yutong, "Mexico Launches State-Owned Lithium Miner in Nationalization Push," *Caixin Global*, August 25, 2022.

‡The Commerce Department, in response to a recommendation from the 100-Day Review under Executive Order 14017, announced the initiation of a Section 232 investigation into neodymium magnets in September of 2021. The investigation, released in a redacted format in September 2022, determined that current quantities and circumstances of neodymium magnet imports are a threat to U.S. national security but did not recommend imposing tariffs on imports. U.S. Department of Commerce, *U.S. Department of Commerce Announces Section 232 Investigation into the Effect of Imports of Neodymium Magnets on U.S. National Security*, September 24, 2021; U.S. Department of Commerce Bureau of Industry and Security, *The Effect of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets on the National Security*, September 21, 2022.

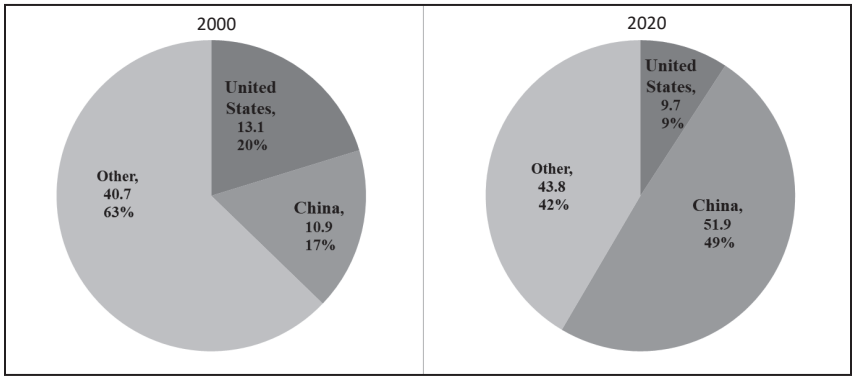
Castings and Forgings Case Study

For generations, the casting industry has played a role in national defense. During World War II, metal castings were vital to the U.S. military response as foundries provided crucial parts for tanks, aircraft, and weaponry, among other things.[104] Each branch of the U.S. military relies on castings found in ships, tanks, trucks, submarines, helicopters, laser-guided missile systems, and other weapons systems and equipment.[105] In his testimony for the Commission, James Brown, CEO of BCI Solutions, noted that his ferrous foundry supplies "over 23 different types of machined complete ductile iron castings to AM General for the military Humvee brand vehicles as a Tier 2 supplier" for DOD.[106] Metal casting is a roughly $44 billion industry in the United States that supports nearly 430,000 workers spread across foundries nationwide, many of which operate as family-owned businesses.[107]

While castings are foundational to the manufacturing economy, and more specifically the defense industrial base, the industry has drastically consolidated over the last 60-some years with much of the manufacturing base moving to China.[108] In 1955, there were 6,150 U.S. metal casting facilities, and there are only 1,750 plants today.[109] The United States still leads the world in casting applications, but it is third in production behind China and India. As the world's largest producer of metal castings, China now produces five times the amount of casting tonnage as the United States (see Figure 1). As more manufacturing has been offshored, the United States has also lost institutional knowledge that equips new trainees with the specialized skillsets and knowledge necessary to enter the industry.

The consolidated and shrunken U.S. casting industry is particularly reliant on China for the raw materials required in the metal casting process, including rare earth elements, pig iron, and scrap metal. The casting industry relies heavily on alloys like silicon, which is largely sourced from foreign suppliers. World supplies are currently low and prices remain high. In his testimony before the Commission, Mr. Brown explained that his company was sourcing silicon from Ukraine but was facing delays due to the Russian invasion, and a number of foundries were sourcing from China and Brazil.[110] U.S. foundries are also experiencing supply chain disruptions in their pig iron shipments due to the crisis in the Black Sea region, from which Russia and Ukraine supplied 62 percent of pig iron imports for the United States in 2021.[111] China is a top producer of pig iron, but until recently it has remained a domestic consumer, exporting little to foreign buyers. China's abundance of inexpensive raw materials has allowed it to quickly fill the supply gap for pig iron in the global market, exporting more tonnage to the United States at higher costs. As Mr. Brown explained, pig iron prices have increased from $400 net ton to $1,200 net ton.[112] Ductile iron castings, like the ones used to make military Humvee brand vehicles, rely on rare earths predominately mined in China (see Table 1).

Figure 1: U.S. and Chinese Share of Castings Production, 2000 vs. 2020 (Millions of Metric Tons and Percent)



Source: Various.[113]

Table 1: Metals and Minerals Used by U.S. Ferrous Foundries and Source Countries

Commodity	Major Import Sources
Graphite	China is the primary source of the material. Also, Mexico, Canada, and India
Magnesium (metal compounds)	China is the primary source. Also, Russia, Ukraine, Israel, Kazakhstan, Brazil, and Turkey
Rare Earth Elements	China is the primary source. Also, Japan, Estonia, and Malaysia
Strontium	China, Mexico, and Germany
Chromium	Russia is the primary source, along with South Africa, Mexico, and Kazakhstan
Fluorspar	Mexico, Vietnam, South Africa, and Canada
Tin	Indonesia, Peru, Malaysia, and Bolivia
Manganese	Gabon, South Africa, Australia, and Georgia

Source: James Brown, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on U.S.-China Competition in Global Supply Chains,* June 9, 2022, 7; U.S Geological Survey, *Mineral Commodity Summaries 2022*, January 31, 2022, 7.

The concentration of traditional and future-oriented component production in China creates a dual challenge for the United States: developing platform capabilities—industries that enable many others—that could provide Beijing with leverage over downstream products as well as the potential for ecosystem lock-in that could afford China durable innovation advantages. Willy Shih, professor of management practice in business administration at Harvard Business School, argued in testimony before the Commission that the castings industry is a key example of a platform capability, for "[i]f you cannot make metal castings efficiently and cost effectively in the quantities you need, you will have trouble making machine tools, plumbing and fluid handling devices, oil field equipment, motor

vehicles, and countless other goods."[114] Control over a platform capability affords strategic supply chain leverage. Meanwhile, China's concentration of production in advanced batteries and permanent magnets affords it an ecosystem advantage that can make supply chain realignment difficult. As the Biden Administration's *100-Day Supply Chain Review* notes: "[i]nnovations essential to military preparedness—like highly specialized lithium-ion batteries—require an ecosystem of innovation, skills, and production facilities."[115] China's prominence across many industries at the component supply chain stage affords it a robust ecosystem that could facilitate its developmental ambitions in future-oriented industries.

Exposure and Consequence: Final Product Stage

The final product stage combines and assembles intermediate and component parts into the final goods that are ultimately consumed. China has a dominant role in this stage, long serving as the world's workshop and assembler of goods. China is the largest single manufacturer of finished automobiles (33 percent), ships (47 percent), refrigerators (50 percent), TV sets (60 percent), solar panels (70 percent), air conditioners (80 percent), computers (80 percent), and mobile phones (90 percent).[116]

- *Information and communication technology (ICT) products:* A 2020 report from Boston Consulting Group assessing U.S.-China economic interdependence found that more than 70 percent of the products produced by the U.S. consumer electronics and telecommunications equipment sectors rely on imports from China.[117]
- *Personal protective equipment (PPE):* Research prepared by the Congressional Research Service shows that in 2019, China accounted for over 70 percent of imports of medical protective articles.[118] In 2020, according to U.S. Census data, 98.3 percent of the United States' $2.7 billion worth of imported N95 respirators were supplied by China, 88.9 percent of imported respirators other than N95 came from China, and 90.7 percent of all imported textile face masks were purchased from China.[119]
- *Assembly, packaging, and testing (APT):* APT is the final stage of the semiconductor production process. China has developed a strong presence in semiconductor APT. Boston Consulting Group and the Semiconductor Industry Association jointly estimate that, in 2019, 38 percent of the world's APT occurred in China.[120] Of the top ten firms in China's assembly and testing ecosystem, the top three are Chinese (JCET, TongFu, and Tianshui), while most of the rest are U.S. firms.[121]

China's control over supplies of finished goods was revealed to be a vulnerability for the United States at the beginning of the COVID-19 pandemic, when Beijing's policies restricted U.S. ability to receive imports of PPE. In a bid to contain the initial outbreak of COVID-19 in February 2020, the Chinese government nationalized control of the production and distribution of medical supplies in China, hampering global supply lines and denying the United States timely access.[122] According to reports by the *New York Times* and *South China Morning Post*, as the global outbreak widened,

the Chinese government directed producers to prioritize supplying local demand over exports.[123] The Chinese government also informally restricted the export of PPE in spring 2020, limiting exports of PPE from companies that did not have "accreditation to sell their products within China," even if they did possess quality certificates necessary to sell to the United States and EU.[124] Although the policy was initially intended to address other countries' complaints of quality issues in exported products, the sweeping and quickly implemented regulation resulted in major supply disruptions just at the moment other nations were most vulnerable.[125] The PPE crisis reveals that at critical moments, the United States may lose access to medical supplies, the associated raw materials to make medical supplies, and many other final products made in China.

Exposure and Consequence: Transportation

China's growing control of maritime supply chain infrastructure could pose a challenge to U.S. supply chains.[126] The smooth functioning of maritime trade is critical to U.S. economic and national wellbeing, as the ongoing fallout from port congestion, shipment delays, and limited container capacity in the United States has made apparent to citizens and policymakers.[127] With 90 percent of the world's merchandise transported by sea, the maritime shipping industry underpins most global supply chains.[128] According to Christopher O'Dea, an adjunct fellow at the Hudson Institute, China is carving out dominance in a triad of critical maritime transportation advantages that could give it undue influence over U.S. supply chains, including container shipping, global ports, and electronic logistics network infrastructure.*[129]

- China's dominance in shipping and port infrastructure owes in particular to two massive SOEs, COSCO Shipping and China Merchants Group. COSCO Shipping has quickly risen to become the largest shipping company in the world.†[130] China Merchants Group, on the other hand, is perched as the largest port and logistics company in the world.[131] These two SOEs, as well as a number of other important though smaller state-linked firms in the shipping and shipbuilding industries, receive an immense amount of formal and informal state support that is unparalleled in size and scope. The Center for Strategic and International Studies conservatively estimates that between 2010 and 2018, firms in these industries received $127 billion in financing from state banks on top of $5 billion in direct subsidies.‡[132] As of 2019, China produces 96 percent of all shipping containers, builds 80 percent of the world's ship-to-shore cranes,

*China also dominates the production of shipping and transportation containers. The United States imported 75.7 percent of its transport containers from China in 2021. United States Census Bureau, *USA Trade*.

†While the Chinese government decries anti-monopolistic practices in the private sector, it has encouraged concentration in state-owned shipping, pushing through a 2016 merger between COSCO and China Shipping, then the second-largest shipping company in China, to create COSCO Shipping. In 2018, it pushed through another merger, this time with Orient Overseas. Brenda Goh, "COSCO Shipping's Takeover of OOCL to Complete by End-June: Vice Chairman," *Reuters*, April 3, 2018; Chris Horton, "COSCO: China's Shipping Giant Expands its Global Influence," *Nikkei Asia,* May 13, 2022.

‡These numbers include 11 listed Chinese shipping companies, 24 listed Chinese port management companies, and 12 listed Chinese shipbuilding companies.

and as of 2020 takes in 48 percent of the world's shipbuilding orders.[133]

- China now holds strategic investments in more than 100 ports in at least 60 different countries as a result principally of investments from China's state-financed companies.[134] A report by C4ADS, a nonprofit research organization focused on transnational security issues, finds that Beijing utilizes these port investments not only to expand commercial interests abroad but also "to generate political influence, stealthily expand Beijing's military presence, and create an advantageous strategic environment."[135]
- Building on data and access afforded via control of strategic global port infrastructure, China is also developing an integrated network logistics infrastructure that can give the CCP a broad view of global shipping and serve as a foundation for new global standards. The National Transportation and Logistics Public Information Platform, or "LOGINK," is at the crux of this system. Governed by China's Ministry of Transport, LOGINK may be analogized to a "super app" for integrating maritime logistics.[136] One industry insider interviewed by the *Wall Street Journal* noted that "[t]he most obvious risk of LOGINK is that it can help Chinese companies grow faster because of its data insights."[137] Through LOGINK, shipping-data experts say China could gain "insight into the unit prices, precise product mix and ultimate recipients of shipments" that could allow them to undercut commercial transactions.[138] This sort of privileged insight could afford the CCP and its SOEs an exploitable "informational advantage in understanding adversaries' intentions and tactics."[139]

China's consolidation over transportation and logistics processes poses several challenges to the United States, including commercially, as Chinese firms may be advantaged, and strategically, as consolidation may complicate U.S. supply chain realignment initiatives. Through its expanding position in global transportation and logistics, China could serve not only as the world's critical node in global manufacturing but also as the world's primary means for transporting goods made in China as well as other countries around the world.[140] Beijing may use the transmission belt it is creating between its physical control of ships, ports, and terminals and its digital infrastructure as a "force multiplier" to support its SOEs and other commercial enterprises.[141] Geopolitically, China's global logistics network could add complications to supply chain realignment efforts, as "moving a plant from China to Vietnam, for example, might reduce exposure to Chinese IP theft but still leave a company dependent on Chinese state-owned entities to ship its goods to world markets."[142] Most concerning, in the event of a military conflict, the United States and its partners could lose access to a substantial proportion of commercial goods shipping capacity.

Widespread Adoption of LOGINK Could Create Economic and Strategic Risks

To increase China's influence in international logistics, China's Ministry of Transport (MOT) is promoting a unified logistics platform formally called the National Transportation and Logistics Public Information Platform and abbreviated as LOGINK (a portmanteau of "logistics" and "link").* Beginning as a Chinese provincial initiative in 2007, LOGINK became part of a regional network in Northeast Asia in 2010 and a global platform after 2014. The platform provides users with a one stop shop for logistics data management, shipment tracking, and information exchange needs between enterprises as well as from business to government. China's government is encouraging global ports, freight carriers and forwarders, and other countries and entities to adopt LOGINK by providing it free of charge. The state-sponsored and -supported platform has now expanded to partner with over 20 ports worldwide as well as numerous Chinese and international companies.

The development and international expansion of LOGINK advances broader Chinese policy initiatives, including China's goal of becoming a transportation superpower through ownership of ports and by accruing dominant market position in shipbuilding and shipping.† Unlike shipbuilding, shipping, and port equipment—in which Chinese companies are competing for a share in well-established markets—logistics management platforms are a new and evolving service. China's state-funded effort to obtain first mover advantage could enable LOGINK to shape how the market evolves, setting the rules of the road in a way that favors Chinese firms by enabling them to compete on unequal footing in the nearly $1 trillion third-party logistics industry, in particular the market for freight forwarding services—companies like DHL that arrange cargo for shippers—estimated at just under $200 billion.[143] State control of the LOGINK platform also potentially provides the CCP access to data collected and stored on the platform and could enable the Chinese government to gain insights into shipping information, cargo valuations via customs clearance forms, and destination and routing information, including for U.S. military cargo shipped via commercial freight.

*For more on LOGINK's background and risks to U.S. interests, see USCC Staff, "LOGINK: Risks from China's Promotion of a Global Logistics Management Platform," *U.S.-China Economic and Security Review Commission*, September 20, 2022.

†In 2019, China's government released a key document that essentially lays out a 30-year plan to become an international leader in transportation, including innovation in transportation equipment and infrastructure as well as operation of transportation and logistics services. Chinese firms have already reached or are rapidly making inroads toward achieving many of these goals. As analysts at the Center for Strategic and International Studies note, in 2019 Chinese companies controlled the second-largest global shipping fleet; produced over a third of ships and more than 80 percent of ship-to-shore cranes; and owned seven of the ten busiest ports in the world (including Hong Kong). Jude Blanchette et al., "Hidden Harbors: China's State-Backed Shipping Industry," Center for Strategic and International Studies, July 8, 2020; Chinese Communist Party Central Committee and State Council, Transportation Superpower Construction Outline (《交通强国建设纲要》), September 19, 2019. Translation.

Exposure and Consequence: Research and Design Stage

The research and design of products conditions the rest of the supply chain stages, informing how, where, and to what specifications goods are to be produced. The R&D stage is generally considered to be the most profitable supply chain segment, though in many industries R&D is directly influenced by production processes, and often multinationals choose to locate R&D close to manufacturing.*[144] The United States enjoys broad advantages in R&D, owing in large part to its world-leading innovation and educational ecosystem.[145] However, Beijing is increasingly focused on accruing a greater position in the design stage across a number of supply chains, with some initial successes that may pose a challenge to the United States, particularly when those gains are derived from illicit technology theft and transfer.

- *Semiconductor design:* After decades of aggressive subsidization, Chinese chip designers are beginning to gain market share in legacy logic and memory chips. Other than packaging and testing, chip design is the market segment China performs most strongly in, with an estimated 9 percent of fabless chip design market share in 2021.†[146] A variety of Chinese semicondcutor firms, including Huawei's HiSilicon, Loongson, Zhaoxin, Micro, and Yangtze Memory Technology Corporation, are making progress in various stages of design.[147] As Jan-Peter Kleinhans, a technology expert at Stiftung Neue Verantwortung (SNV), noted in testimony before the Commission, China's chip design ecosystem and capabilities are "quickly increasing."[148] In August 2022, Biren Technology, using Taiwan Semiconductor Manufacturing Company's (TSMC) 7-nanometer manufacturing process, has reportedly designed a GPU, important for training machine learning algorithms, with drastically improved performance.[149] Consistent with precedents in other sectors,‡ it is the stated intent of China's policies to see the commanding commercial positions of U.S. integrated and specialized design companies such as Intel, NVIDIA, AMD, and Micron undermined, and U.S. strategic strength in this stage of the semiconductor chain eroded.
- *Pharmaceutical innovation:* China is aiming to move beyond dominance in exporting lower-value, upstream APIs and into

*Stan Shih, the founder of the Taiwan information technology company Acer Inc, coined the phrase "smile curve" in 1992, which describes how the two ends of the value chain—product development and conception on one side and marketing and sales on the other—are higher-value-added activities than the middle part of the value chain (manufacturing). As Chinese firms became more competitive manufacturers, they have gradually expanded their existing positions along the curve, though some are still struggling to enter higher-end activity stages such as research and development. Rita Rudnik, "Supply Chain Diversification in Asia: Quitting Is Hard," *MacroPolo*, March 31, 2022.

†According to market research firm IC Insights, China's share of the global fabless chip design market dropped from 15 percent in 2020. This was likely due in large part to Entity List restrictions impacting Chinese chip designers, including Huawei subsidiary HiSilicon. Peter Clarke, "China's Share of Global Fabless IC Market Collapsed in 2021," *EE News*, April 8, 2022.

‡China's approach to foreign investment has sought to create a regulatory framework that forces these foreign companies to work with local partners and share knowledge through JVs and other technology transfer mechanisms and then use the technology to develop competing Chinese products. General Motors' JV with Chinese automaker Shanghai Automotive Industry Corporation (SAIC), which formed in 1995, is a case in point. After helping GM's China operations stay afloat during the Global Financial Crisis, SAIC forced GM into transfer agreements. By 2012, it had developed vehicles using three of GM's core global car platforms. Edward Niedermyer, "The Secret History of GM's Chinese Bailout," *Quartz*, January 24, 2016.

the highest-value-added stage of pharmaceutical innovation to discover and bring new medicines to market.[150] As a recent RAND Corporation report notes, "China intends to shift its pharmaceutical industry up the value chain to become an industry based on innovation rather than low value, low-quality production."[151] So far, though, "China has no companies that have made proprietary drug discoveries… that have achieved success on the international market."[152] But China is increasing global partnerships with multinational corporations, which could facilitate further Chinese innovations.[153]

China's race to acquire superior positions throughout the R&D stage of supply chains is interconnected with its increasingly vigorous and centralized industrial policy endeavors. While the United States continues to remain in a strategically advantageous position across the design stages of many supply chains, as in the semiconductor supply chain, preliminary successes from China's industrial policy, in combination with its strong innovation ecosystem, provide cause for concern. More pressing, China's ongoing and extensive technology theft and transfer operations pose serious risks not only to U.S. economic competitiveness in the design stage but also to the United States' geostrategic advantages.[154] Federal investment in the U.S. research and development pipeline for the defense industrial base plays an important role in ensuring next-generation supply chains are well established and continue to grow in the United States, an endeavor that is undermined by China's industrial policies and interlinked technology theft efforts.

Gaps in U.S. Defense Critical Supply Chains Need to Be Identified

Within DOD and among its supporting contractors, there are significant gaps in the understanding of supply chains and the role of Chinese suppliers. Greater visibility into U.S. supply chains and clarity regarding the responsibility of the stakeholders involved in each stage of the supply chain are crucial to mitigating risks of disruptions and compromises. As noted in DOD's 2022 supply chain report, the department has for several decades "entrusted supply chain visibility and risk management to companies in the private sector that provide it with defense capabilities."[155] Consequently, DOD lacks sufficient visibility into the sub-tiers of those supply chains to mitigate dependencies on China for critical inputs and security risks from untrusted Chinese suppliers.[156] Jennifer Bisceglie, chief executive officer at the supply chain risk management firm Interos, noted that supply chain visibility would increase the U.S. security posture by "enabling the federal government to source responsibly and securely, and by improving the government's ability to act with a ready military at the moment needed."[157]

More Procurement and Industry Data Needed to Identify Critical Vulnerabilities

In February 2022, DOD and six other U.S. cabinet departments released supply chain papers assessing vulnerabilities and needed

measures to increase resilience of critical supply chains.* A common theme of these reports is the lack of information needed to prioritize any policy response, starting with the basic question of identifying "exactly where demand most exceeds reliable supply."[158] That assessment is necessary for determining which inputs or constitutive materials to prioritize for shorter-term measures like stockpiles and longer-term strategies like onshoring or reshoring (discussed below). It would also avoid policies that inadvertently exacerbate supply chain vulnerabilities, such as by increasing demand on commercial suppliers who are themselves dependent on China or investing in production capabilities without addressing necessary increases in the reliable supply of materials constitutive to such production.[159] In its supply chain report, DOD committed to collecting and organizing data through 2023 to inform real-time supply chain management decisions, and it acknowledged that "inadequate data management practices hamper DOD's standardization efforts, investment planning, and the development of key supplier relationships."[160] For instance, without data on the full scope of batteries used by DOD, the department cannot sufficiently implement supply chain risk mitigation solutions at a broader and more strategic level. Consequently, DOD has recommended "centralizing information on the type, volume, and future projections of internal battery demands."[161] In an effort to bolster U.S.-based semiconductor manufacturing, the DOD report also recommends investing in "radiation hardened microelectronics data collection, storage, and analytics to support, centralized DOD SEE [single-event effects] test resource management activities."†[162]

Additional Work Needed to Prevent Counterfeit Products from Entering Defense Supply Chains

DOD has spent considerable efforts to reduce risks of counterfeit integrated circuit products entering supply chains of U.S. military systems and platforms and compromising their performance and security.[163] Whereas semiconductor companies and their authorized distributors subject products to extensive testing for reliability, counterfeit products largely evade testing procedures or quality controls and may fail during crucial operations. These circuits may originate with a Chinese manufacturer but are then resold by multiple, often unvetted, subcontractors before being incorporated into a subcomponent and sold to a primary defense contractor.[164] The U.S. Department of Justice (DOJ) reported in July 2022 that the CEO of more than a dozen U.S.-based companies trafficked more than $1 billion worth of counterfeit networking equipment into the United States from China and Hong Kong.[165] The trafficker sold counterfeit devices to U.S. government agencies, the military, hospi-

*The studies were conducted in response to Executive Order 14017 "directing an all-of-government approach to assessing vulnerabilities in—and strengthening the resilience of—the United States' critical supply chains." In addition to DOD, other agencies releasing reports included the Department of Homeland Security, Department of Commerce, Department of Energy, Department of Agriculture, Department of Transportation, and Department of Health and Human Services. White House, *The Biden-Harris Plan to Revitalize American Manufacturing and Secure Critical Supply Chains in 2022*, February 24, 2022.

†Radiation--hardened electronics are commonly used in military-grade products for DOD because of their resiliency and ability to withstand radiation damage. John Keller, "The Evolving World of Radiation-Hardened Electronics for Space," *Military Aerospace Electronics*, June 28, 2021.

tals, and schools. As DOJ notes, the fraudulent and counterfeit products "suffered from numerous performance, functionality, and safety problems," which in some cases cost customers tens of thousands of dollars.[166] In 2019, the owner of a U.S.-based reseller of electronic components was sentenced for selling counterfeit microelectronics that he obtained from China and resold to U.S. commercial and military customers.[167] He admitted to instructing the Chinese suppliers to re-mark used and discarded components in order to make them appear new and to ordering a testing laboratory in China to produce multiple versions of test reports to obfuscate the components' condition.*[168]

U.S. Customs and Border Protection has taken steps to stop the flow of counterfeits chips from entering U.S. supply chains, including increasing training to identify counterfeit chips and establishing industry-wide partnerships to increase information sharing.[169] DOD's February 2022 report, however, lists the introduction of counterfeit microelectronics as an ongoing challenge.[170] The department cites Naval Air System Command's counterfeit protection program as an exemplar for other supply chain efforts to follow, and it recommends incorporating similar monitoring, documenting, and reporting into all military service supply chains.[171]

Risks of China Deliberately Compromising Microelectronics in U.S. Defense Supply Chains

In addition to low-quality counterfeit microelectronics, sourcing critical components from China presents risks of deliberately compromised or sabotaged products. Chinese military writers, like information warfare theorist Ye Zheng, consider sabotaging and exploiting an adversary's supply chains to be an effective espionage and military tactic. In 2020, a report by SOSI International found that People's Liberation Army strategy documents prioritize "exploiting adversary supply chains and other vulnerabilities," including "hardware hidden mine attacks."[172] That same year, analysts at Pointe Bello reported on hidden "reserved interfaces" or backdoors included in transportation, information, and communication infrastructure.[173] Although not all Chinese-produced hardware poses a national security threat to U.S. infrastructure, it is clear the People's Liberation Army views sabotaging an adversary's supply chains as a warfighting tactic.

Mr. Kleinhans warned that semiconductors are particularly vulnerable to sabotage and other exploits during back-end APT production phases in which China claims substantial market share (see Appendix II: U.S.-China Supply Chain Competition in Semiconduc-

*On May 30, 2019, Rogelio Vasquez was sentenced in U.S. District Court to 46 months in prison and ordered to pay $144,000 in restitution after pleading guilty to one count of wire fraud, two counts of trafficking in counterfeit goods, and one count of trafficking in counterfeit military goods. The owner of PRB Logics Corporation, a California-based reseller or broker of electronic components, Vasquez acquired and resold to defense contractors "old, used and/or discarded integrated circuits from Chinese suppliers that had been repainted and remarked with counterfeit logos." He instructed his Chinese suppliers to re-mark the integrated circuits and ordered a testing laboratory in China to produce multiple versions of the integrated circuit test reports to obfuscate their "used, remarked and/or in poor condition." He admitted to trafficking over 9,000 integrated circuits with a total infringement value of $894,218 from 2009 to 2016 and agreed to forfeit over 169,000 counterfeit integrated circuits that were seized during the investigation. U.S. Department of Justice, U.S. Attorney's Office, Central District of California, *O.C. Businessman Sentenced to 46 Months in Prison for Selling Counterfeit Integrated Circuits with Military and Commercial Uses*, May 30, 2019.

tors for more).[174] The fact that 90 percent of the world's phones and nearly 80 percent of computers are manufactured in China makes exploitation of technology products a serious threat.[175] A 2019 report by the DOD Inspector General found that the department had not developed controls to prevent the purchase of commercial off-the-shelf (COTS) information technology (IT) products with known cybersecurity risks.[176] For example, the report determined that the U.S. Army and Air Force purchased more than $32 million COTS IT items, including Chinese-owned Lenovo computers, with known cybersecurity vulnerabilities.[177] DOD lists cyberespionage, network access, and Chinese government ownership, control, and influence in its threat assessment of Lenovo computers.[178] Persistent sourcing from Chinese suppliers, such as Lenovo, presents serious risks to U.S. defense supply chains.[179]

China Targets IP of Small Businesses Receiving DOD Innovation Funds

China's defense industrial base is using both licit and illicit means to acquire IP from U.S. companies funded by DOD and other departments to develop innovative products and technologies. China's defense industrial base comprises state-owned defense contractors, dual-use manufacturers, academic institutions, and quasi-private investment vehicles.* All of these players work in tandem to enable growth in China's defense industrial base through military-civil fusion programs and acquisition of foreign technologies through investments, technology transfers, IP theft, and industrial espionage, including through accessing programs supported by the U.S. government.[180]

In May 2022, news media reported on China targeting companies participating in DOD's Small Business Innovation Research (SBIR) program in order to gain access to valuable technologies with promising defense applications.[181] SBIR is a federally funded effort to accelerate the commercialization of innovative technologies and build domestic capacity for future defense-critical supply chains.[182] The SBIR program is vulnerable to China's goals of dominating next-generation supply chains and bolstering its defense industrial base because of the program's openness to foreign, possibly compromising, capital and the dearth of information on program participants.† As Jeff Stoff, founder of Redcliff Enterprises, explained in his testimony, DOD's SBIR program and other acquisition programs across DOD lack "standard, DOD-wide capabilities and resources to conduct adequate due diligence on funding recipients pre- and post-award of a contract to assess national security risks or monitor for compliance."[183] Without more robust due diligence in place,

*A report by C4ADS describes "quasi-private investment vehicles" as funds at least partially private that are designed "to promote indigenous innovation in fields related to critical technology." C4ADS, "Open Arms, Evaluating Global Exposure to China's Defense-Industrial Base," October 17, 2019.

†According to DOD, Chinese investors have also taken interest in U.S. space startups and are using similar investment methods to have controlling influence in this burgeoning sector. In September 2021, Colin Supko, then director of DOD's trusted capital program, spoke at the Space Sector Market Conference highlighting DOD's efforts to encourage venture capital firms to undergo vetting by the department in order to receive a "clean capital" approval. As an emerging frontier of opportunity receiving billions of dollars in public and private sector investment, the space sector is particularly attractive to Chinese investors. Sandra Erwin, "DoD Trying to Keep China from Accessing Critical U.S. Space Technology," *SpaceNews*, September 30, 2021.

DOD and other federal acquisition programs are exposed to targeted investments by Chinese state-backed entities. Consequences of this gap in verification have included:

- *Collaboration with China's defense industrial base and talent programs:* In one instance, a firm receiving more than $1 million in SBIR funding was founded by a participant in the CCP's Thousand Talents Program, providing a pathway for his research to be diverted to China's defense industrial base.[184] The company's founder also coauthored research papers with two of China's Seven Sons of National Defense universities as well as other State Administration for Science and Technology Industry for National Defense-run schools.*[185]
- *Forced IP transfer:* For example, a clean energy company that developed polymer solar cells using SBIR funding dissolved in 2020 after establishing subsidiaries in Beijing and transferring its R&D.[186] The Beijing-based subsidiary established a partnership with the CCP-backed Chinese Academy of Sciences Institute of Chemistry at a state-run lab where it continues its R&D for national defense.[187]
- *Foreign ownership, control, or influence (FOCI) concerns:*† Investments from China's state-directed venture capital (VC) firms may be problematic for SBIR recipients and other U.S. small businesses hoping to contract with DOD.[188] Under the direction of China's state entities, such VC firms may gain access to business plans and deal information and in turn influence the target company's investment decisions to China's benefit.[189]

U.S. Defense Procurement and Industry Trends Increase Reliance on China

Fewer Providers of Defense Systems Increases U.S. Vulnerability to Supply Chain Disruptions

Contraction in the U.S. defense industrial base has led to fewer providers of defense systems and materials, lowering capacity for outputs and reducing resilience to disruptions from and dependencies on China. The defense industrial base is struggling to attract new entrants and is experiencing an overall decline in vendors. A February 2022 report by DOD found that since the 1990s "the number of suppliers in major weapons system categories has de-

*These universities are referred to as the "Seven Sons of National Defense," which Mr. Stoff described in his testimony as a "training ground for future military leaders and technicians working on weapons systems and defense programs." Additionally, based on information from City University of Hong Kong (CUHK) and Zhejiang University, where the firm's founder also held positions, he has been involved in more than $90 million in federal research funding from DOD's Office of Naval Research (ONR), the Army Research Office (ARO), the Air Force Office of Scientific Research (AFOSR), and the Defense Advanced Research Projects Agency (DARPA). City University of Hong Kong, "Professor Alex Jen 任廣禹;" Jeff Stoff, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on U.S.-China Competition in Global Supply Chains*, June 9, 2022, 5.

†The U.S. Defense Counterintelligence and Security Agency (DCSA) explains that while foreign investment plays a vital role in the U.S. industrial base, such investment should be consistent with national security interests. A company is considered to be operating under FOCI "whenever a foreign interest has the power, direct or indirect, whether or not exercised, and whether or not exercisable, to direct or decide matters affecting the management or operations of that company in a manner which may result in unauthorized access to classified information or may adversely affect the performance of classified contracts." Defense Counterintelligence and Security Agency, *Foreign Ownership, Control or Influence (FOCI)*, July 26, 2022.

clined substantially: tactical missile suppliers have declined from 13 to 3, fixed-wing aircraft suppliers declined from 8 to 3, and satellite suppliers have halved from 8 to 4."[190] This consolidation began following the Cold War as DOD's defense budget decreased and the defense industry pursued mergers and acquisitions in order to survive the change in demand and account for substantial excess capacity.[191] For instance, in 2020 there were about 55,000 vendors compared to 69,000 in 2016.[192] Mr. Brown noted in his testimony before the Commission that "the number of small businesses in the U.S. defense industrial base shrank by more than 40 percent over the past decade."[193] He also reiterated DOD's warnings that if this trend continues, the United States could lose another 15,000 suppliers in the next ten years.[194]

DOD has identified "promoting competition" as one of its top priorities for safeguarding national security and has laid out several recommendations for increasing defense industrial base competition.[195] These include strengthening merger oversight, addressing IP limitation, increasing new entrants to the market, increasing opportunities for small businesses, and implementing sector-specific supply chain resiliency plans.[196] The use of sole-source contracts due to a lack of competition presents risks should the supplier confront any disruptions to its production.* In addition to these challenges, an approach that has emphasized a cost and efficiency policy has influenced the shift in supply chains.

Consistent DOD Funding and Demand Needed to Stabilize U.S. Defense Industrial Base

The unpredictability of U.S. defense budgets creates uncertainty for manufacturers and has contributed to reliance on foreign suppliers.† While large defense contractors, or primes, may be able to absorb some of the costs associated with varying degrees of revenue, small to medium-sized manufacturers are typically strapped for capital and struggle to sustain production amid fluctuating demand and long lead times.‡[197] For example, the lack of consistent U.S. government purchases has strained the U.S. castings and forgings industry, which primarily consists of small businesses, and contributed to that industry's contraction and outsourcing of production

*For example, DOD procurement offices increasingly rely on sole-source contracts that are noncompetitive procurements and allow a single supplier to avoid full and open competition. Assistant Secretary of Defense Deborah Rosenblum noted in her testimony to the Commission that "U.S. reliance on sole-source suppliers and foreign sources poses risks to domestic capability and capacity to produce the products we require." Assistant U.S. Secretary of Defense Deborah Rosenblum, written testimony before the U.S.-China Economic and Security Review Commission, *Hearing on U.S.-China Competition in Global Supply Chains*, June 9, 2022, 2.

†Delayed appropriations disrupt U.S. defense budgets and may unintentionally stall mission-critical programs and procurements. Defense officials testified before Congress that continuing resolutions (CRs) prevent DOD from starting new contracts or programs and negatively affect military readiness. A CR, if only short term, freezes purchasing power and funding for already scheduled DOD procurements. Jim Garamone, "DOD Officials Say Service Members, Families Pay Price of Continuing Resolutions," *U.S. Department of Defense*, January 12, 2022.

‡DOD's procurement and acquisition lead times also limit its ability to meet U.S. defense needs. Procurement Administrative Lead Times (PALT) are currently very long and believed to be increasing. The 2018 National Defense Authorization Act defined PALT as "the amount of time from the date on which a solicitation for a contract or task order is issued to the date of an initial award of the contract or task order." According to a Bloomberg Government study, the average lead time has increased by 72 percent since 2016. David Berteau Witness Testimony before the Senate Armed Services Committee, Health of the Defense Industrial Base, April 26, 2022. U.S. Department of Defense, Procurement Toolbox; Adrian Dannhauser, "PALT in OFPPS's Crosshairs," *Federal News Network*, September 30, 2021.

to China.[198] The remaining foundries still face unknowns in their business planning for U.S. government customers, complicating equipment upgrades, retention of talent and expertise, and other innovations necessary to stay competitive.*[199] Assistant U.S. Secretary of Defense Deborah Rosenblum testified that the U.S. government's volatile procurement practices create "high startup costs and limited profits for U.S. businesses" that make castings and forgings and other industries more susceptible to China's trade practices and subsidized prices.[200]

U.S. government and domestic commercial demand are insufficient to grow domestic heavy industries and incentivize production of bespoke systems like legacy microelectronics. In castings and forgings, for example, China now produces more tonnage of cast products "than the next seven highest producing countries, and over four times as much as the United States"[201] Assistant Secretary of Defense Rosenblum warned that DOD "counts on China for very large cast and forged products used in the production of some defense systems and many machine tools and manufacturing systems on which DOD is reliant."[202] For microelectronics, DOD relies on legacy chips, and as a report by the Center for Strategic and International Studies argues, "the volume of U.S. defense chip needs is a tiny fraction of the demand generated by the commercial market, making the small-batch supply of chips for the military unattractive for many commercial producers."†[203]

DOD's continued emphasis on COTS products has also contributed to the U.S. defense industrial base's dependencies on China for critical products and components. Following a cost-cutting directive by then Secretary of Defense William Perry in 1994, DOD began shifting toward a policy approach that prioritized commercial products over military specification (MIL-SPEC) designed items procured from defense contractors.[204] Throughout the 1990s, the federal government implemented the Federal Acquisition Streamlining Act (FASA), which provided a broader definition of commercial products, allowing for lower lead times through the purchase of COTS items at a lower cost. As DOD notes in a 2022 report, FASA "included a preference for Commercial off the Shelf (COTS) items instead of the time-consuming and expensive process of creating government-unique items."[205] Over the last 30 years, DOD has increasingly used commercial items, including electronics, largely manufactured in China. DOD reporting explains that "since 2011, commercial items have consis-

*Additionally, tariffs on raw materials have increased costs on U.S. cast and forged parts, driving suppliers out of business as they try to compete with cheaper, government-subsidized parts made in China. U.S. Department of Defense, *Securing Defense-Critical Supply Chains*, June 9, 2022, 27.

†Since the mid-1990s, DOD's Trusted Foundry or Trusted Supplier program has supported resiliency in manufacturing infrastructure utilized by DOD by securely procuring microelectronics from trusted suppliers. Defense Microelectronics Activity manages the Trusted Foundry program and provides accreditation for suppliers of IC-related products and services for military use. However, in recent years, DOD has moved away from the trusted foundry approach to a zero-trust approach for microelectronic procurement that assumes all products are unsafe for use until proven otherwise. DOD has also established other measures to combat the flow of counterfeits into defense-critical supply chains, including the Supply Chain Hardware Integrity for Electronics Defense (SHIELD) program that works to address the issue of counterfeit microchips in military technology. DOD has also trialed other ways to identify legitimate parts in the supply chain and distinguish them from counterfeits through forensically labeling electronics using plant DNA. Defense Microelectronics Activity, *Trusted Access Program Office*, 2022; Kyle Mizokami, "The Pentagon Uses Plant DNA to Catch Counterfeit Parts," *Popular Mechanics*, November 21, 2016.

tently accounted for over 88% of new awards (and as high as 98% of new awards) across DoD."[206] As DOD has continued to emphasize a COTS procurement policy, it has created clear demand signals for commercial items, like electronics, with supply chains that rely heavily on Chinese products that were the subject of manufacturing consolidation in China. Simultaneously, Chinese industrialization promoted "high volume, low cost, export-oriented production" that catered well to U.S. procurement interests.[207] Ms. Bisceglie noted that now "over 95 percent of all electronics components and IT systems supporting U.S. federal IT networks are commercial off-the-shelf (COTS) products, and China's role in this global supply network is significant."[208] An overreliance on COTS equipment may compromise the operational integrity of U.S. armed forces should the commercial alternatives to MIL-SPEC items remain reliant on Chinese manufacturers.

Inconsistency in federal buying also disincentivizes industry to stockpile or provide materials or manufacturing capacity to meet surges in demand. The Defense Production Act (DPA) helps prioritize the resupply of critical defense goods, but it does not account for the speed at which industry can react to new DPA issuances.*[209] Industry does have a history of responding quickly in wartime, namely during World War II, to expedite the production of defense goods, but the manufacturing ecosystem and available weapons stockpile in the United States looks much different today than in the 1940s or throughout the 1950s at the start of the Cold War (see Figure 2 showing the value of U.S. stockpiles peaking in 1952 but since declining).[210] Private defense firms, and the sub-tier suppliers they rely on, largely operate on a "just-in-time" supply chain model to minimize costs and maximize profits, but this model is highly vulnerable to disruptions, lacking a sufficient safety net or stockpile in place to handle surge capacity.†[211] Consequently, many U.S. businesses do not have excess supplies, and without stockpiles they are susceptible to disruptions in their supply chain and unable to surge capacity.[212] Today's defense industry relies on a limited number of Tier I firms that source from a limited number of subcontractors.‡[213] With the closing of many manufacturing facilities, the remaining infrastructure and skilled workforce are limited and may be unable to ramp up production to meet surges in demand.

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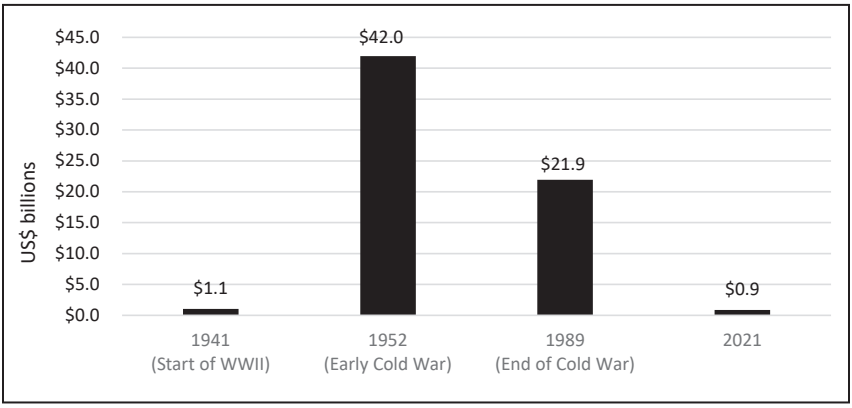
*The DPA has been increasingly used in the last several years to address supply chain vulnerabilities through allocating funds to increase production and supply chain resilience in key areas. The DPA was first enacted at the beginning of the Korean War to mobilize military readiness efforts and ensure critical resources were available for use. Since then, its scope has expanded beyond military readiness to include broad domestic capabilities for national emergencies. Anshu Siripurapu, "What Is the Defense Production Act," *Council on Foreign Relations*, December 22, 2021.

†In a "just-in-time" supply chain model, a product is assembled only after it is ordered. Robert Victor, "How Just-in-Time Delivery Affects Supply Chain Management," *Hollingsworth*, August 27, 2018.

‡A supply chain consists of multiple suppliers or "tiers and sub-tiers" that provide the materials to build the product. For example, a tier three supplier sells its product to a tier two supplier that sells its product to the tier one supplier, or "prime," which often assembles the final product for the buyer.

Figure 2: Inflation-Adjusted Value of U.S. Stockpile Inventory since 1941



Source: Maiya Clark, "Revitalizing the National Defense Stockpile for an Era of Great-Power Competition," *Heritage Foundation*, January 4, 2022.

The war in Ukraine has highlighted the capacity and military readiness challenges resulting from unpredictable DOD procurement practices. As of May, the United States has sent about one-third of its stockpiles of Javelin and one-fourth of its Stinger missiles to Ukraine.[214] Just two U.S. companies produce these weapons, and DOD has not bought any new Stingers in almost 20 years.[215] The defense prime responsible for building the shoulder-fired Stinger missiles said the company is unable to accelerate production of more missiles until 2023 due to parts shortages.[216] In May 2022, DOD issued $309 million in contracts for a new JV with two primes to backfill U.S. stocks affected by the Ukrainian aid.[217] While stockpiles will recover over time, operational readiness will be affected in the near term. DOD has recommended that industry move away from "just-in-time" delivery practices, especially for critical parts or components sourced from foreign suppliers, like China.[218] While not all capacity and surge issues are directly linked to Chinese suppliers, the broader challenge of weak U.S. production capacity creates strategic problems that may compromise U.S. deterrence capabilities should weapons, munitions stockpiles, and other needed supplies continue to be depleted, and could threaten the U.S. ability to wage a protracted conflict.

Strategies and Approaches to Address China's Challenges to U.S. Supply Chains

Like-minded nations are increasingly seeking to restructure supply chains in a manner conducive to building economic security, an umbrella concept that broadly aims to "promote economic growth and competitiveness, protect national security, and shape the international economic environment."[219] A core goal of U.S. economic security is working with allies and partners to mitigate shared vulnerabilities to China, which can be accomplished by ensuring supply chains are increasingly located in nations that commit to high standards, demonstrate reliability and transparency, and adhere to a set of shared values. Increasing coordination between the United States

and its allies and partners poses the possibility that national security, supply chain resilience, and technological competitiveness can be pursued all at once as part of a broad economic security approach with both unilateral and multilateral elements. Toward these ends, as global supply chain realignment efforts intensify, there are several strategies that may be pursued, including reshoring, nearshoring, and friendshoring. This section assesses the costs and benefits of each strategy and notes ongoing initiatives related to each.

Supply Chain Realignment Strategies

Reshoring

The strategy of reshoring involves inducing key nodes in supply chains to relocate back to the United States. Reshoring is tantamount to a strategy to restore U.S. industrial prowess and manufacturing competitiveness while reducing the U.S. economy's reliance on foreign manufacturers. Reshoring entire production lines limits geopolitical vulnerabilities by removing international links in a supply chain that may be exposed to a disruption during a crisis event or conflict. By bringing critical manufacturing capabilities onshore, manufacturers can further reduce transportation costs and the risk of IP theft through illicit technology transfers. In testimony before the Commission, Harry Moser, president of the Reshoring Initiative, estimated that reshoring by U.S. companies and direct investment in U.S.-based operations by foreign companies created 260,000 jobs in 2021, increasing from 6,000 in 2010.[220]

Compared to nearshoring and friendshoring, reshoring would require intensive government policies to incentivize companies to return to the United States, where manufacturers face higher operating costs. Although the cost gap of producing in China compared to domestically in the United States has declined due to rising Chinese labor cost in many sectors, the average Chinese factory price remains 30 percent lower than the U.S. factory price.[221] Mr. Moser suggests that policies to promote reshoring include subsidies, support for workforce skills training, tariffs, and a coordinated industrial strategy.[222] U.S. businesses can also be encouraged to factor in the lifecycle costs of offshoring, which can be facilitated through information sharing and reporting on risks facing U.S. businesses operating in countries of concern. Such information could enable businesses to better assess the costs and risks of operating in a foreign market, such as variable product quality, freight costs, natural disasters, and political instability.[223] For example, the Commerce Department provides a toolbox of public and private resources to assist businesses in calculating the costs of locating production overseas versus reshoring to the United States.*[224]

The U.S. government reshoring efforts have focused on supply chains for critical materials and technologies. The Biden Administra-

*The Access Costs Everywhere webpage published by the Commerce Department collects reports on risks for U.S. businesses to consider when offshoring production and provides links to other government and private sector resources and tools. For example, Access Costs Everywhere directs companies to estimate the Total Cost of Ownership (TCO) of offshoring, which aggregates all cost and risk factors associated with basing operations in a foreign country. Mr. Moser explained that industries or products where the TCO is lower in the United States are ripe for reshoring. Harry Moser, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on U.S.-China Competition in Global Supply Chains*, June 9, 2022, 6; U.S. Department of Commerce, *Access Costs Everywhere*.

tion views government intervention to guide the location of supply chains and industrial bases as necessary to address threats to U.S. economic resilience and national security, a goal that was advanced by legislation in 2022.[225] The Creating Helpful Incentives to Produce Semiconductors (CHIPS) Act of 2022 appropriates $52.7 billion over five years to support domestic semiconductor manufacturing. The funds will be used to finance domestic construction, expansion, or modernization of semiconductor facilities; support workforce development; and subsidize operating costs of these facilities.[226] The act prohibits recipients of the funds, over a ten-year period, from expanding or building new advanced semiconductor manufacturing facilities in China or any other foreign country of concern.*[227] The Inflation Reduction Act of 2022 creates production tax credits worth $30 billion over the next ten years to support U.S.-based clean technology manufacturing of electric vehicle batteries, wind turbines, solar panels, and critical minerals.[228] To be eligible for the credit, the bill requires that a majority of the components are sourced from the United States.† Critical minerals are also eligible for the credit if they are sourced from any country with which the United States has a free trade agreement. The bill provides over $60 billion in total support for reshoring clean energy manufacturing, including investment tax credits and loans for new manufacturing facilities. Such measures could be used to build domestic industrial capacity and address other supply chain vulnerabilities facing the U.S. economy.

The United States currently lacks the capacity to replicate China's expansive industrial ecosystem, and this may make it prohibitively costly for certain businesses, absent perpetual government support, to move back to the United States. The United States has fallen substantially behind China in terms of production capacity.[229] Some key sectors may not be able to immediately replicate supplier networks domestically, particularly with respect to supplies of raw materials. Boston Consulting Group finds that the United States lacks self-sufficiency in 18 critical inputs used in high-technology manufacturing, and many U.S. producers are reliant on suppliers in China.[230] In many U.S. industries, the domestic talent base has shrunk or nearly disappeared as production moved overseas and demand for certain skillsets disappeared. Since the decline in the U.S. industrial base helped create these gaps in the U.S. manufacturing ecosystem, moving more manufacturing back into the United States may stimulate demand for these factors and encourage the creation of a more optimal business environment for manufacturing. Other factors, such as proximity to key suppliers and markets in Asia, cannot similarly be overcome and may create long-term cost disadvantages when reshoring. Additionally, U.S. policies to promote domestic manufacturing, such as procurement policies for non-defense

*This prohibition does not extend to expansion of legacy semiconductor production capacity in China, however, so long as it "predominately serves the market of a foreign country of concern." For the purposes of the legislation, legacy semiconductors are defined as 28 nanometers for logic chips, with legacy memory technology, analog technology, packaging technology, and any other relevant technology to be determined by the Secretary of Commerce, in consultation with the Secretary of Defense and the Director of National Intelligence. Supreme Court Security Funding Act of 2022 § 103, Pub. L. No. 117–167, 2022.

†The domestic content requirements will phase in over time and vary by final product. For example, for an electric vehicle to be eligible for the tax credit, 50 percent of the components in the battery need to be produced in the United States for vehicles placed in service in 2024. This ratio rises to 90 percent by 2028. Inflation Reduction Act of 2022, H.R. 5376, August 15, 2022.

goods, may encourage other economies to impose similar measures, which could limit the export opportunities for U.S. businesses.[231] As some have argued, reshoring, by reducing the United States' interdependence with other countries and making the U.S. economy more insular, may weaken the United States' ability to conduct economic statecraft and may create new geopolitical vulnerabilities.[232]

Nearshoring

Nearshoring refers to the relocation of production and manufacturing capacity to a country neighboring or near the United States.[233] In reducing geographic distances between producers and end consumers, nearshoring serves as an intermediate strategy between moving back entire production lines (reshoring) versus keeping them in China.[234] For the United States, Canada and Latin American and Caribbean countries serve as principal nearshoring locations. According to a 2021 survey of U.S. business executives by consultancy AT Kearney, 70 percent of CEOs have already planned, are considering, or will be nearshoring part of their manufacturing operations to Mexico, with top five drivers being labor cost differentials, labor availability, quality, delivery lead time, and logistics costs.[235] Executives also report they would more closely consider near- and/or reshoring if they saw their competitors make similar choices.*[236] Such shifts may also be attributable to concurrent global economic developments. Peter Anderson, vice president of global supply chain at logistics firm Cummins Inc., observed that a growing number of multinational enterprises are likely to consider regionalizing production around key markets† against the backdrop of U.S.-Mexico-Canada Agreement renegotiations in 2017 and escalations in U.S.-China trade frictions since 2018.[237]

Scholars observe that nearshoring offers lower labor and production costs than reshoring, lower transportation costs than offshoring, and quicker responses to market changes and consumer preferences.[238] Goods produced in the near-abroad may also utilize a higher proportion of U.S. inputs, indirectly boosting U.S. domestic manufacturing output. These goods would also be less geopolitically exposed than in East Asia, where China could interdict or exert control over supply chains. Business executives point to nearshoring as an effective strategy to boost their supplier base and bolster resilience.[239]

Encouraging nearshoring may nevertheless exacerbate offshoring and undercut domestic industrial capacity. Some nearshoring strategies taken by companies still entail manufacturing in Asia, with only final assembly moved closer to consumers.[240] In the wake of U.S.-China trade frictions and the COVID-19 pandemic, U.S. and other multinational firms have relocated only discrete portions of

*U.S. firms appear to be unique in expressing this more favorable attitude toward nearshoring. A separate World Bank survey of multinational enterprises in 2020 found 37 percent and 18 percent of companies were diversifying their sourcing and production bases, respectively, in response to the COVID-19 pandemic. Only a small share (14 percent) planned to nearshore or reshore. Christine Zhenwei Qiang, Yan Liu, and Victor Steebergen, "Global Value Chains in the Time of COVID-19 (Coronavirus)," in *An Investment Perspective on Global Value Chains*, World Bank, 2021, 206.

†A July 2019 special report in the *Economist* explored some of these trends. In the automotive sector, for example, production has become more regionalized around Mexico to serve North American consumers, eastern Europe and Morocco to serve European consumers, and Southeast Asia and China for Asian consumers. *Economist*, "Supply Chains for Different Industries Are Fragmenting in Different Ways," July 11, 2019.

production out of China and toward other emerging markets in the Indo-Pacific as part of a "China + 1" strategy, not geographically closer to the United States.[241] According to research from Bank of America, the cost to U.S. and European companies of moving manufacturing out of China could reach $1 trillion over the next five years, a hefty expense as the pandemic strains corporate finances and crimps investment.[242] Aside from cost, U.S. firms face other challenges in nearshoring production from China, including transportation, logistics, and supply arrangements.

Friendshoring

Friendshoring is a supply chain realignment strategy that would strive to induce supply chains to relocate into economies of treaty allies or trusted partner countries; it is sometimes defined more broadly as to include all free trade agreement countries. This strategy would take as its aim removing to the greatest practical extent adversarial countries from critical supply chains. It is inclusive of, though broader than, nearshoring. According to Elain Dezinski, senior director and head of the Center on Economic and Financial Power at the Foundation for Defense of Democracies, and John Austin, nonresident senior fellow at the Brookings Institution, friendshoring "means leaning into economic partnerships with those who share our values and strategic interests. It means rebuilding our economy with nearby friends with whom we already have tightly wound production and business service networks."[243] In effect, a friendshoring strategy would approximate a return to U.S. international economic policy in the decades following World War II—with the Marshall Plan being the most prominent example—by favoring the development of production and supply networks in and through allied and partner nations.

Current Friendshoring Initiatives

The economic and national security logic undergirding a friendshoring strategy has already seeded a proliferation of initiatives and partnerships. In 2022, the G7 met and agreed to release "unprecedented language acknowledging the harms caused by the People's Republic of China's (PRC) non-transparent, market-distorting industrial directives" and elevate the importance of supply chain resilience.[244] G7 leaders agreed to "make a commitment to intensify development of responsible, sustainable, and transparent critical minerals supply chains and establish a forward strategy that takes into account processing, refining and recycling."[245] In October 2021, the United States led a Summit on Global Supply Chain Resilience with the EU and 14 like-minded countries* to "chart a course to strengthen and diversify the entire supply chain ecosystem over the long term."[246] In late 2021, countries in the Quadrilateral Security Dialogue agreed to improve supply chains for critical technologies as well as rare earths, with Australia, Japan, and India planning to cooperate jointly on mining and processing of minerals.[247]

*The summit included "leaders and representatives from Australia, Canada, Democratic Republic of the Congo, the European Union, Germany, India, Indonesia, Japan, Mexico, Italy, Republic of Korea, Netherlands, Singapore, Spain, and the United Kingdom." White House, *FACT SHEET: Summit on Global Supply Chain Resilience to Address Near-Term Bottlenecks and Tackle Long-Term Challenges*, October 31, 2021.

Japan is further leading in supply chain initiatives that dovetail with a friendshoring strategy. Domestically, Japan established a first-ever ministerial post for economic security, and in May 2022 it passed a new Economic Security Law designed to bolster supply chains and protect technology in the face of increasing concerns about China.*[248] The United States and Japan are undertaking initiatives in this vein as well. In a July 2022 meeting between U.S. policymakers and Japanese businesses, the two sides specifically discussed "bolstering supply chain resiliency and expanding friendshoring."[249] In April 2021, the United States and Japan announced a Competitiveness and Resilience Partnership, which would "revitalize [their] Alliance" through pledges to work jointly on competitiveness and innovation, develop ICT systems, and cooperate "on sensitive supply chains, including semi-conductors, and on the promotion and protection of critical technologies."[250] This resulted in the Japan-U.S. Commercial and Industrial Partnership, which had its first meeting between U.S. Commerce Secretary Gina Raimando and Japanese Minister of Economy, Trade, and Industry Hagiuda Koichi in May 2022. That meeting included "Joint development of Basic Principles on Semiconductor Cooperation, which identify a shared vision, objective, and strategy for strengthening the resiliency of semiconductor supply chains."[251] The U.S.-Japan Economic Policy Consultative Committee is another forum the countries are using to facilitate "closer collaboration on supply chain resilience."[252]

The United States is also working with Taiwan and the EU on similar initiatives that are intended to secure critical supply chain threats from China. In December 2021, the United States and Taiwan launched the Technology Trade and Investment Collaboration framework to strengthen critical technology supply chains, particularly with respect to semiconductors.[253] Meanwhile, in June 2021 the United States and the EU announced the U.S.-EU Trade and Technology Council (TTC) as a forum to push forward a number of priorities, prominently including supply chain cooperation.[254] Following the second meeting of the TTC in May 2022, the two sides released a joint statement resolving "to collaborate to reduce dependencies on unreliable sources of strategic supply, promote reliable sources in our supply chain cooperation, and engage with trusted partners" while recognizing "shared vulnerabilities to critical supply chains for semiconductors, critical minerals, clean energy, and pharmaceuticals."[255]

Advantages and Disadvantages of Friendshoring

Although initiatives and partnerships akin to friendshoring are already underway, analysts and stakeholders disagree on the potential merits and limits of friendshoring. Those promoting the merits of friendshoring argue it can bolster U.S. and allied economic security, reduce supply chain dependencies on China, limit China's ability to exploit technology supply chains, and blunt China's ability to weaponize and extend its economic heft. As a realignment strategy,

*In 2020, Japan earmarked $2.2 billion of its COVID-19-related economic stimulus package to subsidize Japanese companies to shift production out of China, with the majority allocated to reshoring to Japan and the remaining allocated for moving to other countries. Isabel Reynolds and Emi Urabe, "Japan to Fund Firms to Shift Production Out of China," *Bloomberg*, April 8, 2020.

multilateral cooperation could also mitigate costs while increasing sourcing options relative to reshoring and nearshoring. Further, a friendshoring strategy could conceivably bolster a shared innovation base, as the Center for a New American Security has recommended, preserving to the largest extent possible the benefits of globalization and hastening the rate of technological advancement among liberal market democracies and trusted partners relative to China.[256] Friendshoring could thus bolster cohesion among countries that share values and adhere to high standards and could conceivably be part of a broader economic adjustment in response to China's malign practices (for more on U.S. and multilateral efforts in this vein, see Chapter 2, Section 2, "Challenging China's Trade Practices").

Those skeptical of friendshoring note several potential downsides of the strategy. Some, such as former governor of the Reserve Bank of India Raghuram Rajan, see friendshoring as "abandoning free and fair trade" and thus functioning as a potential drag on global growth that will contribute to economic balkanization.[257] Meanwhile, those that prefer reshoring assess that friendshoring may not deliver equivalent restorative benefits to the U.S. manufacturing base.[258] As a result, far-flung supply chain structures will persist. This could be particularly concerning in the case of industries, such as semiconductors, concentrated in U.S. allies and partners in East Asia that remain dangerously exposed to geopolitical interference from China.

Implications for the United States

The United States currently has significant dependence on China for certain supplies, like APIs, rare earth elements, and electronics, among other things that are vital for U.S. economic and national security. While China continues utilizing its supply chain leverage to yield favorable economic outcomes, it continues to build additional leverage for influencing economic constituencies and effecting policies in the United States. Although the United States maintains a measure of leverage over China as a result of its economic dependencies on the Unites States, increasing critical supply chain dependencies further weakens U.S. deterrence capabilities. Beijing's ability to weaponize U.S. supply chains dependencies not only threatens U.S. defense capabilities but may also undermine the will of the American people to support U.S. policy decisions in peacetime, or more concerningly, in wartime.

The CCP is bolstering its supply chain advantages and at the same time seeking to mitigate its longstanding concerns over technological dependences and vulnerabilities. These dual efforts, encapsulated in Beijing's dual circulation strategy, aim to make China more self-reliant while at the same time rendering others more dependent on China. The CCP's confidence in its ambitions, combined with concerns about its own vulnerabilities, is leading to a more pronounced push to acquire or augment advantageous positions across the stages of key global supply chains. This strategy poses a set of interlocking challenges to U.S. economic security, health security, national security, and the broader liberal trade order.

The CCP's supply chain objectives and its willingness to coerce other countries with economic means necessitate action by the U.S.

government to increase resilience in critical supply chains. DOD and its contractors lack a comprehensive framework, sufficient supply chain data, and due diligence processes to mitigate threats of supply chain disruptions or compromise by Chinese suppliers. DOD spending and procurement practices exacerbate these problems as the defense industrial base continues to consolidate the number of suppliers and disincentivize resilience measures like maintaining excess capacity and strategic stockpiles. The delays DOD faces in replenishing weapons sent to Ukraine is a warning of how these challenges can hinder military readiness and the defense industrial base's ability to surge production capacity.

While the advantages and obstacles to supply chain security strategies like reshoring, nearshoring, and friendshoring are under discussion, there is a common goal among the United States and like-minded partners to mitigate shared vulnerabilities to China. In addition to greater supply chain transparency, any supply chain restructuring initiative will also require demand-side draw and more consistent demand. As Mr. Kleinhans wrote in his testimony, if supply chain restructuring efforts are "mainly based on governments 'pushing' in contrast to end-customer industries 'pulling,' the efforts are destined to fail in the long term."[259] Restructuring global supply chains will not occur overnight but rather will require a long-term strategy for returning high-value chains to trusted suppliers.

Appendix I: U.S.-China Supply Chain Competition in Semiconductors

This section provides a case study of U.S. semiconductor supply chains, analyzing the threat China poses and potential mitigation opportunities. This discussion is intended to demonstrate how the strategies identified above can tangibly inform supply chain realignment endeavors.

Semiconductors

Overview

Semiconductors, also called integrated circuits (ICs) or chips, undertake the information processing and data storage that enables modern cars, planes, and all consumer electronics (e.g., phones and laptops) to function. Semiconductors are arguably the most foundational aspect of the modern information technology ecosystem. They are thus of critical importance to the U.S. economy, to consumers, and to the U.S. innovation base. Total sales of semiconductors ballooned during the COVID-19 pandemic to facilitate the transition to the virtual world, shooting up from $412 billion in 2019 to $556 billion in 2021.[260]

As an industry, semiconductor production is distinctive in the high level of investment in both research and development and capital expenditure.[261] Semiconductors come in many types, but this section will touch on the two most prominent: logic and memory.* Logic and memory chips account for the lion's share of sales, at an estimated $155 billion and $154 billion in 2021, respectively.[262] Logic chips are responsible for undertaking the calculations necessary to power the applications on an individual's laptop, phone, car, and other electronics. When people speak of cutting-edge chips of 3–7 nanometers (which refers to the width of an etched transistor on a silicon wafer), they are talking about logic chips. Producing high-end logic chips is among the most complex and technologically advanced undertakings in the world. Memory chips, as the name suggests, are the devices that store the world's digital data, both in edge devices (i.e., phones and laptops) as well in the data centers that comprise "the cloud."

The semiconductor value chain is normally broken into three broad steps: design, manufacturing, and final assembly, packaging, and testing (APT). There are, furthermore, two main business models in the semiconductor industry for undertaking these production steps: the integrated device manufacturer (IDM) model and the "fabless-foundry model." The IDM model entails vertical integration across design, manufacturing, and APT. It is less prominent in advanced logic chip production (with Intel being a major exception) and more common among makers of memory chips. The "fabless-foundry model," meanwhile, entails specialization between "fabless" design companies working with pure-play manufacturing companies called "foundries" and is most common in the more complex production process for leading-edge (3–7 nanometer) logic chips.† The complex-

*Optoelectronics, sensors, and discrete (OSD) semiconductors also play an important role.

†A "fab" refers to a fabrication facility and is inclusive of all types of manufacturing facilities, including foundries. A foundry, however, specifically refers to a type of fab that manufactures chips designed by other companies. TSMC is the quintessential example of a foundry business.

ity and deep technical expertise required to produce semiconductors, coupled with the rise of globalization, has accentuated the importance of the fabless-foundry model and given rise to the even more general phenomenon of "massive modularity,"* or a highly fragmented production process. The modularity in semiconductor production, in turn, has facilitated geographical specialization, with East Asia broadly concentrating in manufacturing and APT and the United States concentrating in design.[263]

Exposure to China

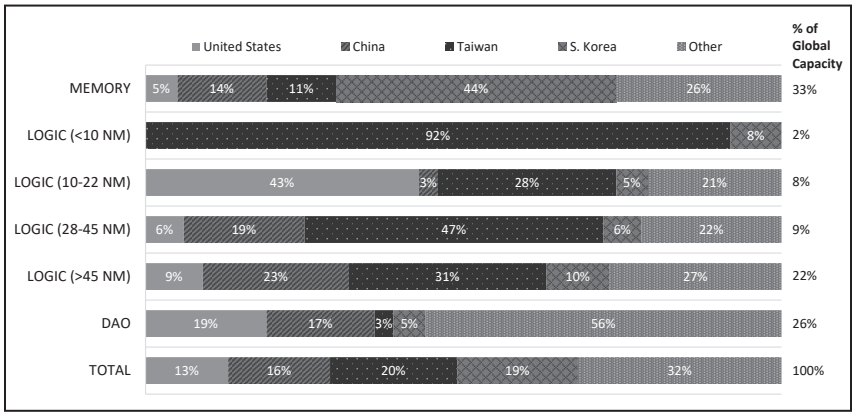
There are four critical areas of exposure to China with regard to semiconductors that require consideration. First, extensive U.S. reliance on East Asia for semiconductor manufacturing exposes the United States to potentially grave geopolitical and military risk from China (see Figure 3). The United States also has capacity gaps in other key material inputs that are concentrated in East Asia, most notably silicon wafer production capacity, for which the United States has hardly any capacity.† [264] A variety of other specific and highly refined solvents, gases, wet chemicals, and substrates for which the United States currently lacks domestic supply are produced overseas, many in East Asia.[265] Second, lack of visibility is a key vulnerability in the semiconductor supply chain, particularly for materials like gases and solvents. Third, the United States faces exposure to backdoor vulnerabilities from integrated circuits that undergo final assembly, packaging, and testing in China.[266] Fourth, the U.S. semiconductor industry's relationship to China's semiconductor ecosystem may pose a risk, as exports of semiconductor manufacturing equipment to China and U.S. licensing of chip designs to Chinese firms may undermine the United States' ability to ensure that China's advances lag behind its own (for more on recent U.S. export controls targeting China's semiconductor ecosystem, see Chapter 2, Section 2, "Challenging China's Trade Practices").[267]

U.S.-headquarted Global Foundries, owned by the United Arab Emirates sovereign wealth fund Mubadala Investment Company, is another. Intel, which had previously built fabs solely as an IDM, is now moving into the foundry business as well. Cheng Ting-Fang and Lauly Li, "Intel to Make Chips for MediaTek in Win for Its Foundry Strategy," *Nikkei Asia*, July 25, 2022.

*Massive modularity in production entails a suite of common traits in a value chain: (i) facets of production are fragmented but interconnected with each other according to standard interfaces; (ii) innovation can take place independently in each module, as long as the interface standard is adhered to and continually updated; and (iii) they can be broken down into smaller, more specialized modules, each with its own evolving standards, replicating the modular pattern at progressively deeper levels. Eric Thun et al., "Why Policy Makers Should Pay Attention to the Concept of Massive Modularity: The Example of the Mobile Telecom Industry," *World Bank Blogs*, June 18, 2021.

†GlobalWafers, a Taiwan-based design and manufacturing company, announced plans in 2022 to build a $5 billion silicon wafer fabrication facility in the United States, the first of its kind to be built in the United States in more than two decades. Production is anticipated to begin in 2025. Akayla Gardner and Debby Wu, "Taiwan's GlobalWafers to Build $5 Billion Chip Plant in Texas," *Bloomberg*, June 27, 2022.

Figure 3: Global Distribution of Semiconductor Manufacturing Capacity by Region, 2019



Source: Antonio Varas et al., "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," *Boston Consulting Group and Semiconductor Industry Association*, April 2021.

China, despite decades of attempted catchup and hundreds of billions of dollars in subsidies, is still weakly positioned across most aspects of the semicondcutor supply chain.[268] Yet there are indicators of forward progress. Based on average over the four quarters ending in March 2022, 19 of the world's 20 fastest-growing chip industry firms came from China, according to Bloomberg data, compared with just 8 at the same point in 2021.[269] China's largest state-subsidized memory chip maker, Yangtze Memory Technology Corporation (YMTC), is now reportedly selling the world's densest NAND memory chips, acquiring roughly 5 percent of global market share, with Apple reportedly planning to use YMTC's chips.*[270] Most recently, China's largest state-subsidized foundry, Semiconductor Manufacturing International Corporation (SMIC), has reportedly begun producing integrated circuits with 7-nanometer process nodes.[271] While critical questions remain on their ability to effectively scale production,† even if China does not come to lead in cutting-edge chip production, it may still acquire a strong position in legacy chips used in applications such as automotive navigation systems, leading to new sources of vulnerability and market manipulation.

*An interim final rule issued on October 7 by the Commerce's Bureau of Industry and Security adds licensing requirements, under a presumption of denial, that will likely restrict U.S. semicondcutor manufacturing equipment makers from selling certain advanced equipment to YMTC. U.S. Department of Commerce Bureau of Industry and Security, "Implementation of Additional Export Controls: Certain Advanced Computing Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification," *Federal Register* 87:62186 (October 13, 2022).

†The most important metric in question is yield, or the proportion of dies (the individual integrated circuits on a wafer) that are functional. Producing several thousand chips at a 7-nanometer node process would be noteworthy, but it is also qualitatively distinct from mass producing millions of chips at the node process. Given SMIC's lack of access to ASML's extreme ultraviolet lithography (EUV) technology, SMIC has likely had to rely on less-advanced deep ultraviolet lithography (DUV) immersion equipment. Experts are skeptical that the yield from SMIC's process is particularly high. Max A. Cherney, "Experts Raise Eyebrows at Claims China Has Successfully Deployed Advanced Chipmaking Technology at Scale," *Protocol*, July 24, 2022.

Mitigation Opportunities

The risks identified above, in conjunction with the semiconductor industry's importance to the U.S. economy and national security, have led some policymakers to conclude that reshoring manufacturing capacity is the only viable path toward resilience. Commerce Secretary Raimondo, for example, recently remarked that "the fact that we're buying two thirds of our chips from Taiwan and these are the chips we need to keep Americans safe and secure—we've got to make those in America, period." She asserted, "It is a huge national security issue and we need to move to making chips in America, not friendshoring."[272] Other analysts however, believe friendshoring is a necessary part of the solution, as indigenizing the entire semiconductor supply chain would be infeasible. Mr. Kleinhans testified before the Commission that "[m]aking chips without relying on allyshoring for front-end or back-end manufacturing would not strengthen the United States' resilience or be economically viable."[273] A number of initiatives have been established with friends and allies, including between the United States, Japan, Taiwan, and the EU. The Quad, for example, has launched a joint initiative to "map capacity, identify vulnerabilities, and bolster supply chain security for semiconductors and their vital components."[274]

The United States is exploring a number of options to realign global fabrication capacity. Initial efforts have focused on incentivizing reshoring leading-edge fabrication capacity via the Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) Act, which has already encouraged Samsung and TSMC to build capacity in Taylor, Texas, and Phoenix, Arizona, respectively. At the same time, Intel is working on expanding fabrication capacity in Columbus, Ohio. Multilateral friendshoring initiatives are also underway, as the United States has forged initiatives with Japan, Taiwan, and the EU to cooperate on semiconductor supply chain realignment in this area. As the White House's 100-day Supply Chain Review notes, however, "[t]he biggest challenge to increasing domestic semiconductor production is cost, both absolute and relative to other countries" and "[t]he most critical factors for determining the best location to manufacture semiconductors include synergies with an existing semiconductor ecosystem/footprint, access to skilled talent, protection for intellectual property, labor costs, and government incentives."[275] With most capacity located in South Korea and Taiwan, diversifying concentration of manufacturing out of East Asia may be a costly yet necessary measure to mitigate the threat of disruption from Chinese aggression.

Appendix II: The U.S. Government's Recent Supply Chain Actions

In the last several years, the federal government has taken a number of steps to begin identifying where the United States is most import-dependent for critical goods and the subsequent vulnerabilities and risks that have resulted from reliance on foreign suppliers, like China. This Appendix provides a list of recent actions aimed at addressing U.S. supply chain security concerns.

Executive Order 14017—On February 24, 2021, U.S. President Joe Biden signed Executive Order (EO) 14017 on *America's Supply Chains* to ensure economic prosperity and national security. The EO required 100-day industrial reviews from seven government agencies. It also required a sectoral report, one year after the order, from each agency to evaluate the state of U.S. supply chains relevant to the agency's mandate. Below are the focus areas of each agency's one-year report:[276]

Sectoral Report Focus Areas:

- Department of Energy Report on the Energy Industrial Base—*America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition*
  - DOE conducted 13 deep-dive supply chain assessments, including on silicon solar cells, semiconductors, and clean hydrogen.
- Department of Transportation Report on the Transportation Industrial Base—*The Freight and Logistics Supply Chain Assessment*
  - Freight infrastructure
  - Data on supply chain performance
  - Technical assistance
- Department of Agriculture Report on the Production and Distribution of Agricultural Commodities and Food Products—*Agri-Food Supply Chain Assessment: Program and Policy Options for Strengthening Resilience*
  - Transportation bottlenecks
  - Food production challenges
  - Industry consolidation, particularly in processing and distribution
  - Ecological risks
  - Trade-related disruptions
- Department of Health and Human Services Report on Public Health and Biological Preparedness Industrial Base—*Public Health Supply Chain and Industrial Base*
  - Personal protective equipment
  - Durable medical equipment
  - Testing and diagnostics

- Pharmaceuticals, including therapeutics and APIs

- Department of Commerce and Department of Homeland Security Report on Information Communications Technology—*Assessment of the Critical Supply Chains Supporting the U.S. Information and Communications Technology Industry*
  - Communications equipment
  - Data storage
  - End-user devices
  - Critical software with dependencies on the enabling hardware including firmware and open-source software
- Department of Defense Report on the Defense Industrial Base—*Securing Defense-Critical Supply Chains*
  - Kinetic capabilities
  - Energy storage and batteries
  - Castings and forgings
  - Microelectronics

Other Supply Chain EOs and Agency Efforts:

- **Executive Order 14005**—*Ensuring the Future Is Made in All of America by All of America's Workers*. On January 25, 2021, President Biden issued EO 14005 to use federal funds to maximize the use of goods, products, and materials produced in, and services offered in, the United States. The EO allows agencies to grant waivers for the procurement of goods not produced in the United States as long as "detailed justification" is provided.[277]
- **Executive Order 14036**—*Promoting Competition in the American Economy*. On July 9, 2021, President Biden released EO 14036, which establishes that it is the policy of the Administration to combat the excessive concentration of industry. Among other things, the EO establishes the White House Competition Council and directs the secretary of defense to submit to the council a review of the state of competition in the defense industrial base.[278]
- **Trump Executive Order 13817**—*Ensuring Secure and Reliable Supplies of Critical Minerals*. On December 20, 2017, then President Donald Trump issued EO 13817 to develop a federal strategy to reduce U.S. vulnerability to disruptions in the supply of critical minerals.[279]
- **Trump Executive Order 13953**—*Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries*. On September 30, 2020, then President Trump released EO 13953 to direct the secretary of the interior and other cabinet members to recommend executive action for building resiliency, health, and growth of the U.S. mining industry.[280]

- The Department of Homeland Security's **Cybersecurity and Infrastructure Security Agency (CISA)** has an ICT Supply Chain Management Task Force for identifying and developing consensus approaches to enhance ICT supply chain security with private sector partners.[281]
- **The Department of Commerce** is engaging in the U.S.-EU Trade and Technology Council that reviews critical technology supply chains and evaluates opportunities for the United States and the EU to cooperate in building supply chain resiliency.[282]
- **The Department of Defense** produces an Industrial Capabilities report each year that identifies vulnerabilities in the defense industrial base.[283]
- **The Department of Defense** also has a Supply Chain Resiliency Working Group that is working to identify and address barriers to supply chain visibility, assess resiliency, and develop solutions for risk mitigation.[284]
- **The Department of Commerce's National Institute of Standards and Technology (NIST)** developed supply chain security risk management guidelines for cybersecurity management designed to increase public and private sector supply chain resilience.[285]

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