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Semiconductors and the CHIPS Act: The Global Context

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SUMMARY

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Semiconductors and the CHIPS Act: The Global Context

In 2021, Congress enacted legislation in response to its concerns that the United States lacked critical domestic semiconductor production capabilities and, more broadly, was losing its competitive edge in the global semiconductor industry. Through the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America program, Title XCIX of P.L. 116-283, the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA), Congress authorized an incentive program for building and equipping semiconductor fabrication facilities in the United States. It also authorized research and development activities to support U.S. leadership in semiconductor manufacturing technology.

Subsequently, in appropriating funding for P.L. 116-283's CHIPS for America provisions, Congress combined provisions from a number of previously introduced bills into a single bill. These proposals sought to increase U.S.-based semiconductor fabrication and to address concerns about the adequacy of U.S. investment in research and development (R&D) and the development of the U.S. science and engineering workforce. After resolution of differences between the House and Senate versions of these bills, the bill became known as (though not officially named) the CHIPS and Science Act. In July 2022, Congress enacted the CHIPS and Science Act (P.L. 117-167), which President Joe Biden signed into law in August 2022. P.L. 117-167 (Division A) provides funding for the CHIPS for America provisions enacted in the 2021 NDAA. The act appropriates $52.7 billion to increase semiconductor manufacturing capacity in the United States by providing financial incentives for building, expanding, and equipping domestic fabrication facilities and companies in the semiconductor supply chain. In addition, the act includes provisions that fund federal semiconductor R&D activities at the National Institute of Standards and Technology, a National Semiconductor Technology Center (in partnership with U.S. industry), a National Advanced Packaging Manufacturing Program, and the establishment of up to three Manufacturing USA institutes. P.L. 117-167 also created and funded three additional funds that seek to bolster U.S. semiconductor capabilities for national defense, workforce development, and international cooperation.

Some other countries have long-standing support programs for their semiconductor industries. East Asia—in particular, South Korea, Taiwan, Japan, Malaysia, and Singapore—is home to globally competitive semiconductor firms and industries. The semiconductor industry in East Asia has relied on various forms of government support to develop and sustain its globally competitive position. Governments in East Asia, among others, have announced new investments and support measures, in part as a response to the CHIPS Act of 2022, to bolster their position in global semiconductor supply chains. U.S. semiconductor firms are heavily invested in these markets, either through a direct corporate presence or the use of contracted services. The United States relies primarily on Taiwan for the fabrication of leading-edge logic chips (microprocessors and microcontrollers that function as the "brains" of computing devices) and South Korea for leading-edge memory (data storage) chips, while relying on Taiwan, South Korea, and increasingly China to meet demand for mature-node chips.

China is catching up to leading nations in both semiconductor production capacity and capabilities, in large part due to government capital outlays that subsidize domestic firms, fund the purchase of imported equipment and software, and finance China's acquisition of foreign semiconductor firms. U.S. officials have expressed concerns about the ways in which China's state-led semiconductor policies are pressuring or encouraging U.S. and other foreign semiconductor companies to transfer key technology, intellectual property, talent, and R&D to China, thereby boosting China's competitiveness in the industry. India—a global leader in information technology (IT) software services—is investing heavily in IT hardware and seeking to boost investment in semiconductors and microelectronics. European-headquartered semiconductor firms account for about 10% of global semiconductor sales and specialize in niche markets (e.g., automotive, energy, and industrial automation).

This report examines U.S. actions in a broader context by highlighting recent actions by other governments to boost their semiconductor industries. U.S. policy efforts to promote and protect U.S. semiconductor capabilities will shape and be influenced by these broader dynamics. Consideration of the global context may raise additional considerations for Congress, particularly with regard to how the United States might consider cooperation and collaboration among allies and close partners while potentially seeking to restrict the development of semiconductor capabilities of strategic competitors such as China. Among U.S. allies and close partners, other considerations involve how to maximize the role of markets and achieve the appropriate balance of government and market roles, and how to avoid overcapacity and other potential market distortions.

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Introduction

In July 2022, Congress enacted the CHIPS Act of 2022 (Division A of P.L. 117-167), which was signed into law by President Joe Biden on August 9, 2022. The act appropriated funding for the CHIPS for America provisions enacted in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year (FY) 2021 (2021 NDAA, P.L. 116-283). It also revised the 2021 NDAA CHIPS for America provisions and established three additional funds to support efforts that seek to address semiconductor-related challenges in defense, workforce and education, and international technology security and innovation. In total, the act appropriated $52.7 billion for these activities for FY2022-FY2027.

This report—one of a series of CRS reports that discuss provisions in the CHIPS Act of 2022, U.S. competitiveness in semiconductors, and the semiconductor sector more broadly—provides information on the broader global context in which U.S. policy actions are being undertaken. Specifically, the report outlines the recent actions that other governments have taken to support the semiconductor industry in their countries. Some of these efforts are long-standing, and some have been adopted specifically in response to provisions in the CHIPS Act of 2022. Other reports in this series provide information about the U.S. semiconductor industry and key technologies and segments of the supply chain; and the provisions and implementation of the CHIPS Act of 2022, responses to frequently asked questions, and some key issues and considerations for Congress.[1]

U.S. Policy Context

Over the past several years, some Members of Congress and other U.S. policymakers have expressed concern that only a small share of the world's most advanced semiconductor fabrication production capacity is located in the United States. The U.S. position in the global semiconductor supply chain has shifted over time as markets in Asia developed their semiconductor manufacturing capacity, and as U.S.-headquartered semiconductor companies built fabrication facilities (commonly referred to as fabs) overseas and shifted other related parts of the supply chain outside the United States. Additionally, a number of U.S.-headquartered semiconductor companies separated design and manufacturing functions, abandoned manufacturing, and shifted to a fabless business model, moving their production to overseas contract foundries (primarily in East Asia). U.S. policymakers have expressed concerns about the loss of U.S. leadership in semiconductors, including the extent to which U.S. industry has fallen behind industry in Taiwan and South Korea in advanced chip capabilities.[2] U.S. policymakers also express concern about U.S. industry ties and operations in China and how U.S. firms may be supporting China's industrial ambitions in the semiconductor sector. Other concerns relate to the potential economic and military implications of a further decline or loss of U.S. leadership in semiconductors.

[1] See CRS Report R47523, *Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation*, by John F. Sargent Jr., Manpreet Singh, and Karen M. Sutter and CRS Report R47508, *Semiconductors and the Semiconductor Industry*, by Manpreet Singh, John F. Sargent Jr., and Karen M. Sutter.

[2] "On Senate Floor, Chairman Warner Urges Quick Action on Bill to Boost American Manufacturing & Innovation." Office of Senator Mark Warner, July 26, 2022; "Cornyn Amendment to Bring Production of Semiconductors Back to U.S. Passes in NDAA," Office of Senator John Cornyn, July 21, 2020; "Remarks by U.S. Secretary of Commerce Gina Raimondo: The CHIPS Act and a Long-term Vision for America's Technological Leadership," U.S. Department of Commerce, February 2023.

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Semiconductors are a uniquely important enabling technology. They are fundamental to nearly all modern industrial and national security activities, and they are essential building blocks of other emerging technologies, such as artificial intelligence, autonomous systems, 5G communications, and quantum computing. The federal government and U.S. companies pioneered the development and early adoption of semiconductors, and throughout the 1960s and 1970s, the United States led the world in semiconductor manufacturing. Subsequently, a variety of factors led to a concentration of semiconductor manufacturing in East Asia. These factors included, among others, other nations subsidizing the construction and operation of semiconductor fabs and lower or subsidized operating costs in these overseas locations. Other factors involve the shift by some semiconductor companies to a fabless model that relies on contracting with external semiconductor foundries due to the high cost and complexity of semiconductor manufacturing. Additionally, a preference for being physically proximate to the electronics business clusters and clients in East Asia has also played a role in this concentration of production in East Asia.

U.S. policymakers raising concerns also have focused on the risks of potential supply chain disruptions. The concentration of chip production in East Asia creates semiconductor supply chain vulnerabilities in the event of a trade dispute, military conflict, natural disaster, or other disruption, as well as vulnerability to the risk of product tampering and intellectual property (IP) theft. Concerns about supply chain vulnerabilities and gaps in U.S. fabrication capacity intensified during the COVID-19 pandemic.[3] Shifting consumer and industrial demands, production declines, and logistics disruptions led to supply chain shortages of certain semiconductor chips, among other industrial products and inputs. The People's Republic of China (PRC or China) government's efforts to tighten control over the technology sector—and its growing use of economic coercion to influence political and economic outcomes—intensified concerns about semiconductors and related technology supply chains.[4]

Congressional concerns about the U.S. semiconductor industry are also informed by China's state-led efforts—unprecedented in scope and scale—to develop an indigenous vertically integrated semiconductor industry. China's government outlays (an estimated $322 billion to date) and its role as a central production point for global consumer electronics generate strong incentives for U.S. and foreign firms to develop semiconductor capabilities in China.[5]

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[3] The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based: 100-Day Reviews under Executive Order 14017*, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

[4]The PRC government tightly controls access to capital, trade, investment, technology, and research opportunities, which, in turn, allows it to calibrate incentives that can be offered and retracted to create pressure on foreign firms, governments, and other actors to adhere to China's commercial and political demands. China's coercion involves both the offer and withdrawal of access to its market, the application of commercial pressures to achieve certain outcomes—such as the transfer of technology or other terms of trade and investment deals—and the use of other economic levers that China controls to pressure or incentivize certain behavior. China uses ad hoc trade restrictions and brinkmanship to commercially and politically pressure trading partners, to deter foreign countries, nongovernmental organizations, and companies from actions that the government views as inimical to its economic and political interests, and to take action against those entities deemed to have challenged those interests. This pressure or action may take the form of (real or threatened) trade restrictions (on either imports or exports), popular boycott campaigns, restrictions on Chinese outbound tourism, suspension of contracts, the imposition of restrictions in China and other costs ostensibly related to regulations, and formal sanctions and countersanctions. See CRS Report R46915, *China's Recent Trade Measures and Countermeasures: Issues for Congress*, by Karen M. Sutter.

[5] This estimate includes the China Integrated Circuit Investment Industry Fund (CICIIF)'s initial announcement to channel an estimated $150 billion in state funding in support of domestic industry, state-directed overseas acquisitions, and the purchase of foreign semiconductor equipment. It also includes the second fund that China announced in October 2019 with an estimated capitalization of $29 billion and China's plans announced in December 2022 to provide an additional $143 billion to support the development of PRC fabs and the costs of related semiconductor (continued...)

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Meanwhile, the PRC government views access to foreign capabilities in the near term as a key pathway to accelerate indigenous development. Also of concern to many U.S. and allied government policymakers are China's state-led efforts to acquire companies and access semiconductor technology through both licit and illicit means, including technology-transfer pressures and targeted IP theft.[6] A series of PRC acquisitions of semiconductor firms in the United States and allied countries since 2014 have prompted governments in the United States, several European countries and the EU, Japan, South Korea, and Taiwan to undertake policy actions that seek to both promote and protect their semiconductor capabilities vis-à-vis China.[7] Some policymakers express concern that China's industrial policy efforts, if successful, could significantly shift global semiconductor production and related design and research capabilities to China, challenging the competitiveness and leading positions of U.S. and other foreign semiconductor firms.[8] Although China's current share of the global industry is still relatively small, and its companies produce mostly low-end chips, China's industrial policies aim to establish global dominance in semiconductor design and production by 2030.[9] China's emerging and future semiconductor competencies could support a range of technology advancements, including military applications.

Actions by Other Governments to Support their Semiconductor Industries

The CHIPS Act of 2022 provides federal funding and tax incentives for certain semiconductor-related activities in the United States. Its provisions support both commercial operations and commercial and government-led research and development (R&D). The provisions seek to promote collaboration and joint use of certain R&D resources. While the nearly $53 billion in

manufacturing equipment. See CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter. Christopher Thomas, *A New World Under Construction: China and Semiconductors*, McKinsey & Company, November 2015; Yoko Kubota, "China Sets up New $29 Billion Semiconductor Fund," *Wall Street Journal*, October 25, 2019; Tianlei Huang, "Government-Guided Funds in China: Financing Vehicles for State Industrial Policy," China Economic Watch, Peterson Institute for International Economics, June 17, 2019; OECD, Trade and Agricultural Directorate, Trade Committee, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019, pp. 94-95; Julie Zhu, "China Readying $143 Billion Package for its Chip Firms in Face of U.S. Curbs," *Reuters*, December 13, 2022; "Battered by Covid, China Hits Pause on Giant Chip Spending Aimed at Rivaling US," *Bloomberg*, January 4, 2023; Monica Chen and Jessie Shen, "Chinese Foundries are Quietly Making Equipment Purchases," *DigiTimes*, February 3, 2023.

[6] For examples of such efforts, see Department of Defense, Defense Innovation Unit-Experimental, Michael Brown and Pavneet Singh, *China's Technology Transfer Strategy: How Chinese Investments in Emerging Technologies Enable a Strategic Competitor to Access the Crown Jewels of U.S. Innovation,* January 2018; U.S.-China Economic Security and Review Commission, Sean O'Connor, *How Chinese Companies Facilitate Technology Transfer from the United States,* May 6, 2019; and National Counterintelligence and Security Center, *Protecting Critical and Emerging U.S. Technologies from Emerging Threats,* October 2021.

[7] Executive Office of the President, President's Council of Advisors on Science and Technology, "Report to the President: Ensuring Long-Term U.S. Leadership in Semiconductors," January 2017.

[8] See Senate floor debate on the National Defense Authorization Act for Fiscal Year 2021, Congressional Record, vol. 166, part 128 (July 21, 2020), p. S4325; Jeanne Whalen, "U.S. Restricts Tech Exports to China's Biggest Semiconductor Manufacturer in Escalation of Trade Tensions"; "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification," BIS Rule, October 13, 2022; Alexandra Alper and David Sheperdson, "U.S. Official Acknowledges Japan, Netherlands Deal to Curb Chipmaking Exports to China," *Reuters*, January 31, 2023; and Jamie McIntyre, "New House Foreign Affairs Committee Chairman Michael McCaul has China on his Mind," *Washington Examiner*, February 17, 2023.

[9] China's State Council, "Guideline for the Promotion of the Development of the National Integrated Circuit Industry," June 2014; "Made in China 2025 (2017)," Publishing House of the Electronics Industry, 2017, in Chinese language.

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U.S. government funding for the industry is quite large by U.S. government current and historic standards, it is small in comparison to the aggregate capital investments and other forms of market support and preferences that other governments currently offer and have offered to promote their domestic semiconductor industries. It is also small relative to the investments that U.S. and foreign semiconductor companies make on their own in the United States and globally. A 2021 survey of 153 companies by the Korea Semiconductor Industry Association reported a $450 billion commitment in outlays in South Korea through 2030, for example.[10]

East Asia—in particular, South Korea, Taiwan, Japan, Malaysia, and Singapore—is home to globally competitive semiconductor firms and industries. At present, the United States relies primarily on Taiwan for leading-edge logic chips and South Korea for leading-edge memory chips, and on Taiwan, South Korea, and increasingly China to meet demand for mature-node chips.[11] Semiconductor firms in East Asia have used various forms of government support to help develop and sustain this globally competitive position in semiconductors. [12] Large-scale public investment in semiconductor fabrication has supported firms in South Korea and Taiwan and increased their competitiveness related to U.S.-headquartered firms. A Department of Commerce analysis of the global semiconductor supply chain notes that the Taiwan government provides subsidies and other support for fabrication facilities, including 50% for land costs, 45% for construction and facilities, and 25% for semiconductor production, in addition to R&D investments and tax incentives.[13] Arguably, these investments have helped Taiwan companies become global leaders in producing the most advanced semiconductor chips. South Korea and Singapore's semiconductor subsidies reduce the cost of facility ownership by 25-30%, thereby boosting the competitiveness of firms headquartered or operating in these markets.[14]

China is coming from behind in all parts of the supply chain but is catching up quickly to other leading semiconductor producing nations in both capacity and capabilities, arguably due in large part to sizeable government capital outlays that subsidize domestic firms, fund the purchase of imported equipment, and finance China's acquisition of foreign semiconductor firms. China also benefits (as do a number of other countries) from its sustained ties with U.S. and foreign industry, its ability to tap U.S. and global talent, its leveraging of global basic and applied research to develop its own talent pool, and its participation in U.S.-led open source technology platforms. Such platforms support PRC firms in chip design and hardware capabilities. The Organisation for Economic Co-operation and Development (OECD) assessed in 2019 that China's subsidies and other forms of state support for the industry, and particular national champion firms, is well above

[10] Kim Jaewon, "South Korea Plans to Invest $450bn to Become Chip 'Powerhouse'," *NikkeiAsia*, May 13, 2021.

[11] The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based*: *100-Day Reviews under Executive Order 14017*, June 2021. Node is an industry label used to track successive generations of chip technologies and historically referred to the size of key electronic features on the chip measured in nanometers (nm), or 1 billionth of a meter. While node no longer reflects the actual size of features in recent generations of chips, the industry continues to use these labels to market new products with smaller numbers implying more powerful chips (e.g., 5 nm chips can offer higher performance than 10 nm chips). There is no industry standard on how recent node labels are assigned, however, and which nodes are "mature" chip technologies. For a further discussion of types of semiconductor chips, see CRS Report R47523, *Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation*, by John F. Sargent Jr., Manpreet Singh, and Karen M. Sutter.

[12] OECD, Trade and Agricultural Directorate, Trade Committee, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019.

[13] The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based: 100-Day Reviews under Executive Order 14017*.

[14] Ibid.

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what other countries have typically offered and represents significant potential for distorting global markets.[15]

These semiconductor policy support efforts by governments in East Asia have influenced U.S. offshoring and the ceding of certain U.S. semiconductor capabilities and production activity for some time, going back to at least the 1980s.[16] The U.S. government and U.S. industry have previously initiated U.S. antidumping cases and brought other charges against Japanese and South Korean semiconductor firms with regard to semiconductor subsidies and their distortive effects on semiconductor chip exports to the United States.[17] East Asia has also benefitted from decisions by U.S. industry to shift to a fabless model in which chips are designed internally and then produced by a contract manufacturer, generally outside the United States. The negotiation of lower tariffs through plurilateral trade deals on many inputs and finished products related to semiconductor and microelectronics production has also facilitated U.S. offshoring and the related expansion of the semiconductor industry in East Asia. Fabricators and packaging firms operating in East Asia have benefitted from the increased ease and cost effectiveness of moving wafers and chips across borders, in some cases numerous times, for design, production, testing, and packaging, as well as from easier and cheaper export of chips, including those embedded in finished products.[18] Taiwan's leading firms (e.g., Taiwan Semiconductor Manufacturing Corporation, TSMC) and South Korean firms (e.g., Samsung) have developed capabilities in part through commercial partnerships and licensing agreements with U.S. firms. Apple, for example, reportedly accounts for over 20% of TSMC's annual business.[19] Globalization of the semiconductor industry has led to increased efficiencies as industry has kept pace with growing demand, but has also introduced new risks, including the decline of U.S.-based production and challenges to U.S. leadership in the industry.

Many factors are currently driving foreign governments' efforts to revitalize or strengthen their semiconductor industries, including

- technology changes across a range of consumer, industrial, government, and military applications that are increasing demand for semiconductors, including advanced chips;

[15] Organisation for Economic Co-operation and Development (OECD), Trade and Agricultural Directorate, Trade Committee, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019.

[16] Offshoring is the location of production functions (e.g., chip fabrication) outside the nation in which a company is headquartered. See, for example, "Offshoring: U.S. Semiconductor and Software Industries Increasingly Produce in China and India," U.S. Government General Accountability Office (GAO), September 2006.

[17] Doug Irwin, "The U.S.-Japan Semiconductor Trade Conflict," in The Political Economy of Trade Protection, ed., Anne O. Krueger, University of Chicago Press, 1996; Hyun Young Lee, "The Japan-U.S. and Korea-U.S. Semiconductor Trade Dispute," *Far Eastern Studies*, Vol. 3, March 2004.

[18] In July 2015, the World Trade Organization expanded the Information Technology Agreement (ITA), first signed in 1996, which has more than 80 signatories, including the United States. Beginning on July 1, 2016, the signatories agreed to eliminate some tariffs immediately and then phase out others by January 2024, on 201 information technology products not included in the original 1996 ITA. China is a signatory to both agreements, but still has high tariffs on certain products. Mexico, a substantial location for electronics assembly that incorporates finished semiconductors in electronic goods, is not party to the agreements. For details on the ITA of 1996 and the ITA expansion in 2015, see https://ustr.gov/issue-areas/industry-manufacturing/industry-initiatives/information-technology and https://unctad.org/system/files/official-document/tn_unctad_ict4d05_en.pdf. Some industry groups are currently advocating for a third expansion of the ITA.

[19] Eamon Barrett, "How TSMC Convinced Apple it would be a Trustworthy Partner, Landing the Taiwan Company its most Significant Semiconductor Contract to Date," *Fortune*, February 10, 2023.

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- global shortages of semiconductor chips during the Coronavirus Disease 2019 (COVID-19) pandemic;[20]
- potential implications of China's state-led semiconductor policies; and
- U.S. efforts to boost its domestic industry and related policy efforts to strengthen critical supply chains among allies and close partners.[21]

Japan

Semiconductor firms headquartered in Japan have approximately 9% market share of global semiconductor production, a significant fall from the 1980s, when Japan accounted for over half of global production.[22] However, Japanese firms remain competitive in producing certain types of chips, such as memory chips, sensors, and power semiconductors. Japan also has a leading role in semiconductor manufacturing equipment (a 35% global market share) and in semiconductor materials, including the manufacture of semiconductor wafers and photoresists (a 50% global market share).[23] Some analysts attribute the decline in Japan's market share to three factors: Japanese industry's decision to focus on memory at the expense of logic chips; offshoring and challenges due to global shifts to a fabless model of chip design and production; and the 1986 U.S.-Japan Semiconductor Agreement. In that agreement, the parties negotiated a 20% market share for U.S. industry in Japan and committed Japan to allow greater foreign competition in its market.[24]

The Japanese government has recently sought to boost its semiconductor industry and align its efforts with those of the United States. Following visits to Japan by Secretary of Commerce Raimondo in November 2021 and by President Biden and Secretary of State Blinken in May 2022, the two countries established the U.S.-Japan Economic Policy Consultative Committee (EPCC), sometimes referred to as the "Economic 2+2." During the first EPCC meeting in July 2022, U.S. and Japanese officials discussed a joint action plan to promote and secure critical and emerging technologies, and issued a statement on joint innovation and plans to develop a new joint international semiconductor research hub.[25]

In June 2021, Japan's Ministry of Economy, Trade, and Industry (METI) published a "Strategy for Semiconductor and Digital Industries." The strategy aims to sustain Japan's current level of market share in the global semiconductor industry at 10%. It also seeks to develop logic chips and next generation semiconductor technologies in cooperation with the United States, and new

[20] Dashveenjit Kaur, "Two More Years of Shortages: No 'Chips to make Chips'," *TechHQ*, June 30, 2022; "Automotive Semiconductor Supply Chain Working Group Releases Interim Report Titled Efforts to Make Automotive Supply Chains Resilient," METI, July 1, 2022.

[21] "Executive Order on America's Supply Chains," E.O. 14017, February 24, 2021; The *CHIPS and Science Act of 2022* (P.L. 117-167).

[22] "Japan—Country Commercial Guide," International Trade Administration, U.S. Department of Commerce, November 21, 2022.

[23] Ibid. A photoresist is a light-sensitive material used in semiconductor manufacturing processes to form a patterned coating.

[24] Mathieu Duchatel, "Racing for the New Rice - Japan's Plans For its Semiconductor Industry," Institut Montaigne, August 4, 2021; Doug Irwin, "The U.S.-Japan Semiconductor Trade Conflict," in The Political Economy of Trade Protection, ed., Anne O. Krueger, University of Chicago Press, 1996.

[25] "Joint Statement of the U.S.-Japan Economic Policy Consultative Committee: Strengthening Economic Security and the Rules-Based Order," Media Note, Office of the Spokesperson, U.S. Department of State, July 29, 2022; "Announcement Regarding Efforts Toward the Establishment of Design and Manufacturing Bases for Next-Generation Semiconductors," Japan's METI, November 11, 2022. For an English language summary of Japan's R&D efforts, including with the United States, see https://www.meti.go.jp/english/press/2022/pdf/1111_001a.pdf.

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photovoltaic "fusion" technologies that could involve new materials beyond silicon.[26] Japan's approach emphasizes "strategic indispensability"—sustaining and expanding Japan's role in the global supply chain in certain key products—and "strategic autonomy"—an effort to develop certain capabilities important for Japan. One European scholar has paraphrased this approach as "owning chokepoints and cultivating strengths."[27] The strategy emphasizes R&D in advanced technologies, expanding domestic chip production, protecting sensitive technologies, and cooperating with like-minded countries, an approach similar to that taken by the United States.[28] METI has created a Leading-Edge Semiconductor Technology Center, to focus on R&D and to lead research cooperation with the United States, and Rapidus, a joint venture firm among eight entities.[29]

In November 2021, the Japanese government approved $6.8 billion to support domestic semiconductor manufacturing. This package included $3 billion to support TSMC, in partnership with Sony, to build a new foundry in Kumamoto prefecture in southwest Japan to produce chips at the 22 to 28 nanometer (nm) node. The government also approved $143 million to subsidize a new TSMC R&D center for advanced semiconductor packaging and testing in Ibaraki prefecture, which is just outside Tokyo. In 2022, the Japanese government enacted a new economic security law that includes provisions to strengthen strategic supply chains and provide government funding for R&D in technologies it deems important for economic security, such as semiconductors.[30] In other activity, a Japanese industry consortium in 2022 purchased U.S. company ON Semiconductor's facility in Japan (renamed JS Foundry) and announced plans to upgrade the facility to produce chips for the auto industry.[31] METI is providing U.S. firm Micron up to $320 million in subsidies to produce DRAM memory chips at its facility in Hiroshima (Micron acquired Japan's Elpida Memory in 2012, which included Elpida's operations in

[26] The strategy is available in Japanese at https://www.meti.go.jp/press/2021/06/20210604008/20210603008-1.pdf. For English language summaries see https://www.meti.go.jp/english/press/2021/0604_005.html and https://www.meti.go.jp/english/press/2021/pdf/0604_005a.pdf. For a discussion of the strategy, see, for example, "Japan's Three-Stage Strategy to Revive the Semiconductor Industry," UTMEL Electric blog post, April 1, 2022, https://www.utmel.com/blog/news/other/japan's-three-stage-strategy-to-revive-the-semiconductor-industry.

[27] Mathieu Duchatel, "Racing for the New Rice - Japan's Plans For its Semiconductor Industry," Institut Montaigne, August 4, 2021.

[28] "On the Creation of a New International Order," Policy Research Council, Liberal Democratic Party of Japan, December 16, 2020, provisional translation in English available at https://jimin.jp-east-2.storage.api.nifcloud.com/pdf/news/policy/201021_5.pdf. For discussion of this strategy, see Mariko Tagashi, "Japan Prioritises Semiconductor Industry in Bid to Enhance Economic Security," International Institute for Strategic Studies blog, March 30, 2022.

[29] Entities tied to this research center include the University of Tokyo, Japan's National Institute of Advanced Industrial Science and Technology, RIKEN (Japan's largest research institution), the U.S. National Semiconductor Center, Europe's Interuniversity Microelectronics Institute (IMEC), and U.S. and Japanese companies. See Scott Foster, "Japan's Grand Plan to Home Grown 2nm Chips," *Asia Times*, November 14, 2022. Shareholders in Rapidus include Kioxia, Sony, Softbank, Toyota, Denso, NTT, NEC, and Mitsubishi UFJ Bank. Ibid. Yochiro Hiroi, "Japan's New Chipmaker Seeks to Break Free from 'Lost Decade'," *Nikkei Asia*, November 12, 2022. Rapidus has formed partnerships with non-Japanese companies, including a joint development agreement with IBM to work alongside IBM researchers to develop IBM's 2 nanometer (nm) node technology. IBM Newsroom, "IBM and Rapidus Form Strategic Partnership to Build Advanced Semiconductor Technology and Ecosystem in Japan," December 12, 2022.

[30] For a copy of the act in Japanese language, see https://www.cas.go.jp/jp/houan/208.html. "Japan Passes Economic Security Bill to Guard Sensitive Technology," *Reuters*, May 11, 2022; "Japan's Economic Security Promotion Act and the Implications for Businesses," *Strategic Comments*, Volume 28 Comment 32, December 2022; Kana Itabashi, Junko Suetomi, Daisuke Tatsuno, Izumi Matsumoto, Ayumu Shinozaki, Mami Ohara, and Takumi Hasegawa, "Japan: New Act on the Promotion of Japan's Economic Security Enacted," Baker McKenzie, July 10, 2022.

[31] Ibid.

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Hiroshima), and up to $644 million in subsidies to U.S. firm Western Digital to expand production in Japan with its Japanese partner Kioxia.[32]

South Korea

An estimated 20% of South Korea's total exports are semiconductors and related products. South Korea's government support for the semiconductor industry has focused on developing specialized capabilities in memory chip fabrication among leading firms, such as Samsung and SK Hynix. Private-public cooperation since the 1970s—notably through the (South Korean) Electronics and Telecommunications Research Institute—helped companies like Samsung and SK Hynix emerge as leading semiconductor firms. These firms enjoy close ties with the government and a vertically integrated conglomerate structure that has allowed them to achieve scale in particular segments of the semiconductor industry, such as dynamic random access memory (DRAM) chips.[33]

South Korea, since 2022, has focused on boost domestic competencies while also more closely aligning with the United States. China has responded to these efforts by trying to pressure Seoul with regard to how South Korean industry may be affected by certain U.S. policies directed at China, such as export controls.[34] South Korea's Special Act to Protect and Foster the National High-Tech Strategic Industry took effect on August 4, 2022. Under the law, firms producing designated "national high-tech items," including semiconductors, receive tax benefits, regulatory exemptions and other preferential treatment to spur more R&D and increase production output.[35] In late March 2023, South Korea's National Assembly passed an amendment to the Act on Restriction of Special Taxation that expands tax deduction rates for companies that invest in industries that the government categorizes as strategic. This measure implements the earlier proposal by the Ministry of Economic and Finance of tax credits for large firms of up to 15% for investments in semiconductor manufacturing among other strategic technologies. The tax credits for similar investments by small and medium sized firms are from 16% to 25%. Any additional investment in semiconductors in 2023 could also qualify for an additional 10% tax break, with potential total tax benefits for semiconductor benefits ranging from 25% for small firms to 35% for larger firms.[36] The National Assembly is also reportedly considering amendments to further expand benefits for the chip industry and semiconductor engineer training programs.[37] South Korean officials said in July 2022 that the government aims to locally source 50% of the

[32] Kana Inagaki and Leo Lewis, "Japan Grants Micron $320mn in Deepening U.S. Chip Alliance," *Financial Times*, September 30, 2022; Evelyn M. Rusli, "Micron to Acquire Elpida Memory in Deal Valued at $2.5 Billion," *The New York Times,* July 2, 2012.

[33] S. Ran Kim, "The Korean System of Innovation and the Semiconductor Industry: A Governance Perspective," Science Policy Research Unit and Sussex European Institute, December 1996, https://www.oecd.org/korea/2098646.pdf.

[34] Kim Eun-jin, "China Putting Pressure on South Korea Concerning Chip 4 Alliance," *Business Korea*, July 26, 2022; Seong Hyeon Choi, "Tech War: China-Korea Semiconductor Trade Ties Start to Fray Under U.S. Pressure," *South China Morning Post*, February 3, 2023.

[35] For a copy of the law in Korean language, see https://www.law.go.kr.

[36] Dan Robinson, "South Korea to Offer Tax Breaks to Hedge Semiconductor Woes," *The Register*, January 3, 2023; Kang Yoon-seung, "South Korea to Expand Tax Incentives for Chip Industry," *Yonhap News Agency*, January 3, 2023; Dan Robinson, "Korea passes tax break-driven 'Chips Act' as protectionism fears mount," *The Register*, March 30, 2023.

[37] "Urging the National Assembly to Pass the K-Chips Act, 'Our Life and Death Depend on Semiconductors," *Financial News*, September 14, 2022, in Korean language at https://www.fnnews.com/news/202209141821433364in.

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semiconductor manufacturing materials, components, and equipment used in South Korean semiconductor production by 2030, up from the current level of 30%.[38]

A number of other South Korean initiatives are under way at the national, provincial, and company levels. The Ministry of Trade, Industry, and Energy is spending an estimated $900 million to develop artificial intelligence (AI) chip technologies by 2026.[39] In April 2021, the government created a special committee to develop support measures for the industry, partly in response to current chip shortages.[40] Relatedly, in Gyeonggi province on the outskirts of Seoul, South Korea's government and its semiconductor industry have plans to create the world's largest semiconductor production base by the 2040s; this base would employ 84,000 workers across as many as 19 production lines.[41] In part likely in response to these initiatives, U.S.-headquartered equipment firm Applied Materials announced in June 2022 that it would open an R&D center in Gyeonggi province.[42] In July 2022, Samsung announced plans to invest about $192 billion in the United States over the next 20 years, including 11 new semiconductor production lines in Texas.[43] Toward this goal, in late 2021 Samsung announced plans for a $17 billion facility in Tyler, Texas.[44] SK Hynix is also reportedly planning to build an advanced chip packaging plant in the United States.[45]

Taiwan

Almost 90% of global high-volume, leading-edge semiconductor chip production is now concentrated in Taiwan.[46] Taiwan firms also play important roles in other parts of the global semiconductor supply chain, including in chip design; R&D; semiconductor materials (e.g., silicon wafers); and assembly, packaging, and testing.[47] The government of Taiwan has supported the development of its semiconductor industry since the mid-1970s. The Taiwan government provided about half of the initial $200 million in start-up funding for TSMC, with Phillips providing $30 million and other Taiwan firms providing the balance.[48] Government-sponsored

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[38] Joyce Lee, "S. Korea Targets Localising 50% of Chip Materials Supply by 2030," July 20, 2022.

[39] "MSIT to announce the 'Support Plan for AI Semiconductor Industry Promotion,'" Ministry of Science and ICT Press Release, June 27, 2022, at https://www.msit.go.kr/eng/bbs/view.do?sCode=%20eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=702&searchOpt=ALL&searchTxt=.

[40] "DP Launches Special Committee to Prop Up Semiconductor Makers Amid Growing Global Competition," *Yonhap News*, April 23, 2021.

[41] Hakjae Kim, "South Korea's Semiconductor Industry," Kotra Express, December 2019, https://www.investkorea.org/upload/kotraexpress/2019/12/images/1912_Full.pdf.

[42] Robert Castellano, "Applied Materials Establishes R&D Center in Korea as Korean Sales Plummet," *Seeking Alpha*, June 9, 2022.

[43] Kim Eun-jin, "Samsung Electronics Unveils a US$200bn Investment Plan in the U.S.," *Business Korea*, July 25, 2022.

[44] Samsung press release, "One Year Since Samsung Electronics' Taylor Expansion Announcement," November 28, 2022.

[45] "SK Hynix to Break Ground on New U.S. Chip Packaging Plant Early Next Year," Reuters, August 12, 2022.

[46] See CRS Report R46581, *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, by Michaela D. Platzer, John F. Sargent Jr., and Karen M. Sutter; and Rick Switzer, *U.S. National Security Implications of Microelectronics Supply Chain Concentrations in Taiwan, South Korea, and the People's Republic of China,* p. 4, September 2019, as prepared for the U.S. Air Force, Office of Commercial and Economic Analysis.

[47] See CRS Report R46581, *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, by Michaela D. Platzer, John F. Sargent Jr., and Karen M. Sutter.

[48] Patrick Windham, "The Taiwanese Approach," in "Securing the Future: Regional and National Programs to Support the Semiconductor Industry," National Academies Press, 2003.

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institutes, such as the Industrial Technology Research Institute, have spurred investment in research and talent, and have spun off major Taiwan firms, including TSMC.

The Taiwan government continues to provide R&D subsidies and tax and tariff incentives for the semiconductor industry.[49] In 2019, the government combined its National Nano Development Lab and Chip Implementation Center to create the Taiwan Semiconductor Research Institute.[50] Government support includes science park "ecosystems" in cities such as Hsinchu; these offer high-quality, subsidized factory buildings, tax and import duty exemptions, grants and subsidized credit, and connections with local universities and institutes.[51] In January 2023, Taiwan's legislative body, the Legislative Yuan, amended Taiwan's Act for Industrial Innovation and added tax benefits for firms that domestically innovate technologies that have a critical role in global supply chains. Qualifying firms could receive tax deductions equal to 25% of R&D expenditures and 5% of spending on new equipment during a fiscal year.[52]

In the context of these preferences and support, in 2021, TSMC announced plans for $100 billion in new investments over the following three years to expand advanced semiconductor R&D production in Taiwan, including $12 billion for a 5 nm fabrication facility in Arizona, a new materials facility in Japan, and a $3 billion expansion of a 28 nm foundry in China. [53] TSMC's most significant and technologically advanced capabilities (e.g., 2-3 nm fabrication) are in Taiwan. TSMC announced, in May 2020, that TSMC would build a semiconductor fabrication plant in Arizona, a commitment that TSMC negotiated with the Department of Commerce.[54] This facility represents a small part of TSMC's broader expansion plans that focus primarily on Taiwan and, to a lesser extent, other parts of the world, including the PRC, Japan, and Europe. According to TSMC, its first fab in Arizona is scheduled to begin production of N4 process technology in 2024. TSMC has committed to build a second fab which is under construction and scheduled to begin production of 3nm process technology in 2026.[55]

China Ties and Concerns

U.S. export control actions highlight the extent to which PRC companies and institutes, including many of concern to the U.S. government, appear to be fabricating advanced semiconductors at TSMC in Taiwan. Many PRC firms and institutes—including some that are listed on the U.S. Department of Commerce's Bureau of Industry Security's Entity List—appear to be using membership in U.S. open source technology platforms to access the U.S. technology and capabilities to design advanced semiconductor chips that they can then fabricate in Taiwan.[56] Taiwan has also been a target of PRC talent poaching and IP theft in the semiconductor sector. High profile incidents of PRC poaching of Taiwan's engineering talent and IP theft exposed gaps in Taiwan's Trade Secrets Act. The Legislative Yuan, in May 2022, amended Taiwan's National

[49] "Taiwan Key Innovative Industry: Semiconductors," Ministry of Economic Affairs, 2017, available in English language at https://www.roc-taiwan.org/uploads/sites/30/2018/03/Semiconductors.pdf.

[50] For more about the institute and its history, see https://www.tsri.org.tw/en/introduction.html.

[51] "Taiwan Key Innovative Industry: Semiconductors," Ministry of Economic Affairs, 2017.

[52] "Legislature Passes R&D Tax Break Bill," *Taiwan News*, January 8, 2023.

[53] Lisa Wang, "TSMC Announces US$100bn Plan for R&D and Expansion," *Taipei Times*, April 2, 2021.

[54] TSMC, "TSMC Announces Intention to Build and Operate an Advanced Semiconductor Fab in the United States," press release, May 15, 2020.

[55] "TSMC Announces Updates for TSMC Arizona," TSMC Press Release, December 6, 2022.

[56] For further discussion of this issue, see CRS Report R46915, *China's Recent Trade Measures and Countermeasures: Issues for Congress*, by Karen M. Sutter.

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Security Act to make it a crime to engage in economic espionage or the unapproved use of critical national technologies and trade secrets outside of Taiwan.[57]

Southeast Asia (Malaysia and Singapore)

Already a global center for assembly, packaging, and testing (APT), and some fabrication of mature-node chips, Malaysia and Singapore, and other Southeast Asian countries, seem poised to benefit from increased government and private sector investment in semiconductor foundries in South Korea, Taiwan, Japan, and the United States. Some Malaysia-based semiconductor experts assess that an expansion of U.S. foundry capacity will generate follow-on demand for outsourced APT functions.[58] As other markets focus on advanced chip investments, Malaysia, Singapore, and other Southeast Asian countries (and China) may be positioned to pick up more investment in the production of mature-node semiconductors.

Malaysia

The government of Malaysia has previously looked to South Korea and Taiwan as models in leveraging government support to develop its semiconductor sector.[59] In 1985, the government created the Malaysian Institute of Microelectronics Systems, which then spun off the semiconductor firm Siltera in 2000.[60] Malaysia offers a range of tax and other incentives for foreign investment in manufacturing and priority sectors such as semiconductors. The government offers companies in priority sectors a five-year partial income tax exemption on 70% of their statutory income. Approved high technology companies in priority sectors have a full tax exemption for up to 10 years. The government provides allowances for re-investments and many other infrastructure and related input benefits tied to specific investment zones.[61]

Malaysian government incentives appear to have encouraged new semiconductor investment in the country, and Malaysia has been a key location for PRC offshore semiconductor expansion. Siltera restructured and in 2021 was acquired by a firm backed by China's state semiconductor fund.[62] PRC-controlled Nexperia announced a global R&D center in 2021 and expanded a production and raw material warehouse facility in Malaysia as part of its global expansion plans.[63] Other firms, including Infineon and Intel, have announced new chip production and

[57] Under the changes, sentences would be up to 12 years and 10 years in jail, respectively. The changes stipulate that any individuals or organizations that have been entrusted or subsidized by the Taiwan government to conduct operations involving critical national technologies will have to receive government approval for any trips to China. See "Amendments to the National Security Act and the Act Governing Relations between the People of the Taiwan Area and the Mainland Area," Lee and Li Law Firm, May 27, 2022. The act is available in English language at https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=A0030028.

[58] The Star, "Malaysia's semiconductor industry to benefit from Chips and Science Act," August 15, 2022, at https://www.thestar.com.my/business/business-news/2022/08/15/malaysia039s-semiconductor-industry-to-benefit-from-chips-and-science-act.

[59] Willem Thorbecke, "Strengthening Semiconductor Manufacturing: Lessons from East Asia," Centre for Economic Policy Research, October 15, 2021.

[60] See https://www.silterra.com/about-us/corporate-profile#our-profile.

[61] "Malaysia: Investment in the Manufacturing Sector: Policies, Incentives, and Facilities," Malaysia Investment Development Authority," January 6, 2023, at https://www.mida.gov.my/wp-content/uploads/2023/01/2023-01-06-MIDA_Policy-Booklet_-English-Version.pdf.

[62] Peter Clarke, "China Applies Pressure to Close Foundry Acquisition Deal," *EENews Analog*, January 18, 2021.

[63] "Nexperia Malaysia Ramps Up Chip Production with New Facility in Negeri Sembilan," *New Straits Times*, December 9, 2021; "Nexperia Announces Plans to Grow Global Production and Increase R&D spending," Nexperia corporate announcement, February 9, 2021. For more context on how the PRC government facilitated China's (continued...)

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packaging facilities in Malaysia.[64] Some U.S. semiconductor equipment firms, such as Lam, have restructured their Asia-Pacific operations and shifted to Malaysia in response to U.S. export controls that restrict certain semiconductor activity in the PRC.[65]

Singapore

The Singaporean government offers a range of incentives relevant to attracting semiconductor investment, including grants for talent development and tax benefits for R&D and registration of related IP.[66] In May 2022, Taiwan's TSMC opened talks with Singapore's Economic Development Board, seeking incentives to set up chip production facilities with 7nm and 28 nm technology.[67]

Europe

European-headquartered semiconductor firms account for about 10% of global semiconductor sales, with top ranked firms STMicroeletronics (Netherlands, France, and Italy), Infineon Technologies (Germany), and NXP Semiconductors (Netherlands) responsible for much of this share.[68] European firms tend to specialize in niche markets, including the automotive industry, energy applications, and industrial automation; these firms do little production of computer- and consumer-related chips.[69] Some analysts consider European companies to be strong in chip architecture, mobile telecommunications and industrial applications, and security chips.[70] Europe is also a leader in advanced and specialized semiconductor manufacturing equipment. Aixtron in Germany makes CVD (chemical vapor deposition) and MOCVD (metal organic chemical vapor deposition) machines and related services. ASML in the Netherlands is the only global producer of EUV (extreme ultraviolet) lithography equipment used for patterning in advanced chips beyond 7 nm and specializes in other types of chip machinery and manufacturing techniques. IMEC, a Belgium-headquartered semiconductor R&D hub is focused on nanotechnology and digital technologies.[71] Aixtron was the previous target of an attempted PRC state-led acquisition, and ASML reportedly has been a recent target of PRC IP theft.[72]

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acquisition of NXP's RF power business through PRC antitrust actions, see CRS Report R46915, *China's Recent Trade Measures and Countermeasures: Issues for Congress*, by Karen M. Sutter.

[64] "Semiconductor Boom–How Long Will it Last?," Malaysian Investment Development Authority, August 6, 2022.

[65] "Semiconductor Firms Ramp up Malaysia Investments," Argus Media, December 16, 2022.

[66] "Incentives and Schemes for Businesses," Economic Development Board Singapore, at https://www.edb.gov.sg/en/how-we-help/incentives-and-schemes.html.

[67] Yang Jie and Keith Zhai, "TSMC Looks to Build Multibillion-Dollar Chip Plant in Singapore," *The Wall Street Journal*, May 19, 2022.

[68] In 2018, Qualcomm, NXP's rival, proposed a takeover of NXP, a move that it has since abandoned.

[69] Page Tanner, "Germany to Drive Growth in European Semiconductor Market," *Market Realist*, December 24, 2015, at http://marketrealist.com/2015/12/germany-drive-growth-european-semiconductor-industry/.

[70] "Semiconductors: European Chip Industry Aims to Get Back on the Map," *Handelsblatt*, April 30, 2018, at https://www.handelsblatt.com/today/companies/semiconductors-european-chip-industry-aims-to-get-back-on-the-map/23582014.html.

[71] For more on IMEC, see the center's website at https://www.imec-int.com/en.

[72] For more on the Aixtron Group, see https://www.aixtron.com/en/company/about-aixtron/company. For more on ASML, see https://www.asml.com/en/technology. "Aixtron Sale Stopped," DW, October 24, 2016; William Wilkes, "Chinese Takeover of Aixtron Collapses after U.S. Ban," *The Wall Street Journal*, December 8, 2016; and Jess Weatherbed, "A major global chipmaking supplier claims an employee stole manufacturing secrets," *The Verge*, February 15, 2023.

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In May 2013, the European Commission (EC) announced an initiative aimed at increasing Europe's share of global semiconductor fabrication by providing $11.3 billion (€10 billion) in public funding for R&D activities. These public funds aim to induce about $113 billion (€100 billion) in industry investment in manufacturing.[73] The initiative called for a multipronged approach that included easing access to capital financing by qualified companies; pooling European Union (EU), national, and regional subsidies to enable larger-scale projects; and improving worker training.[74] The commission said its goal was for European firms to account for 20% of global chip manufacturing by 2020.[75] The years-long program did not reach its market share goals but may have helped to prevent Europe's market share in wafer fabrication from declining. France, Germany, Italy, and the United Kingdom received EC approval at the end of 2018 for a $2 billion (€1.7 billion) joint microelectronics project focused on Internet-of-Things (IoT) chips.[76]

More recently, the EC drafted a European Chips Act.[77] The stated purpose of the act is to address chip shortages and strengthen Europe's technological leadership in semiconductors. The act seeks to mobilize $46.7 billion (€43 billion) in public and private investment. The act also revives the commission's previous goal of increasing Europe's share of the global semiconductor market to 20%. Areas of emphasis include investments in next-generation technologies and innovation in advanced chip design, packaging, and production. The act also emphasizes the importance of trusted chips for critical applications and supply chain security and the need for processes to better anticipate shortages and for partnerships with like-minded countries.[78] Finally, the act seeks to improve the business environment for investment in chip production, financing for small firms, and talent development.[79]

The EC reached a provisional deal with the European Parliament on April 18, 2023 that still needs to be finalized, endorsed, and formally adopted by both institutions.[80] As part of the compromises made to reach agreement, the act: 1) specifies that the Chips Joint Undertaking under the Chips for Europe Initiative will be responsible for selecting the centers of excellence; 2) expands the definition of "first of its kind" facilities to include semiconductor equipment

[73] European Commission, "Commission Proposes New European Industrial Strategy for Electronics—Better Targeted Support to Mobilize 100 Billion Euro in New Private Investments," press release, May 23, 2013, at https://ec.europa.eu/commission/presscorner/detail/en/IP_13_455.

[74] The initiative was named 10/100/20 to reflect its three main goals. SEMI, *Supporting Competitive Semiconductor Advanced Manufacturing*, February 24, 2014, at http://www.semi.org/eu/sites/semi.org/files/docs/SEMI%20Europe%20News-Feb%2024%202014.pdf. Also see European Commission, "Electronics Strategy for Europe," at https://ec.europa.eu/digital-single-market/en/electronics-strategy-europe.

[75] Ibid.

[76] Foo Yun Chee, "EU Okays $2 Billion Microelectronics Project by France, Germany, Italy, UK," *Reuters*, December 18, 2018. Also see European Commission, "State Aid: Commission Approves Plan by France, Germany, Italy, and the UK to give €1.75 Billion Public Support to Joint Research and Innovation Project in Microelectronics," press release, December 18, 2018. The European Commission needs to be notified and approve state aid (a subsidy or any other aid) for projects by Member States, especially those that target a particular sector prior to its initiation.

[77] Paul Timmers, "How Europe Aims to Achieve Strategic Autonomy for Semiconductors," The Brookings Institution, August 9, 2022; Dan Robinson, "EU Still Getting its Act Together on European Chips Act Funding," *The Register*, November 24, 2022.

[78] Trusted chips refer to efforts by the U.S. government and military in cooperation with industry to control the supply chain of production to ensure that the production of chips for sensitive applications are secure, reliable, and trustworthy.

[79] See European Commission's Europe Chips Act homepage at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en.

[80] Foo Yun Chee, "EU Chips Act likely to get green light on April 18," *Reuters*, April 5, 2023; "Chips Act: Council and European Parliament strike provisional deal," European Council Press Release, April 18, 2023.

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production and design centers; and 3) emphasizes the importance of international cooperation and IP protection in developing a European semiconductor ecosystem. The agreement commits $3.6 billion in funding for the Chips for Europe Initiative through existing frameworks. Specifically, it creates a new semiconductor objective in the Digital Europe Programme and leverages funding from the Horizon Europe research framework.[81]

Some experts at the Brookings Institution have cautioned that what they call the slowness of EU decisionmaking, the absence of a specific public procurement mechanism that would allow for bidding for semiconductor projects, and the lack of a process to coordinate projects and screen foreign investments received by member states could impede implementation of the European Chips Act.[82] Moreover, the Brookings experts caution that the amount of public-private investment may be insufficient to meet the act's targets. The proposed talent efforts do not appear to address more systemic issues in the European innovation system, including the need for competitive salaries to attract talent to particular projects.[83] Despite these challenges, some analysts see the effort as an important step forward in strategizing and coordinating thinking in Europe on how to promote and protect technological innovation, including with regard to China. Some analysts assess that while the plan could be more focused on European strengths such as R&D, the plan appears to be helping stimulate new investments.[84]

At the member-state level, in July 2022, the French government announced plans to invest $5.45 billion into joint European investment projects for semiconductors as part of part of *France 2030*, a plan the government launched in late 2021 to support France's industrial development in strategic sectors.[85] In December 2021, the government of Germany announced approval of funding for 32 semiconductor materials, design, and manufacturing projects under the EC's Important Project of Common European Interest (IPCEI) program, which includes a $12 billion investment fund for microelectronics projects.[86] In May 2022, the German government announced $14.7 billion in government support for semiconductor investment.[87]

In response to European government incentives, in March 2022, Intel committed to investing $88 billion in Europe over the next ten years. Initial commitments toward this larger target include $19 billion for a foundry in Germany, $13 billion to expand a facility in Ireland, and $4.9 billion for an assembly and packaging facility in Italy. Intel also announced plans to build a R&D center and set up its main European foundry design center in France.[88] In July 2022, STMicroelectronics and GlobalFoundries announced plans for a $5.7 billion wafer fab in France that reportedly is receiving assistance from the French government.[89]

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[81] Ibid.

[82] Paul Timmers, "How Europe Aims to Achieve Strategic Autonomy for Semiconductors," The Brookings Institution, August 9, 2022.

[83] Ibid.

[84] See, for example, Alicia García Herrero and Niclas Poitiers, "Europe's Promised Semiconductor Subsidies Need to be Better Targeted," Bruegel Institute, October 17, 2022.

[85] Anne-Françoise Pelé, "France Invests Over €5B in Semiconductors," *EETimes Europe*, July 13, 2022.

[86] "32 microelectronics projects ready to take off, Minister Habeck: 'We Need to Bring the Production of Semiconductors Back to Germany and Europe," Press Release, German Federal Ministry for Economic Affairs and Climate Action, December 20, 2021.

[87] Dan Robinson, "Germany Makes New Move to Attract Chip Manufacturers," *The Register*, May 6, 2022.

[88] Kris Holt, "Intel Plans to Build a $19 billion Chip Plant in Germany," *TechCrunch*, March 15, 2022.

[89] Maria Deutscher, "STMicro and GlobalFoundries to Build $5.7B Semiconductor Fab in France," *Silicon Angle*, July 11, 2022.

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India

India is a global leader in information technology (IT) software services and has been attracting significant foreign investment in IT hardware. The Indian government has also sought to boost investment in semiconductors and microelectronics. India has benefited from major U.S. information technology firms such as Apple, Dell, and Flextronics that have turned to India in seeking to move certain lower-end production out of China.[90] India has also been a focus of U.S. government efforts to develop secure supply chains in critical sectors, including semiconductors, among allies and like-minded countries. In May 2022, the U.S. and Indian governments announced a new initiative on Critical and Emerging Technology (iCET) and pledged cooperation in defense and other strategic technologies, including semiconductors.[91]

In 2019, the Modi government launched the India Semiconductor Mission as a part of its "Made in India" initiative. In late 2021, the government renewed its commitment of $10 billion to develop India's semiconductor industry with an emphasis on attracting foreign investment and leveraging partnerships with U.S. and foreign firms. The government has committed to cover 50% of the costs of setting up a fab for any technology node size, and for the production of displays, compound semiconductors, photonics, and sensors. The subsidies also cover chip assembly, packaging, and test and design facilities.[92]

These efforts build on a series of incentive schemes that the Indian government has launched over the past several years. The government's Production-Linked Incentive (PLI) scheme seeks to attract up to $25 billion in semiconductor investment and offers financial incentives over a four to five year period of up to 6% of net incremental sales (assessed over a base year) of goods manufactured in India. The initiative includes laptops, tablets, PCs, and servers.[93] The government's Design-Linked Incentive (DLI) initiative offers financial incentives and infrastructure support over a five-year period.[94] The PLI scheme for Large Scale Electronics Manufacturing has sought to boost domestic manufacturing and attract foreign investment in mobile phone manufacturing, electronic components, and assembly, testing, marking, and packaging (ATMP) facilities. The Scheme for the Promotion of Electronic Components and Semiconductors (SPECS) has sought to position India as a global hub for design and manufacturing, including in Electronics System Design and Manufacturing (ESDM), by encouraging capabilities in core components. The program finances 25% of capital expenditures for firms producing certain electronics and semiconductor components, including chipsets and sub-assemblies.[95] The Modi government has also created high technology clusters with a target of building at least two new semiconductor fabs and two new display fabs. Under the plan, the

[90] "Production Linked Incentive Scheme (PLI) for IT Hardware," Ministry of Electronics and Information Industry, Government of India, at https://www.meity.gov.in/esdm/pliithw.

[91] United States and India Elevate Strategic Partnership with the initiative on Critical and Emerging Technology (iCET)," White House Fact Sheet, January 31, 2023.

[92] "Modified Programme for Semiconductors and Display Fab Ecosystem," Ministry of Electronics and Information Industry, Government of India, at https://www.meity.gov.in/esdm/Semiconductors-and-Display-Fab-Ecosystem.

[93] "Production Linked Incentive Scheme (PLI) for Large Scale Electronics Manufacturing," Ministry of Electronics and Information Industry, Government of India, https://www.meity.gov.in/esdm/pli.

[94] Shaumik Ghosh, "India-US Semiconductor Cooperation: Can India Insert Itself into the Pantheon of Global Chipmakers with a Little Help from Washington?," *The Diplomat*, December 12, 2022.

[95] "Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS)," Ministry of Electronics and Information Industry, Government of India, https://www.meity.gov.in/esdm/SPECS.

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government is offering to fund up to 50% of the cost of fabs and up to 50% of certain costs for design firms.[96]

Bureaucratic inefficiencies and water and energy shortages have reportedly affected India's ability to attract foreign investment.[97] Despite these limitations, India is attracting new projects, likely in response to growing global demand and efforts by IT firms to develop alternative markets to China.[98] Recently, ISMC—a semiconductor joint venture between Abu Dhabi-headquartered Next Orbit Ventures and Tower Semiconductors, an Israeli-based firm acquired by U.S.-headquartered Intel in 2022—announced plans to invest $3 billion in a semiconductor fab in India's southern Karnataka state.[99] India's oil, gas, and mining conglomerate Vedanta is partnering with Taiwan's Foxconn to invest $19.5 billion to build a semiconductor and display fab in Gujarat, the home state of Indian Prime Minster Modi. The Gujarat state is reportedly providing subsidies for capital expenditures and electricity. Foxconn is providing the technology and Vedanta is providing the financing for the project.[100]

China

Key Policy Efforts

The scope and scale of China's state-led efforts are unprecedented when considering the amount of state funding involved, the Chinese government's stated ambitions to lead across all segments of the entire semiconductor value chain, the targeting of U.S. and other foreign capabilities, and the particular methods that China is using. U.S. officials have assessed many of these practices violate, circumvent, or otherwise challenge current global trade rules.[101] The executive branch has expressed its concerns about the ways in which China's state-led semiconductor policies are pressuring or encouraging U.S. and other foreign semiconductor companies to transfer key technology, IP, talent, and R&D to China, thereby boosting the competitiveness of China's semiconductor industry.[102]

In June 2014, the PRC government published a plan, Guideline for the Promotion of the Development of the National Integrated Circuit Industry, with the apparent goal of establishing a world-leading semiconductor industry in all areas of the integrated circuit supply chain by 2030. The document included measures to support an aggressive growth strategy intended to meet 70% of China's semiconductor demand with domestic production by 2025. In 2018, China revised the goal, setting an objective of expanding its domestic production of semiconductors (including production by foreign firms in China) to meet 80% of domestic demand by 2030, as part of its

[96] "Cabinet Approves Programme for Development of Semiconductors and Display Manufacturing Ecosystem in India," Government of India Press Release, December 15, 2021, at https://pib.gov.in/PressReleasePage.aspx?PRID=1781723.

[97] Srishti Khemka, "India's Prospects in the Global Semiconductor Manufacturing Race," Council on Foreign Relations blog, December 21, 2022.

[98] Ibid.

[99] Munsif Vengattil, "Chip Consortium ISMC to Set Up $3 billion Plant in India's Karnataka," *Reuters*, May 1, 2022.

[100] Munsif Vengattil and Aditya Kalra, "Vedanta, Foxconn to invest $19.5 billion in India's Gujarat for Chip, Display Project," *Reuters*, September 13, 2022.

[101] *Executive Office of the President, President's Council of Advisors on Science and Technology,* Report to the President: Ensuring Long-Term U.S. Leadership in Semiconductors, January 2017.

[102] CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter; James A. Lewis, Learning the Superior Techniques of the Barbarians: China's Pursuit of Semiconductor Independence, Center for Strategic and International Studies, January 2019; and Office of the United States Trade Representative (USTR), Section 301 Report, March 22, 2018, p. 113.

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Made in China 2025 industrial strategy.[103] The semiconductor market research company IC Insights estimates that integrated circuits produced in China accounted for approximately 16% of China's total domestic market for semiconductors in 2020, valued at $143.3 billion.[104] While China is likely to fall short of its actual targets, such ambitious targets and policies tied to these targets are accelerating efforts to develop China's industry.

China's policies feature a substantial and central role for the government in directing and financing Chinese businesses to obtain foreign IP related to semiconductors. The Chinese government uses production targets; subsidies; tax preferences; trade and investment barriers (including pressure to engage in joint ventures); it also uses antitrust, IP, procurement, and standards practices that are widely viewed as discriminatory.[105] The policies seek to leverage China's central role in global consumer electronics manufacturing and potential as a semiconductor production hub to incentivize and pressure foreign companies to localize production, share technology, and partner with the Chinese government and affiliated entities. To implement its semiconductor plan, China created a government fund—the China Integrated Circuit Investment Industry Fund (CICIIF)—to channel an estimated $150 billion in state funding in support of domestic industry, state-directed overseas acquisitions, and the purchase of foreign semiconductor equipment. In October 2019, China announced a second semiconductor fund with an estimated capitalization of $28.9 billion.[106] In December 2022, reports indicated that China was planning to roll out an additional $143 billion to support the development of PRC fabs and the capital costs of related semiconductor manufacturing equipment. Bloomberg reported in January 2023 that these plans might be on hold as the PRC government deliberated how best to structure its support, but other reporting indicates that new funds may already be supporting the significant uptick in PRC firms' purchase of imported semiconductor equipment.[107]

Since August 2020, the PRC government has issued several new policy measures to boost the development of its semiconductor and software industries. In August 2020, China's State Council issued the Notice on Several Policies to Promote the High-quality Development of the Integrated

[103] China's State Council, "Guideline for the Promotion of the Development of the National Integrated Circuit Industry," June 2014; China's State Council, "Notice on Issuing Several Policies to Promote the High-Quality Development of the Integrated Circuit Industry and the Software Industry in the New Period," Guofa (2020) 8, August 4, 2020; Center for International Governance Innovation, "Beyond 'Forced' Technology Transfers Analysis of and Recommendations on Intangible Economy Governance in China," CIGI Papers No. 239, March 2020, at https://www.cigionline.org/sites/default/files/documents/no239_2.pdf; John VerWey, "Chinese Semiconductor Industrial Policy: Past and Present," USITC, *Journal of International Commerce and Economics*, July 2019; U.S. Chamber of Commerce, *Made in China 2025: Global Ambitions Built on Local Protections*, 2017; and Made in China 2025 (2017), Publishing House of the Electronics Industry, 2017, in Chinese language.

[104] Scott Foster, "Get Real about the Chinese Semiconductor Industry," *Asia Times*, January 18, 2021.

[105] For a discussion of China's semiconductor policies, see CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter.

[106] Christopher Thomas, *A New World Under Construction: China and Semiconductors*, McKinsey & Company, November 2015, at http://www.mckinsey.com/global-themes/asia-pacific/a-new-world-under-construction-china-and-semiconductors; Yoko Kubota, "China Sets up New $29 Billion Semiconductor Fund," *Wall Street Journal*, October 25, 2019; Tianlei Huang, "Government-Guided Funds in China: Financing Vehicles for State Industrial Policy," China Economic Watch, Peterson Institute for International Economics, June 17, 2019; and OECD, Trade and Agricultural Directorate, Trade Committee, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019, pp. 94-95.

[107] Julie Zhu, "China Readying $143 Billion Package for its Chip Firms in Face of U.S. Curbs," *Reuters*, December 13, 2022; "Battered by Covid, China Hits Pause on Giant Chip Spending Aimed at Rivaling US," *Bloomberg*, January 4, 2023; Monica Chen and Jessie Shen, "Chinese Foundries are Quietly Making Equipment Purchases," *DigiTimes*, February 3, 2023.

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Circuit Industry and Software Industry in the New Era, which provides a broad framework.[108] In March 2021, the Chinese government issued several implementing measures that include criteria that companies must meet to qualify for government preferences, as well as tax and tariff provisions. China's new policies encourage U.S. and foreign semiconductor companies—including those from Taiwan, Hong Kong, and Macau—to transfer certain technology, IP, talent, and R&D to separate corporate operations in China that are registered under PRC laws and other controls.

These policies target capabilities across the semiconductor value chain, including integrated circuit (IC) design, fabrication, equipment, software design and tools, packaging and testing, and materials. The policies offer preferential terms over a 10 year period—including tax, tariff, financing, and IP protection—for firms willing to establish capabilities, including production facilities, in China. The policies require companies to transfer certain IP—including a specific number of invention patents, depending on the subsector—to ownership by a China-based business that is legally separate from its corporate parent. This requirement potentially gives the PRC government greater control over certain technologies, including through the use of China's new export control law. Incentives include a 10-year corporate income exemption for advanced technology process nodes (28 nm and below), a 5-year exemption for fabrication lines of 65 nm and below nodes, a 2-year exemption for 130 nm and below fabrication lines, and import duty exemptions for IC manufacturers to purchase imported semiconductor materials and equipment.[109]

State of China's Industry and Role of Foreign Ties

China-headquartered semiconductor firms have made significant advances but remain dependent on foreign technology, expertise, and global markets.[110] China's domestic semiconductor production met 16.7% of China's $186.5 billion market demand in 2021. Some analysis project that this share could increase to almost 20% by 2025 but would fall short of the government's localization targets of 70% by 2025 and 80% by 2030.[111] Of the $31.2 billion of chips produced in China in 2021, PRC-headquartered firms produced $12.3 billion (an estimated 6.6% of total market demand) while foreign firms operating in China produced $18.9 billion, according to media reporting of industry estimates.[112]

China's reliance on foreign technology highlights the ways in which U.S. and other foreign industry ties are building China's capabilities.[113] China has looked to joint ventures and foreign acquisitions to further its position in semiconductors. Leading U.S. technology firms with semiconductor-related expertise have partnered with or have invested in Chinese state firms tied

[108] China's State Council Notice of Several Policies to Promote the High Quality Development of the Integrated Circuit (IC) and Software Industries in the New Era, Guofa [2020] No. 8, August 2020, available in Chinese language at http://www.gov.cn/zhengce/content/2020-08/04/content_5532370.htm.

[109] See CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter.

[110] OECD, Trade and Agricultural Directorate, Trade Committee, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019, p. 21.

[111] IC Insights, "China to Fall Far Short of its "Made-in-China 2025" Goal for IC Devices," press release, May 21, 2020; "China Forecast to Fall Far Short of its "Made in China 2025" Goals for ICs," Design and Reuse, January 7, 2021; and Che-Jen Wang, "China's Semiconductor Breakthrough: SMIC's 7nm process advancement – despite heavy U.S. sanctions – will have major implications for East Asia," *The Diplomat*, August 20, 2022.

[112] Ibid.

[113] Saif M. Khan, *Maintaining the AI Chip Competitive Advantage of the United States and its Allies*, Center for Security and Emerging Technology, CSET Issue Brief, December 2019, p. 4.

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to China's national semiconductor plan.[114] In fabrication, in 2015, Qualcomm and IMEC[115] established a joint R&D venture with Shanghai Manufacturing International Corporation (SMIC) and Huawei to support the Chinese firms' efforts to make 14 nm logic chips.[116] Foreign acquisitions have positioned China in the advanced packaging market, including a 2015 acquisition of Singapore-based STATS ChipPac that was funded by China's national semiconductor fund.[117] In 2016, China-headquartered Nantong Fujitsu took an 85% equity stake in AMD's packing and testing businesses in Malaysia and China. In 2015, Beijing E-Town Capital, a shareholder in China's national semiconductor fund, acquired U.S.-headquartered Mattson Technology, thereby gaining specialized capabilities in etchers and rapid thermal processing equipment and strip tools used in semiconductor production.[118] In 2015, a PRC consortium sponsored by China's national semiconductor fund acquired Integrated Silicon Solutions, Inc., and gained specialized chip expertise.[119]

Since 2016, the executive branch has sought to counter China's statist industrial policies by tightening foreign investment reviews and the licensing of dual-use technologies to China (see "U.S. Export Controls"), and through actions against PRC IP theft. Since 2016, the Committee on Foreign Investment in the United States (CFIUS) has thwarted or, through referral to the president for action, blocked PRC state investments or acquisitions of several semiconductor firms, including Aixtron, Fairchild, Lattice, Micron, Western Digital, and Xcerra.[120] In 2018, the Department of Justice charged a Chinese state-owned company, Fujian Jinhua Integrated Circuit, allegedly in concert with the Taiwan firm United Microelectronics Company, for stealing technology for the manufacture of DRAM chips from Micron Technology.[121] The Department of

[114] John VerWey, *Chinese Semiconductor Industrial Policy: Past and Present*, USITC, *Journal of International Commerce and Economics*, July 2019.

[115] IMEC is the Belgium-based Interuniversity Microelectronics Centre, an international research and development organization focused on nanoelectronics and digital technologies.

[116] "SMIC, Huawei, Imec, and Qualcomm in Joint Investment on SMIC's New Research and Development Company," SMIC, *PRNewswire*, June 23, 2016.

[117] Securities and Exchange Commission, EDGAR System, Semiconductor Manufacturing International Corporation, "Inside Information Announcement: Co-Investment Agreement and Investment Exit Agreement in Relation to Proposed Acquisition," December 22, 2014, at https://www.sec.gov/Archives/edgar/data/1267482/000130901415000021/exhibit1.htm; and Mark Lapedus, "Consolidation Hits OSAT Biz," *Semiconductor Engineering*, February 18, 2016.

[118] Securities and Exchange Commission, EDGAR System, at https://www.sec.gov/Archives/edgar/data/928421/000119312515392660/d46587dex992.htm; "Mattson Technology, Inc. Announces Completion of Acquisition by Beijing E-Town Dragon Semiconductor Industry Investment Center," Yahoo! Finance, https://finance.yahoo.com/news/mattson-technology-inc-announces-completion-131206198.html.

[119] "GigaDevice to Merge with ISSI, Say Sources," *China Flash Market*, November 22, 2016.

[120] Allison Gatlin, "Micron Snubs Tsinghua, Favors Another Chinese Partnership: Analyst," *Investor's Business Daily*, February 16, 2016; James Fontanella-Khan, "Fairchild Rejects $2.6bn Chinese Offer," *Financial Times*, February 16, 2016. Joshua Jamerson and Eva Dou, "Chinese Firm Ends Investment in Western Digital, Complicating SanDisk Tie-Up," *Wall Street Journal*, February 23, 2016. U.S. Department of Treasury, "Statement on the President's Decision Regarding Lattice Semiconductor Corporation," press release, September 17, 2017; Securities and Exchange Commission, EDGAR System, Xcerra Corporation, 8-K filing, February 22, 2018, at https://www.sec.gov/Archives/edgar/data/357020/000119312518054209/d533034d8k.htm.

[121] Department of Justice, "PRC State-Owned Company, Taiwan Company, and Three Individuals Charged with Economic Espionage," press release, November 1, 2018. The Department of Justice also announced a new initiative aimed at countering IP theft from China. For more information, see "Attorney General Jeff Sessions Announces New Initiative to Combat Chinese Economic Espionage," press release, November 1, 2018.

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Commerce sanctioned Fujian Jinhua by restricting its access to U.S. technology through U.S. export controls.[122]

U.S. Export Controls

The U.S. government uses export controls to prevent China from acquiring leading-edge technology, including semiconductors, which can be used for military as well as commercial purposes. Export controls restrict and require licenses for the transfer of controlled technologies.[123] Since 2020, the U.S. government has curtailed the export of dual-use technologies to certain PRC firms such as Huawei, and SMIC.[124] BIS retains licensing discretion on a case-by-case basis, however. In October 2021, the House Foreign Affairs Committee released BIS licensing data for Huawei and SMIC from November 2020 to April 2021. Much of it involved semiconductor technology: BIS approved 113 licenses for Huawei ($61.4 billion); and returned 48 ($29.8 billion) without action. BIS approved 188 licenses for SMIC ($41.9 billion), and returned 17 ($1.2 billion) without action.[125]

China has worked around export control restrictions through corporate restructuring, the use of R&D centers in the United States, and active participation in U.S.-led open source technology platforms, such as RISC-V, as an alternative way to access U.S. semiconductor expertise.[126] In November 2020, China's government, acting through the Shenzhen branch of the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), took control of Huawei's smartphone business, Honor, allowing the firm in the absence of subsequent BIS actions to evade U.S. export controls on Huawei.[127] Since restructuring, Honor has resumed

[122] Department of Commerce, "Addition of Fujian Jinhua Integrated Circuit Company, Ltd. (Jinhua) to the Entity List," press release, October 29, 2018 (effective October 30, 2018).

[123] The United States has imposed controls on exports from China related to semiconductors and semiconductor manufacturing equipment in various forms since the Cold War. The U.S. Department of Commerce's BIS and the Department of State's Directorate of Defense Trade Controls (DDTC) are the two primary agencies that administer export controls. They focus on dual-use technologies, including semiconductor goods, which can potentially have both commercial and military applications. In addition, DOD's Defense Technology Security Administration (DTSA) coordinates the technical and national security review of direct commercial sales export licenses and commodity justification requests, including reviewing and commenting on proposed and final rule changes on export controls from the Departments of Commerce and State. See also CRS In Focus IF11627, *U.S. Export Controls and China*, by Karen M. Sutter and Christopher A. Casey.

[124] The Entity List identifies persons involved, or with the potential to be involved, in activities contrary to U.S. national security or foreign policy interests. BIS typically requires a license for U.S. shipments of Export Administration Regulations (EAR) items to those on the Entity List. BIS presumes denial for some parties, but still can approve licenses on a case-by-case basis. BIS, "Commerce Addresses Huawei's Efforts to Undermine Entity List, Restricts Products Designed and Produced with U.S. Technologies," press release, May 15, 2020, at https://www.commerce.gov/news/press-releases/2020/05/commerce-addresses-huaweis-efforts-undermine-entity-list-restricts; and BIS, interim final rule and request for comments, "Export Administration Regulations: Amendments to General Prohibition Three (Foreign-Produced Direct Product Rule) and the Entity List," 85 *Federal Register* 29849, May 19, 2020, at https://www.federalregister.gov/documents/2020/05/19/2020-10856/export-administration-regulations-amendments-to-general-prohibition-three-foreign-produced-direct.

[125] "McCaul Brings Transparency to Tech Transferred to Blacklisted Chinese Companies," Press Release, Office of Representative McCaul, October 21, 2021.

[126] Thilo Hanneman, Daniel H. Rosen, Cassie Gao, and Adam Lysenko, "Two-Way Street: US-China Investment Trends-2020 Update," *Rhodium Group*, May 11, 2020; Michael Brown and Pavneet Singh, "China's Technology Transfer Strategy," *Defense Innovation Unit Experimental (DIUx)*, January 2018; Runhua Zhao, "Briefing: China Sets up Domestic Chip Alliance," *Xinhua News Agency*, November 9, 2018; "China Mobile Deepens O-RAN Research, Showcasing Significant Achievements at MWC2019," *PRNewswire*, February 26, 2019.

[127] Scott Livingston, "Huawei, HONOR, and China's Evolving State Capitalist Tool Kit," CSIS Brief, December 2020; Chen Qingqing and Shen Weiduo, "Update: Former Chief Executive of Honor Zhao Ming becomes CEO of 'New' (continued...)

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cooperation with Huawei's original suppliers, including Intel, MediaTek, Micron, Microsoft, Qualcomm, and Samsung.[128] U.S. open source technology platforms offer PRC firms and government institutes access to top U.S. technology talent to train and troubleshoot on particular projects.[129] For example, in 2019, Pingtouge, the chip subsidiary of PRC-headquartered Alibaba, released its first processors—Xuantie 910 and Hanguang 800—that relied on foreign technology and expertise shared through RISC-V to develop the chips.[130]

Effective August 12, 2022, BIS issued controls on electronic design automation (EDA) software for the development of advanced logic chips that use a particular transistor architecture pursued by semiconductor manufacturers to produce the most advanced logic chips at nodes of 3 nm and below.[131] In October 2022, BIS enacted new restrictions on the exports of certain advanced chips which can be used for supercomputing and AI applications to China. Additionally, BIS introduced new license requirements for various semiconductor equipment and services by U.S. persons that are used in the production of advanced logic and memory chips in PRC facilities. These new controls aim to slow the indigenous ability of China to develop and mass-produce advanced chips.[132] Licenses for exports to advanced semiconductor manufacturing facilities owned by PRC companies face a "presumption of denial." BIS has discretion on whether to approve or deny licenses under the measures. According to news reports, in February 2023 the United States reached an agreement with the Netherlands and Japan to restrict certain advanced semiconductor equipment sales to China.[133]

U.S. export controls policy and licensing practices may be inadequate in light of recent progress that leading PRC firms, such as SMIC and YMTC, have made in chip fabrication. For example, with new plurilateral export control restrictions on certain EUV lithography equipment in place for China, some analysts assess SMIC may continue to focus on an optical-only (non-EUV) approach to fine tune its first generation 7 nm approach; other analysts assess SMIC could also go

Company After Sub-brand Sold by Huawei," *Global Times*, November 17, 2020; "Huawei Officially Sold Glory to Shenzhen Zhixinxin: The Shareholder Structure Behind it is Disclosed," *Sina Technology*, November 17, 2020.

[128] Zhao Juecheng and Shen Weiduo, "Honor 50 Series Handset Powered with Qualcomm Chips Launched in Shanghai," *Global Times*, June 16, 2021.

[129] The nature of open source allows participants in one country to gain from the technological expertise that resides in another country. Proponents of open source technology highlight its ability to speed technology development, ensure interoperability, and increase security by identifying and resolving problems more quickly. Critics highlight that open technology platforms explicitly threaten the core IP that has been developed by leading U.S. software and hardware companies. Others argue that open technology platforms are rapidly developing in a direction that could be used to exploit gray areas or gaps in U.S. export control authorities. See Caroline Meinhardt, "Open Source of Trouble: China's Efforts to Decouple from Foreign IT Technologies," *Mercator Institute for China Studies*, March 18, 2020; and Laura Dobberstein, "Beijing wants to Level up China's Software Industry, with an Emphasis on FOSS," *The Register*, December 1, 2021.

[130] Josh Horwitz, "Alibaba's Chip Division Releases First Core Processor," *Reuters*, July 26, 2019; Fangyu Cai, "Alibaba Open Sources Its MCU to Boost AI Research," *Synched*, October 10, 2019; Arjun Kharpal, "Alibaba Unveils Its First AI Chip as China Pushes for Its Own Semiconductor Technology," *CNBC*, September 25, 2019.

[131] New ECCN 3D006 added to the CCL. Bureau of Industry and Security, "Commerce Implements New Multilateral Controls on Advanced Semiconductor and Gas," press release, August 12, 2022.

[132] BIS placed restrictions on items destined for fabs in the PRC producing logic chips at 16 nm or below, DRAM memory chips at 18 nm and below, and NAND flash memory chips with 128 layers or more. Bureau of Industry and Security, "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)," press release, October 7, 2022.

[133] "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification," BIS Rule, October 13, 2022; Alexandra Alper and David Sheperdson, "U.S. official acknowledges Japan, Netherlands deal to curb chipmaking exports to China," *Reuters*, January 31, 2023.

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to 5 nm or even 3 nm with such an optical-only approach.[134] BIS added YMTC to the Entity List in December 2022; some analysts assert that the resulting restricted access to U.S.-based equipment suppliers and technical support will impact the ability of YMTC to mass produce the most advanced NAND chips.[135]

- SMIC has developed a high-density logic cell density that is similar to the first generation 7 nm processes previously developed by Samsung and TSMC. TSMC's first generation 7 nm process was an all-optical process with no EUV layers. SMIC's CPP (a combination of gate length, contact width, and gate-to-contact spacer thickness) appears to be closer to a "10 nm" type process, which may suggest that SMIC may still be struggling to operationalize its advanced technology processes.
- In August 2022, YMTC reportedly started to produce and sell to its customers a high density (200+ layers) 3D NAND using a technology it calls Xtacking 3.0. YMTC has declined to publicly disclose more information about its process technology, possibly because of concerns that this information about its use of foreign technologies could inform future U.S. export controls.[136] YMTC reportedly uses process tools from U.S.-headquartered Lam and licenses technology from U.S.-headquartered Adei (Xperi).[137] YMTC is currently operating one fab outside Wuhan, which the PRC government supported to keep open in the early part of the pandemic by providing exceptions to shutdowns and transporting workers to the facility.[138] YMTC's second fab is reportedly almost built out with equipment, and the company plans for two additional fabs each producing 100,000 wafers per month. YMTC has received an estimated $24 billion in PRC government subsidies.[139]

CHIPS Act Guardrails

While the CHIPS Act set a threshold that companies receiving financial awards under the act may not produce semiconductor technology in China below the 28 nm node for 10 years, China's industrial policies consider and incentivize semiconductor technology at the 28 nm technology node as advanced technology.[140] This gap in approach between the United States and China appears to leave China a strategic opening that could accelerate U.S. technology transfer and offshoring in the 28 nm segment of semiconductor chips and related equipment and services to China and relatedly allow for the potential concentration of global semiconductor capacity at this

[134] Scotten Jones, "Does SMIC have 7nm and if so, what does it mean," SemiWiki Forum, September 7, 2022; Che-Jen Wang, "China's Semiconductor Breakthrough: SMIC's 7nm process advancement – despite heavy U.S. sanctions – will have major implications for East Asia," *The Diplomat*, August 20, 2022.

[135] Bureau of Industry and Security, "Additions and Revisions to the Entity List and Conforming Removal From the Unverified List," 87 *Federal Register* 77505-77518, December 16, 2022; TrendForce, "YMTC Could Abandon Market for 3D NAND Flash by 2024 Following US Government's Decision to Place It on Entity List, Says TrendForce," press release, December 16, 2022, at https://trendforce.com/presscenter/news/20221216-11503.html.

[136] Dylan Patel, Semi analysis Blogpost, August 12, 2022.

[137] "Xperi Licenses Hybrid Bonding Technology to Yangtze Memory Technologies Co., Ltd. (YMTC)," *BusinessWire*, October 12, 2021.

[138] Cheng Ting-Fang and Lauly Li, "China Lets Wuhan Tech Plants Bypass Lockdown to Stay Open," *Nikkei Asian Review*, March 4, 2020.

[139] "China's top memory chip maker treads path to semiconductor self-sufficiency as US ponders trade sanctions," *South China Morning Post*, September 26, 2022.

[140] See CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter.

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technology node in China.[141] The 28 nm node is cost effective for many applications that are seeing increasing demand, including connectivity (e.g., 5G technologies, bluetooth, wireless); power electronics for electric vehicles; display systems (e.g., mobile phone and television screens); the internet of things (e.g., smart devices for watches and home applications); and sensing applications. A great deal of current and emerging advanced semiconductor functions leverage or have the potential to leverage the 28 nm node among other technology nodes. China may take a leadership in mature technology nodes for which U.S. technology licensing, trade, and investment are not restricted. Additionally, China may also make advancements through the advent of new materials and semiconductor production and packaging approaches that allow for a broader use of different types of chips and expanded functions for chips at current technology nodes.

Some semiconductor industry experts say that there is a significant overlap in technology from one node to the next, with new nodes incorporating approximately 80% of the technology from previous nodes. This technology overlap potentially gives China an important baseline in critical capabilities from which they could advance to smaller nodes.[142] There are risks that China could lead globally in 28 nm production and leverage this leadership position to move up the technology value chain into more advanced applications and technology. China appears poised to gain significant ground in this segment due to the scope and scale of China's industrial policy efforts and the degree of government support and prioritization. PRC firms benefit from state backing in addressing challenges that companies generally face in shifting to more advanced levels of production. Additionally, the size of China's market and its role as the global center for consumer electronics production and emerging technologies using chips, such as electric vehicles give it unique advantages to scale production. While a shift into more advanced chips is challenging and expensive, this is a top goal of China's industrial policies and the PRC government is likely to subsidize costs and support efforts to overcome these challenges.[143]

Policy Implications and Issues for Congress

Congress has acted to provide almost $53 billion in support to sustain and boost U.S.-based semiconductor fabrication capacity and U.S. competitiveness in the semiconductor industry. Many U.S. allies and partners have long supported and subsidized their semiconductor industries, and are again seeking to support their industries to maintain their competitive edge, revitalize certain capabilities, and move into new areas. China arguably presents a unique and serious U.S. policy challenge, as it is advancing rapidly across all segments of the supply chain and technology levels, due in large part to the amount of state support and its market scale, as well as through ties to industry, research universities, and open source technology in the United States and U.S. allied countries.

Congress laid out its legislative intent on this issue with the CHIPS Act of 2022. Given the amount of money involved, the complexity of the semiconductor industry, the key role of global supply chains, and the relative lack of U.S. government experience in industrial policy and executing programs of this type, Congress might consider engaging in active oversight of the

[141] Chris Park, "Potential Dependency Oversight in U.S.-South Korea Chip Policy," Council on Foreign Relations Blog, September 19, 2022.

[142] CRS discussion with U.S. semiconductor firm experts on September 21, 2022.

[143] For the last several decades, manufacturers advanced to next generation nodes by shrinking electronic features (i.e., transistor) on the chip on a two dimensional (2D) plane; after the 28 nm node, top manufacturers pursued three-dimensional transistor architectures to continue advancing chip performance due to technical constraints leading to many substantial changes in the manufacturing process and higher costs.

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implementation of this law. For example, Congress could engage regularly and actively in an effort to understand implementation details as they are being shaped or announced. As Congress oversees the implementation of the CHIPS Act of 2022, considerations include

Policy coordination and market competition among allies and partners

- With regard to coordinated efforts with allies and partners, the U.S. government is navigating tensions of both shared interests and market competition to ensure that U.S. policy measures are effective. A key objective of the CHIPS Act was to ensure U.S.-based fabrication to address advanced chip needs. Currently only TSMC and Samsung produce chips at the most advanced nodes. U.S.-based investment by these firms will likely be important as will advancing the capabilities of existing and new U.S. firms. Some analysts have noted that Europe will also need help from like-minded countries in Asia to realize its policy objectives.[144]
- In an effort to coordinate approaches to supporting the semiconductor industry, in March 2022, the Biden Administration proposed a "Chip 4" alliance among the United States, Japan, South Korea, and Taiwan to strengthen supply chain ties and leverage the respective capabilities of each partner.[145] In addition, the Biden Administration has created a policy initiative to coordinate with India on semiconductors and other technologies.[146]
- Congress might assess progress and challenges in the Administration's efforts to work with U.S. allies and partners. Among issues Congress could consider are whether U.S. efforts are consistent with the act's direction to boost U.S.-based capacity in semiconductor fabrication, U.S. advanced semiconductor capabilities across the supply chain, and innovation. Among issues that have arisen are the extent to which the U.S. government can assure U.S. and foreign companies that it will protect their corporate secrets from being shared with competitors. Other issues are outlined below in the discussion of economic effects and export controls.

Economic and market effects and counter-effects

- Congress gave the Secretary of Commerce significant discretion with regard to programmatic activity and disbursement of funds, including which parts of the supply chain or companies to prioritize and fund. Potential implementation risks include spending or programs that do not sufficiently align to key goals, programmatic waste, unintended or unforeseen market counter-effects, and a failure to mobilize follow-on market activities that sustain or introduce new investments and market activity in areas that the U.S. government seeks to encourage. For example, there may be tradeoffs in prioritizing short-term over long-term needs, or one market segment of the supply chain over another.
- There is a risk that foreign governments will seek to outspend one another to boost their industries and create serious market distortions in an industry already susceptible to large market swings. There may be tradeoffs in favoring

[144] Arjun Kharpal, "Europe Wants to Become a Leader in Chips. But It's Going to Need Help," *CNBC*, February 10, 2022.

[145] Dashveenjit Kaur, "Japan, US Join Forces to Stay Ahead in the Semiconductor Race," *TechHQ*, August 2, 2022.

[146] "Fact Sheet: United States and India Elevate Strategic Partnership with the initiative on Critical and Emerging Technology (iCET)," Office of the White House, January 31, 2023.

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established or new market players. A new government role may not necessarily be as effective or efficient as market forces, and this new effort to rebalance market and government roles may be hard to get right. Additionally, increased government funding frees up some corporate capital with few conditions about where and how firms will invest their own funds.

- Congress might track new investment deals and patterns as well as market effects. Congress could consider new measures that introduce an additional market role. For example, Congress could consider whether to require or incentivize matching corporate contributions among recipients of U.S. government monies or seek other ways to pool or leverage private monies to support its goals. In similar fashion, Congress might look to end user markets of semiconductor chips to assess the extent to which Commerce's allocation of funds has addressed supply chain vulnerabilities and aligned with market demand. Congress also might examine options to incentivize the use of U.S. manufactured chips by particular end customers and industries, and incentivize the development of production supply chains that use semiconductor chips among allies and like-minded trade partners. For example, while the United States has a large auto production base to use U.S.-produced semiconductor chips, the information communications technology (ICT), consumer electronics, and industrial electronics firms (e.g., data servers) do a great deal of production offshore and may not necessarily be committed to using U.S.-produced chips and developing such supply chains without additional policy measures. There may be synergies as some consumer electronics production, for example, is shifting outside of China to other markets, including Southeast Asia, India, and Mexico.
- Congress might consider whether to require that U.S. policies to implement the act explicitly seek to avoid counterproductive semiconductor subsidies competition among allies and other friendly nations. With many countries supporting increased semiconductor industry capacity, the United States and others have shared interests in avoiding global overcapacity in the sector. Congress could oversee the extent to which Department of Commerce and other U.S. agencies are collaborating with allies and partners to ensure that respective efforts are coordinated and mutually beneficial. Congress also might consider and examine policy options to address potential future semiconductor overcapacity in China. Following the U.S.-European Union Trade and Technology Council (TTC) meetings in May 2022, both sides said that they would aim to avoid a semiconductor subsidy competition by abiding by World Trade Organization rules and setting "common goals for incentives granted in respective territories and an exchange of information regarding such incentives on a reciprocal basis." This commitment appears to be quite broad and may be difficult to implement without more specific policy efforts.
- Given the number of governments offering semiconductor incentives, Congress might also consider whether U.S. firms (and foreign firms) should be allowed to accept, or be restricted from competing for, incentives from both the United States and other countries, and how U.S. corporate investments overseas support or detract from U.S. government supported-investments.
- Congress might look to shape U.S. trade and foreign policies to more specifically support the provisions and goals of the CHIPS Act. Congress might evaluate the extent to which provisions in the act create the intended market effects, including multiplier effects, in the U.S. market and more broadly across the global

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semiconductor supply chain. Congress might consider whether to pursue new measures to further incentivize market-based corporate activity. In this regard, Congress might consider how to strengthen, shift, or develop new global supply chains that align with the investments the U.S. government is making in the U.S. semiconductor industry. For example, developing ICT and electronics production in Mexico or Latin America might support the development of supply chains centered on U.S. chip production that could sustain and create new drivers for additional U.S.-based production.

- Congress could assess what types and levels of government support for a strategic industry such as semiconductors are effective and what types of current or new plurilateral or global rules and principles should govern such investments. Congress might also examine the ways in which governments' support for semiconductors are similar or diverge. For example, China's policies stand out in their requirements and incentives for foreign technology transfer and localization and the use of state-funded acquisitions of foreign companies to gain capabilities.

Balancing, aligning, and leveraging industry and government expertise and goals

- The use of a public-private partnership model to implement key parts of the CHIPS Act, such as the formation of the National Semiconductor Technology Center, leans on private sector leadership and goals.[147] On the one hand, this format helps ensure that industry expertise guides program development and sets priorities. On the other hand, there may be risks that industry's interests may not be consistent with government goals, priorities, or requirements. Congress may opt to consider mechanisms that ensure the alignment of these firms' interests with the interests Congress has expressed.
- In this context, Congress might oversee how the executive branch considers changes occurring within the industry and how technological and business trends might affect U.S. programs and policies intended to promote and protect the U.S. semiconductor industry. Congress might assess how agile current approaches are in the event that adjustments are needed. Industry changes underway include the use of new materials, open source technology platforms and architectures for hardware and software, evolution of the fabless model, the trend toward smaller-node chips, the creation and use of chiplets and system-on-chip (SoC) methods, AI applications, and the use of chips in a wider array of products and applications.

National Security Guardrails

Congress might consider the extent to which current investment restrictions in the CHIPS Act are adequate in general and to address specific concerns about China or whether additional conditions and protections are needed to secure federal investments and to help ensure intended outcomes. For example, while the U.S. government is not restricting semiconductor technology at the 28 nm node and above, PRC government policies incentivize investments in 28 nm node chips, which are used in a wide range of popular commercial products (e.g., mobile phones and smart devices), as well as military systems. Congress may opt to explore whether U.S. policy has left open a key semiconductor market

[147] For more information on the National Semiconductor Technology Center, see CRS Report R47523, *Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation*, by John F. Sargent Jr., Manpreet Singh, and Karen M. Sutter.

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segment in which China can develop and advance with significant global market effect. Congress might also assess to what extent U.S. export control policies, in design and in practice, are aligned with CHIPS Act restrictions, and whether to seek additional restrictions.

- To what extent are existing restrictions on U.S. investment in China's semiconductor adequate to address U.S. national security concerns? To what extent are additional conditions and protections needed to secure federal investments and to help ensure intended outcomes? For example, while the U.S. government is not restricting semiconductor technology at the 28 nm node and above, PRC government policies incentivize investments in 28 nm node chips, which are used in a wide range of popular commercial products (e.g., mobile phones and smart devices), as well as military systems.
- Congress might consider what the U.S. position on foreign collaboration in U.S. semiconductor R&D should be, in light of potential competition and national security concerns. Congress could examine whether current IP protections and other provisions in the CHIPS program related to entities of concern are adequate. Congress could determine whether there should there be closer R&D partnerships with key allies and partners and, if so, under what conditions and frameworks. Congress could determine the appropriate U.S. policy posture regarding PRC ties and participation in U.S. basic and applied research related to current and emerging semiconductor technologies and related fields.
- In contemplating such provisions, Congress might opt to consider the lifecycle and uses of a particular technology funded in whole or in part by the federal government. Congress may also opt to consider any potential touchpoints for China to access or obtain the know-how through the entire lifecycle of a technology, from the initial research stage through commercialization. Relatedly, Congress might consider whether China's targeting of U.S. R&D capabilities and its ability to leverage open source technologies merits additional U.S. government oversight and controls.
- In export controls, alignment and collaboration with key U.S. allies and trading partners arguably is critical to prevent China from exploiting policy incongruity toward semiconductor-related trade and investment. Government officials and foreign firms are likely concerned that any restrictions on technology trade are comprehensive and implemented consistently in practice to avoid scenarios in which some firms are not restricted from certain trade while others are allowed to trade through licenses.[148] U.S. policies will likely require or otherwise incentivize other governments to respond in kind with U.S. aligned approaches or new policies of their own.[149] Some companies' leaders have expressed concern that such restrictions may result in lost market opportunities in China. To what extent are companies adjusting and creating new ways to continue to operate in China in light of the new restrictions?[150]

[148] "US likely to limit S. Korean production of advanced chips in China: US official," Yonhap, February 24, 2023; Gregory C. Allen and Emily Benson, "Clues to the U.S.-Dutch-Japanese Semiconductor Export Controls Deal Are Hiding in Plain Sight," CSIS, March 1, 2023.

[149] Tobias Gehrke and Julian Ringhof, "The Power of control: How the EU Can Shape the New Era of Strategic Export Restrictions," European Council on Foreign Relations, May 17, 2023.

[150] Stephen Nellis and Jane Lee, "Nvidia Tweaks Flagship H100 Chip for Export to China as H800," *Reuters*, March 21, 2023.

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- In the fall of 2022, the Biden Administration announced new export controls on certain advanced chips used commonly in AI applications and supercomputers, as well as certain semiconductor equipment, software, and services for the production of advanced chips in China. Additionally, the United States has reached an agreement with the Netherlands and Japan to coordinate control of the export of certain semiconductor equipment and other technologies to China. Congress may opt to explore to what extent such controls will involve licenses or prohibitions on exports, as well as how strong and comprehensive the provisions are with regard to other types of chips and other parts of the supply chain that might remain unrestricted or less restricted.[151]
- Congress might explore whether to call for additional conditions or controls on the export of U.S. semiconductor equipment, tools, and software, exports that arguably play a critical role in advancing China's fabrication capabilities. U.S. sales of these items to China have increased nearly five-fold since 2014, when the PRC government launched its national semiconductor policy. Congress might consider whether to require the enactment of plurilateral controls and monitor them in practice to ensure they are exercised as intended.

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[151] Brad Glosserman, "High-Tech Tensions in the Japan-U.S. Relationship," *The Japan Times*, November 8, 2022.

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