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POLICY BRIEF

22-13 CHIPS Act Will Spur US Production but Not Foreclose China

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INTRODUCTION

The CHIPS and Science Act, signed by President Joseph R. Biden Jr. on August 9, 2022, represents the biggest US foray into industrial policy in 50 years.[1] Indeed, the most recent precedent, 66 years ago, was President Dwight Eisenhower's National Interstate and Defense Highway Act of 1956, also justified in large part by security concerns. The CHIPS Act provides $52.7 billion for US semiconductor research, development, manufacturing, and workforce development, including $39 billion in manufacturing incentives and $13.2 billion in R&D and workforce development. It also provides a 25 percent investment tax credit to incentivize semiconductor manufacturing in the United States. Together, the CHIPS investments and tax credit are meant to revitalize American semiconductor manufacturing and strengthen the global semiconductor supply chain.

Five forces pushed semiconductors to the apex of US industrial policy. First, a fear of Chinese technological ascendency in general and semiconductors in particular; second, an acute post-pandemic shortage of chips for making everything from automobiles to laptops; third, the claim that US semiconductor production dropped from 37 percent of the global total in 2000 to 12 percent in 2021;[2] fourth, an urgent concern to deny China and Russia access to advanced chips and chip-making machinery; and fifth, the vulnerability of advanced chips produced in Taiwan and South Korea (with US technology) to natural disaster or Chinese attack or blockade.

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1 See Gary Clyde Hufbauer and Euijin Jung, *Scoring 50 Years of Industrial Policy*, PIIE Briefing 21-5, Peterson Institute for International Economics, 2021.

2 The source of this claim is the influential report by Antonio Varas et al. for the Boston Consulting Group (BCG) and the Semiconductor Industry Association (SIA), titled *Government Incentives and US Competitiveness in Semiconductor Manufacturing*, September 2020. In February 2022, Mark Muro and Robert Maxim of the Brookings Institution relied on the BCG/SIA report to advocate for what became the CHIPS Act. See "The chip shortage won't be fixed without major federal investment," February 1, 2022.

These forces combined to enact a US semiconductor subsidy bill, dubbed the Creating Helpful Incentives to Produce Semiconductors Act (or CHIPS Act), with a headline cost of $76 billion, including $52 billion in grants to support advanced chip manufacturing and R&D in the United States and $24 billion in investment tax credits for chipmakers by letting them write off 25 percent of capital expenses incurred in manufacturing semiconductors and related equipment. The $76 billion is divided between increasing fabrication capacity ($65 billion) and supporting R&D ($11 billion). The CHIPS Act included "guardrail" statutes to discourage firms from expanding their plants in China by prohibiting recipients of US federal funding from "expanding or upgrading their advanced chip capacity in China for 10 years." The Act was also accompanied by trade policy initiatives enlisting allies to deny advanced chips and chip-making machinery to China and Russia.

Former US Labor Secretary Robert Reich, a progressive Democrat, characterized the CHIPS Act as "extortion." Reich was joined by conservative Republicans, such as former UN Ambassador Nikki Haley, who lamented the departure from free enterprise. But the bill—which also authorizes $170 billion spending on innovation beyond semiconductors—passed the House with a bipartisan majority of 243 to 187, and the Senate with 64 to 33. The national mood for ramping up domestic semiconductor production and boosting innovation in high-tech industries could not be stronger.

This Policy Brief assesses whether the CHIPS Act and companion trade policies will fulfill the multiple aspirations of their advocates. We conclude that:

- CHIPS Act subsidies will surely increase US chip production and spur US chip research.
- The measures will not, however, materially erode China's role as the dominant producer of basic chips, nor will they relieve acute chip shortages faced by US manufacturing firms in 2021 and 2022.
- Jobs created because of the CHIPS Act will make an important contribution to local regions, even though creating jobs was not a major goal of the CHIPS Act and the number of jobs created will be small in the national labor market.
- The United States should not pursue self-sufficiency but should instead continue to follow the logic of comparative advantage, exporting advanced, high-value chips and importing basic, lower-value chips.
- The combination of "guardrails" within the CHIPS Act and companion trade policies will delay the Chinese and Russian quest for advanced chips.
- But US semiconductor agreements with allied and friendly countries should do more than control exports. As well, they should ensure free trade in chips between participating countries and shine a spotlight on subsidies.

LANDMARK INDUSTRIAL POLICY

Large Subsidies—Yet Relatively Modest. Despite totaling $76 billion over five years, CHIPS Act subsidies to US semiconductor production will represent a modest percentage of the industry's prospective cumulative R&D and capital expenditures between 2022 and 2030. Based on experience of the past decade, US firms will spend almost 31 percent of sales on R&D and capital outlays, about equally divided between the two. Assuming the historic percentage share is maintained, arithmetic indicates hundreds of billions of dollars of R&D and capital outlays in the years ahead, even if semiconductor industry sales slow in 2023 and 2024.

Given projected growth (about 80 percent) of world chip sales in constant dollars between 2021 and 2030, reaching a global total of $1 trillion, sales by US-headquartered firms should rise from $258 billion in 2021 to $464 billion by 2030. That figure implies cumulative sales by US-headquartered firms, between 2022 and 2030 inclusive, of $3.3 trillion, and in turn cumulative R&D and capital outlays of $1 trillion (31 percent of $3.3 trillion). By comparison, the CHIPS Act will provide US-headquartered firms less than 8 percent of their prospective intellectual and physical capital outlays. Moreover, CHIPS Act subsidies are marginally smaller than subsidies reported for Taiwan and South Korea, and substantially smaller than subsidies reported for China (discussed below).

Physical Plants Favored. CHIPS Act subsidies, concentrated on US soil, are lopsided in favor of physical plants (85 percent of total subsidies) rather than R&D (15 percent). The political economy of this division is obvious (jobs, jobs, jobs!), but the history of US industrial policy shows that the greater national strength is advanced research, not physical plants.[3] A larger share of the subsidy pie should have been delivered to R&D.

But an increase in US chip production is almost guaranteed. The influential report from the Boston Consulting Group (BCG) and the Semiconductor Industry Association (SIA), published in 2020, forecast that if the CHIPS Act had provided only $50 billion of subsidies, not the $76 billion enacted, US "manufacturing capacity" would reach 13 to 14 percent of the world total in 2030, rather than the 10 percent projected without new subsidies. High US inflation since 2020 (and prospectively more ahead) probably means that larger subsidies—$76 billion rather than $50 billion—will not generate much more than the BCG/SIA forecast share of world "manufacturing capacity."

Construction Delays. At the core of semiconductor production is the fabrication plant (fab),[4] huge ultra-clean factories with advanced machinery for producing silicon wafers embedded with electronic circuits. Between January 2021 and 2022, nearly $80 billion in new semiconductor investments have been announced in the United States through 2025, including a $12 billion Taiwan Semiconductor Manufacturing Corporation (TSMC) plant in Phoenix, Arizona; a $20 billion Intel plant outside Columbus, Ohio; a $17 billion Samsung plant in Taylor, Texas (near Austin); and a $30 billion Texas Instruments plant in Sherman, Texas (near Dallas). Construction delays, unreliable access to vast amounts of water and electricity, and shortages of key equipment (especially chip machines) and skilled engineers will continue to constrain the expansion of chip manufacturing capacity in the United States and abroad. Severe winter weather in February 2021 in Texas, for example, shut down several fabs clustered around Austin owned by Samsung Electronics, NXP, and Infineon. New fabs announced in anticipation of the CHIPS

3 Hufbauer and Jung, *Scoring 50 Years of Industrial Policy*, chapter 5.

4 A semiconductor fabrication plant, commonly called a "foundry" or "fab," is a factory where integrated circuits and other such semiconductor chips are manufactured.

Act will not come online for at least two years—meaning they will not arrive in time to alleviate current shortages. Latest press reports, however, indicate slower chip demand as central banks rein in inflation. Hence, the chip shortages of 2021 and 2022 will probably soon fade without help from the CHIPS Act.

Consequently, the main impact of subsidies will be to shift the location for constructing new fabs to US soil, rather than to enlarge chip output in the near term. As well, subsidies should help retain the US lead in semiconductor R&D. The global locational battle for fabs resembles, on a world scale, the battle between US states for automotive plants and other industrial prizes. Asian producers have historically subsidized their semiconductor firms. At this writing, it is not known whether Asia will "up the ante" in an effort to offset new US subsidies. Alarmed by the CHIPS Act, however, the European Union announced a €43 billion European Chips Act to retain its footing in the global industry. Having committed these huge sums, the United States and European Union earnestly proclaimed their desire to avoid a subsidy race.

SEMICONDUCTOR INDUSTRY BACKGROUND

US-Headquartered Firms versus US Production. In 2021, in terms of sales revenue, US-headquartered semiconductor firms (listed in table 1) sold 46 percent ($258 billion) of world semiconductors ($556 billion), marginally down from 50 percent in 2000. Second-place Korean-headquartered firms sold 21 percent of world output, while Chinese firms sold only 7 percent. About 43 percent of US-headquartered semiconductor wafer capacity was located in the United States. This figure suggests that US-headquartered firms sold chips worth about $111 billion in the United States in 2021, almost 20 percent of world sales.

Of course the semiconductor supply chain is more complex than the story portrayed by sales revenue. Chad P. Bown recounts the industrial detail.[5] Some firms have fabrication plants and others do not ("fabless"), as identified in table 1. Some firms, notably TSMC, produces chips to designs specified by other firms, such as Qualcomm, Nvidia, and Broadcom. The data in table 1 reflects sales revenue, not fab production.

A figure of 20 percent of world sales revenue considerably exceeds the 12 percent of "manufacturing capacity" highlighted by the influential BCG/SIA report (page 4 and exhibit 2). "Manufacturing capacity" is calculated by number of chips, not their value. After 2000, US plants increasingly specialized in chip design and advanced high-value chips, while Chinese plants continued to specialize in lower-value chips.[6] Basic fabs, such as those common in China, cannot be repurposed to create advanced chips, which explains why chip-making equipment is subject to US export controls. Moreover, between 2000 and 2021, the spectrum of chips widened considerably. To invoke an automotive metaphor, in 2000 the chip spectrum resembled the difference between a Ford and a

5 Chad P. Bown. "How the United States Marched the Semiconductor Industry into Its Trade War with China." *East Asian Economic Review* 24, no. 4, Special Issue (December 2020).

6 This description reflects both the unit value data in table 5 and successive SIA Factbooks on the US semiconductor industry.

Mercury. By 2020, the spectrum extended from a Ford to a Lincoln and beyond. Hence, while the US share of world production dropped between 2000 and 2021, the drop in sales revenue was from 25 to 20 percent, a lesser decline than the widely cited 37 to 12 percent decline of "manufacturing capacity."[7]

Table 1
Semiconductor industry sales revenue, 2019-21

Country	Company	Sales revenue (millions of US dollars)		
		2019	*2020*	*2021*
United States	Intel	70,800	76,330	72,536
	Micron Technology	22,410	22,540	28,624
	Qualcomm**	14,390	19,360	27,093
	Broadcom Corporation**	17,240	17,740	18,793
	Texas Instruments Incorporated	13,650	13,570	17,272
	Nvidia Corporation**	10,620	14,660	16,815
	Advanced Micro Devices Incorporated (AMD)**	6,730	9,760	16,299
	GlobalFoundries	5,443	4,440	6,204
	Total	**161,283**	**178,400**	**203,636**
South Korea	Samsung Electronics	55,710	61,850	73,197
	SK Hynix Incorporated	23,190	27,080	36,352
	DB HiTek	568	658	854
	Total	**79,468**	**89,588**	**110,403**
Taiwan	Taiwan Semiconductor Manufacturing Co. (TSMC)*	34,670	45,570	50,073
	MediaTek**	7,970	10,990	17,617
	United Microelectronics Corporation (UMC)*	4,497	5,356	6,451
	Powerchip Semiconductor Manufacturing Corporation (PSMC)	1,120	1,436	2,068
	Vanguard International Semiconductor Corporation (VIS)	873	1,022	1,356
	Total	**49,129**	**64,374**	**77,565**
China	Semiconductor Manufacturing International Corporation (SMIC)	2,897	3,475	4,982
	Hua Hong Semiconductor Limited (HH Grace)	907	927	1,562
	Total	**3,803**	**4,401**	**6,544**

7 According to the SIA Factbook 2015, in 2000 global chip production amounted to about $200 billion, and the share of US-headquartered firms was about 50 percent, of which half were produced in the United States. In value terms US chip production amounted to about 25 percent of the world total.

Country	Company	Sales revenue (millions of US dollars)		
		2019	*2020*	*2021*
Japan	Kioxia	8,760	10,550	10,593
	Total	**8,760**	**10,550**	**10,593**
Other	STMicroelectronics (Switzerland)	9,530	10,180	12,729
	Infineon (Germany)	11,140	11,230	10,770
	Tower Semiconductor (Israel)	1,234	1,266	1,508
	Total	**21,904**	**22,676**	**25,007**
Total		**324,347**	**369,989**	**433,749**

* Foundry (a semiconductor fabrication plant, commonly called a “foundry” or “fab,” is a factory where integrated circuits and other such semiconductor chips are manufactured).

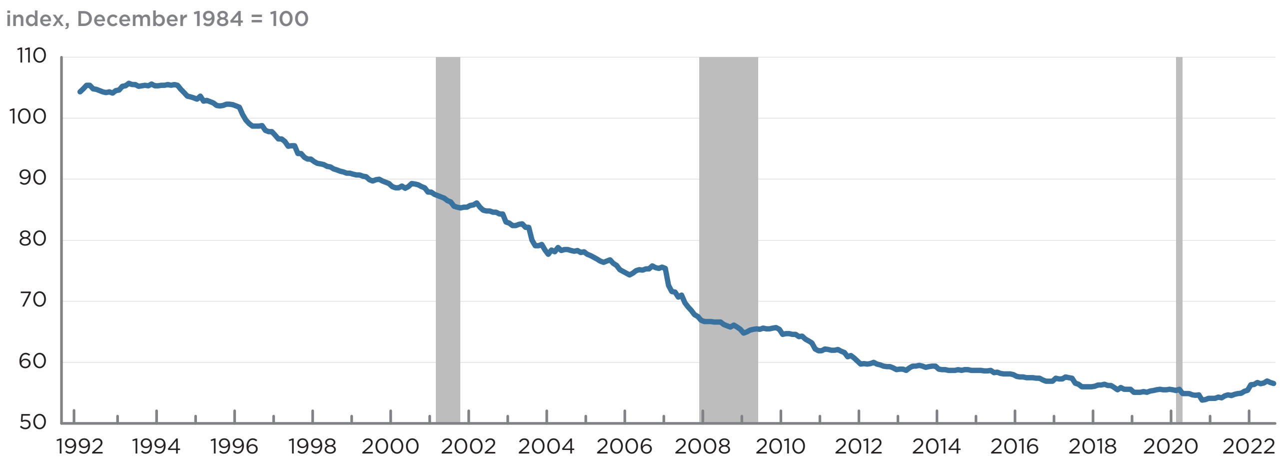
** Fabless

Note: 2019 and 2020 sales revenue for Samsung Electronics, Intel, TSMC, MediaTek, SK Hynix Incorporated, Micron Technology, Qualcomm, Nvidia Corporation, Broadcom Corporation, Texas Instruments Incorporated, AMD, Infineon, STMicroelectronics, and Kioxia is revenue from the sale of semiconductors as reported by the IC Insights McClean Report 2020 via Statista. 2021 sales revenue for Samsung Electronics, Intel, MediaTek, SK Hynix Incorporated, Micron Technology, Qualcomm, Nvidia Corporation, Broadcom Corporation, Texas Instruments Incorporated, and AMD is revenue from the sale of semiconductors as reported by Gartner. All sales revenue for UMC, GlobalFoundries, SMIC, HH Grace, PSMC, VIS, DB HiTek, and Tower Semiconductor, and 2021 sales revenue for TSMC, Kioxia, Infineon, and STMicroelectronics is revenue from the sale of semiconductors as reported by each company’s financial statements.

Sources: Statista (https://www.statista.com/statistics/283359/top-20-semiconductor-companies/). Gartner (https://www.gartner.com/en/newsroom/press-releases/2022-04-14-gartner-says-worldwide-semiconductor-revenue-grew-26-percent-in-2021). United Microelectronics Corporation Form 20-F 2021 (https://www.umc.com/upload/media/08_Investors/Annual_Reports/Form-20_pdf_eng/Form_20-F_December_31_2021.pdf). GlobalFoundries Form 20-F (https://investors.gf.com/static-files/49c272c7-45e0-4d38-a7f9-a22aaa288694). Semiconductor Manufacturing International Corporation (SMIC) 2021 Annual Report (https://smic.shwebspace.com/uploads/e00981-2.pdf). Semiconductor Manufacturing International Corporation (SMIC) 2020 Annual Report (https://smic.shwebspace.com/uploads/e00981.pdf). Hua Hong Semiconductor Limited 2021 Annual Report (http://media-huahonggrace.todayir.com/20220407121601367010205034_en.pdf). Hua Hong Semiconductor Limited 2020 Annual Report (http://media-huahonggrace.todayir.com/2021041312080183749715768_en.pdf). Powerchip Semiconductor Manufacturing Corporation 2021 Annual Report (https://www.powerchip.com/upload/docDB/a1f7c689-9910-4e43-998f-434d31d7d462.pdf). Powerchip Semiconductor Manufacturing Corporation 2020 Annual Report (https://www.powerchip.com/upload/docDB/7b7557f5-2c23-4400-a38d-e5d126cf5554.pdf). VIS Annual Report 2021 (http://media-vis.todayir.com/20220513182111378945482_en.pdf). VIS Annual Report 2020 (http://media-vis.todayir.com/20210518100431357633284_en.pdf). Kioxia FY2021 ended March 31, 2022 Financial Results (https://www.kioxia-holdings.com/content/dam/kioxia-hd/en-jp/about/asset/Financial-Results-FY2021-4Q-en.pdf). STMicroelectronics Form 20-F (https://investors.st.com/static-files/6e2389e7-3503-485d-b9d7-65df0e71d26f). Infineon 2021 Annual Report (https://www.infineon.com/dgdl/Infineon+Annual+Report+2021.pdf?fileId=8ac78c8b7d507352017d622b5bfb0161). TSMC Annual Report 2021 (https://investor.tsmc.com/static/annualReports/2021/english/index.html). Tower Semiconductor Form 20-F 2021 (https://ir.towersemi.com/static-files/c0d8dc97-0c26-49f0-a595-40a265ab3a6a). Tower Semiconductor Form 20-F 2020 (https://ir.towersemi.com/static-files/88c9e0ea-bb32-4a93-99d0-84670c8108cb). DB HiTek 2021 Consolidated Statements of Income (https://dbhitek.com/eng/Data/investment/Financial%20Statements%202021.pdf).

As manufacturing techniques have improved, chip prices have progressively declined. The producer price index for semiconductor manufacturing (figure 1) fell steadily after 1992, with only a small increase around 2021 reflecting the global semiconductor shortage induced by the COVID-19 pandemic. Today, the semiconductor demand boom appears to have faded, as higher interest rates dampen purchases of products that use semiconductors. Ironically, the United States is committing more than $50 billion to its domestic semiconductor industry at a time when chipmakers are planning to cut back on expenditures and slow expansion to brace for uncertainties as the Federal Reserve tightens monetary policy.

Figure 1
Producer price index by industry: Semiconductor and other electronic component manufacturing, monthly, not seasonally adjusted



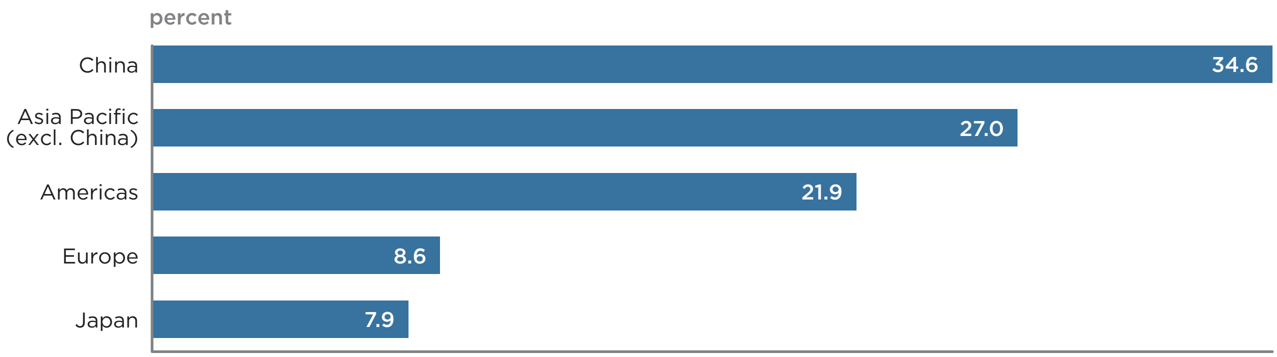
Note: Shaded bars indicate US recessions.
Source: US Bureau of Labor Statistics *via* Federal Reserve Economic Data, Federal Reserve Bank of St. Louis (https://fred.stlouisfed.org).

Whatever the near-term outlook, world chip production is forecast to reach $1 trillion by 2030, and much of the jostling over subsidies concerns the location of future production. Similar competition characterizes other industries, but transportation costs are exceptionally low for semiconductors, giving the industry an especially footloose character.

From the US industrial policy perspective, the problem is not the commanding global position of US-headquartered firms, but rather the fact—previously mentioned—that only 43 percent of their production takes place on US soil. As figure 2 illustrates, far more chip production takes place in Asia than other regions. Dominant reasons, according to BCG/SIA, were lower wage costs in Asia and government incentives.

US versus Asian Wages and Incentives. Relevant metrics show that US semiconductor production is highly capital-intensive, both physical capital and intellectual capital. According to the BCG/SIA report, capital expenditures for a new US advanced memory fab are about $20 billion and the number of employees about 6,000, indicating some $3.3 million in physical capital per employee, far above the US average for manufactures.

Figure 2
Global semiconductor production, 2021 (market share in percent)



Source: SIA Factbook 2022 (https://www.semiconductors.org/wp-content/uploads/2022/05/SIA-2022-Factbook_May-2022.pdf).

Another metric is annual physical capital plus R&D outlays per employee: In 2021 the figure for US semiconductors was $206,000.[8] The industry paid for these outlays with sales revenue per employee of $670,000 in 2021. For all US manufacturing, the comparable figures (2020 data) are much lower: Physical capital and R&D outlays per employee were $47,000[9] and net sales per employee were $117,000.[10]

As might be expected given its high capital intensity, chip production is a high-wage industry. According to ZipRecruiter, in 2022, average annual compensation in the chip industry was $83,874,[11] compared with $57,620 for all manufacturing. In 2021, total US chip employment, including research scientists and skilled engineers, numbered 277,000.

High US wages are one reason for US-headquartered firms to produce in Asia.[12] Indeed, almost half of Asian semiconductor sales in 2021 were produced by US-headquartered firms. Illustrating the wage disparity, Chinese semiconductor wages in 2019/2020 averaged $22,000 per employee, around a quarter of the US level.

While average Chinese sales per employee, at around $240,000, were only 40 percent of the US figure in 2021, the overall comparison (wages versus sales) was favorable to China.[13] The same is true, though to a lesser extent, in South Korea and Taiwan. High US wages are not, however, a decisive determinant for

8 In 2021, R&D outlays were about $50 billion and physical capital outlays about $40 billion. Thus, on a per employee basis, R&D outlays modestly exceeded physical capital outlays. See SIA Factbook 2022, pages 18 and 22.

9 Based on 13.9 million manufacturing employees, $258 billion physical capital outlays, and $384 billion R&D outlays (all business firms) in 2020. For more, see Statista; US Census Bureau; and National Science Foundation.

10 Based on data from the Federal Reserve Bank of St. Louis.

11 The US Bureau of Labor Statistics reports 2021 annual mean wages for semiconductors and other electronic components of $78,580.

12 See Exhibit 4 of the BCG/SIA report.

13 Chinese 2019/2020 data on employment and sales refer only to integrated circuits, accounting for about two-thirds of total Chinese semiconductor sales in 2021 ($193 billion, reported in the SIA Factbook 2022, page 5).

US firms to build fab plants in Asia. For the United States, semiconductor wages are approximately 12 percent of sales; for China, the figure is approximately 9 percent.[14] Lower wages, like proximity to the market (especially for consumer goods), merely add to the Asia attraction.

Another strong reason for Asian production is government incentives. Exhibit 8 of the BCG/SIA report contains striking comparative data, reproduced in part as table 2. While US incentives (both federal and state) reduced the "total cost of ownership" (TCO) by 10 to 15 percent (pre-CHIPS Act), the reduction of TCO through South Korean and Taiwanese subsidies is 25 to 30 percent and through Chinese subsidies, 30 to 40 percent.[15] Complementing these estimates, table 3 gives press reports of recent subsidy packages in China, Japan, and South Korea.

Table 2
Government incentives for semiconductor manufacturing (percent reduction through subsidies)

Reduction type		China	Taiwan	South Korea	United States[a]	Japan
Capital expenditures (Capex)	Land	100	50	100	50	75
	Construction and facilities	65	45	45	10	10
	Equipment	35	25	20	6	10
Operating expenses (Opex)	Labor and benefits	33	5	5	5	5
Tax	Corporate tax	75	n.a.	60	n.a.	n.a.
	State tax	n.a.	n.a.	n.a.	100	n.a.
	Property tax	n.a.	n.a.	100	100	100
Overall		**30-40**	**25-30**	**25-30**	**10-15**	**~15**

n.a. = not available

a. Based on a best-case scenario with incentives and recent agreements as of September 2020.

Note: Incentives are on the first ten years of operation. All economies also include a 100 percent reduction on equipment-import costs and a 5 percent R&D write-off and deferral; not exhaustive.

Source: BCG/SIA Report (https://www.semiconductors.org/turning-the-tide-for-semiconductor-manufacturing-in-the-u-s/).

14 For the United States: (83,874/670,000) x 100 = 12.5 percent. For China: (22,000/240,000) x 100 = 9.2 percent.

15 The OECD has examined semiconductor subsidies across firms in detail, but the report does not contain simple comparative tables.

For years, it has thus been financially attractive for US-headquartered firms to produce chips in Asia, taking advantage of lower labor costs and more generous subsidies. This is particularly true for basic chips requiring less sophisticated research and engineering talent. According to a recent report (written before the CHIPS Act was signed) China will build 31 fabs between 2020 and 2024, compared with 19 in Taiwan and 12 in the United States. New fabs will ensure China's continuing role as the dominant world supplier for a wide range of end users from autos to home appliances to consumer electronics.

Table 3
Recent semiconductor subsidy packages in China, Japan, and South Korea

Economy	Date	Package name/ description	Details
China	2014	Guidelines to Promote National Integrated Circuit Development	Supports an aggressive growth goal of meeting 70 percent of China's semiconductor demand with domestic production by 2025 through a variety of measures, including developing a "leading group" of high officials to mobilize resources to boost the semiconductor sector; developing a special national industry investment fund for the sector; providing new credit products and financial services, issuing financing tools, and developing insurance products for the sector; and implementing preferential tax policies for the sector.
	2015	Made in China 2025	Initially set a goal to raise the local content of semiconductor chips to 40 percent by 2020 and 70 percent by 2025. Revised in 2019, setting a new goal of expanding domestic semiconductor production to meet 80 percent of domestic demand by 2030.
	July 2022	Hengqin Special Economic Zone subsidies	Offers (1) up to 30 million yuan ($4.4 million) each for semiconductor firms to set up new offices or conduct R&D activities in Hengqin; (2) 5 million yuan and 50 percent of tapeout cost to firms that establish R&D programs in Hengqin; (3) up to 25 million yuan to firms involved in 14-nanometer or lower chip processing design; (4) more than 100,000 yuan each to researchers and senior managers who signed contracts with mainland semiconductor firms and were assigned to work in Hengqin for a three-year period; and (5) 1 million yuan to companies that "can nurture semiconductor talent in Hengqin."

Economy	Date	Package name/ description	Details
Japan	November 2021	Fiscal 2021 Supplementary Budget	Allocates 600 billion yen ($5.2 billion) of the fiscal 2021 supplementary budget for advanced semiconductor manufacturing. Approximately 400 billion yen will go towards the construction of a new Taiwan Semiconductor Manufacturing Co. (TSMC) chip plant in Kumamoto prefecture and the remaining 200 billion yen will go towards the construction and/or enhancement of other factories. Projects by Micron Technology (an American firm) and Kioxia Holdings Corporation (a Japanese firm) are currently under consideration.
	June 2022	Taiwan Semiconductor Manufacturing Co. (TSMC) subsidiary subsidies	Offers 476 billion yen ($3.5 billion) for the construction of a chip plant—a joint venture between TSMC, Denso Corporation, and Sony Semiconductor Solutions Corporation—in Kumamoto prefecture. Part of the subsidies are reserved under the Fiscal 2021 Supplementary Budget.
	July 2022	Kioxia Holdings Corporation and Western Digital Corporation subsidies	Offers up to 92.9 billion yen ($680 million) to enhance the capacity of a chip plant in Yokkaichi, Mie prefecture, a joint venture by Kioxia Holdings Corporation (a Japanese firm) and Western Digital Corporation (an American firm). Part of the subsidies are reserved under the Fiscal 2021 Supplementary Budget.
South Korea	May 2022	K-Semiconductor Belt Strategy	Supports the chip industry by offering infrastructure, tax breaks, and finance. Provides tax credits up to 50 percent for investment in R&D and up to 20 percent for facility investment, as well as low-rate loans to chipmakers for facility investment, to encourage more than 150 private South Korean companies to invest 510 trillion won ($452 billion) in chips. Samsung Electronics plans to invest 171 trillion won in nonmemory chips through 2030, and SK Hynix plans to spend 230 trillion won on existing production sites and four new factories in Yongin.

Sources: South China Morning Post (https://www.scmp.com/tech/big-tech/article/3186934/china-ramps-subsidies-lure-chip-firms-hengqin-island-near-macau). China Daily USA (http://usa.chinadaily.com.cn/business/2014-06/25/content_17613997.htm). Congressional Research Service (https://crsreports.congress.gov/product/pdf/R/R46767). Center for Strategic and International Studies (https://www.csis.org/blogs/new-perspectives-asia/how-are-washington-and-beijing-utilizing-industrial-policy-bolster). *The Japan Times* (https://www.japantimes.co.jp/news/2022/07/26/business/kioxia-western-digital-subsity/). Nikkei Asia (https://asia.nikkei.com/Business/Tech/Semiconductors/Japan-allocates-5.2bn-to-fund-chip-plants-by-TSMC-and-others). Nikkei Asia (https://asia.nikkei.com/Business/Tech/Semiconductors/Japan-chip-subsidy-requires-10-year-pledge-from-TSMC-others). CNBC (https://www.cnbc.com/2021/05/17/semiconductors-nations-deploy-wartime-like-efforts-to-win-chip-race.html). Xinhuanet (http://www.xinhuanet.com/english/asiapacific/2021-05/13/c_139943361.htm).

According to the BCG/SIA study, federal subsidies of $50 billion—less than the CHIPS Act provides—will bring the US TCO to within 5 to 10 percent of experience in Korea, Taiwan, and Singapore. Given other US advantages, that will make the United States fully competitive with those Asian locations for new fabs constructed between 2022 and 2030 according to the BCG/SIA study, increasing the number of new US fabs to 19 from a pre-CHIPS Act forecast of just 9. US "manufacturing capacity" will rise to 13 to 14 percent of the world total, compared with the current 12 percent and a potential decline to 10 percent without the CHIPS Act.

Chip Consumption. US consumption of semiconductors now accounts for somewhat less than 20 percent of world sales.[16] In other words, US production by value approximately equals US consumption by value, but the menus of production and consumption differ sharply, illustrated by trade statistics discussed below. Chinese consumption, by contrast, now accounts for 35 percent of world chip sales. Consumer goods, such as cell phones and computers, are major chip consumers, for which China is a leading producer and exporter. That explains the outsized share of Chinese consumption. Unless the United States extends the reach of industrial policy to encompass American self-sufficiency in end-use industries, the current relative shares of US and Chinese consumption are likely to persist.

Once complex chip-making machinery is installed in a fabrication plant, the flexibility to produce different types of chips is limited. US fabs do not currently specialize in the type of chips demanded by automotive, household appliance, and other manufacturers of consumer goods. Those chips tend to fall in the basic end of the chip spectrum. By comparison, US fabs concentrate at the advanced end of the spectrum. For that reason, a large share of US production is exported to foreign users of advanced chips, while the United States imports substantial quantities of basic chips.

International Chip Trade. Table 4 presents a matrix of trade flows for 2021, expressed in millions of dollars. Of the five major semiconductor producing economies examined—China, Taiwan, South Korea, the United States, and Japan—China was by far the largest global exporter of chips ($207.6 billion), followed by Taiwan ($162.9 billion), South Korea ($148.1 billion), and the United States ($61.5 billion). Japan came in last, exporting $47.0 billion worth of semiconductors, roughly a quarter of China's total semiconductor exports.

As shown in table 4, world semiconductor exports totaled a whopping $1.03 trillion in 2021. However, 2021 global semiconductor industry sales to users—such as cell phone, automotive, and aircraft firms—reported by SIA add up to only $556 billion. The discrepancy can be partly explained by the large but unreported share of trade that takes place between subsidiaries of the same semiconductor company located in different countries, trade not recorded as sales to end users.

Table 4 highlights the importance of two-way trade: Each of the major semiconductor producers is both a large exporter and a large importer. For example, China—the largest global exporter—was also the single largest export destination for the other four economies, importing $167.9 billion worth of semiconductors. Likewise, Taiwan was the second largest export destination for every exporter except China.

16 SIA Factbook 2022 says the Americas accounted for 21.9 percent of world sales in 2021; presumably, that includes North and South America, but World Semiconductor Trade Statistics (WSTS) does not break out the United States. See SIA Factbook 2022, page 13.

Table 4
Global semiconductor trade, 2021 (millions of US dollars)

Exporter	Exporting to						
	China	*Taiwan*	*South Korea*	*United States*	*Japan*	*Rest of world*	*World*
China	n.a.	22,726	22,844	2,522	4,554	154,987	207,634
Taiwan	52,425	n.a.	11,920	2,453	12,291	83,768	162,857
South Korea	90,383	16,969	n.a.	3,798	2,338	34,618	148,106
United States	13,322	5,111	2,926	n.a.	1,320	38,832	61,510
Japan	11,731	10,912	3,912	2,567	n.a.	17,909	47,031
Rest of world	215,935	16,984	7,749	17,775	5,820	140,171	404,434
Total	**383,795**	**72,701**	**49,350**	**29,116**	**26,323**	**470,285**	**1,031,571**

n.a. = not available; NAICS = North American Industry Classification System; HS = Harmonized System

Note: All figures reflect HS commodity codes equivalent to NAICS code 334413 (see table A.1 in appendix A for the full NAICS HS concordance file used). South Korean export figures are Chinese, Japanese, Taiwanese, America, rest of world, and total world imports of South Korean semiconductors. For political reasons, the United Nations is not allowed to show trade statistics referring to Taiwan; in UN Comtrade databse, Taiwan trade statistics are labeled "Other Asia, nes." For more information, see UN Statistics Wiki (https://unstats.un.org/wiki/display/comtrade/Taiwan%2C+Province+of+China+Trade+data).

Source: UN Comtrade database (https://comtrade.un.org/data/).

The massive volume of two-way trade underscores the fact that chips are far from identical products. SIA distinguishes nine major chip categories and 63 types,[17] and many chips are tailor-made to the buyer's needs. One measure of sophistication is the width of connections within a semiconductor, the current best being 5 nanometers (about one-tenth thousandth the width of a human hair), though 3 nanometers is in sight. As table 5 based on 2021 data reveals, the average unit value (price per chip) for a given destination differs considerably between exporting countries. Take exports to China as an example: The average unit value of US chip exports to China was $4.28, whereas the average unit value of Korean exports to China was just $0.89, and that of Taiwanese exports to China, only $0.16.

US average export unit values are generally far higher than other chip suppliers, reflecting advanced US chip production. To illustrate, for exports to Japan, the average US unit value was $1.16, compared with the average Chinese unit value of $0.17, the average Korean unit value of $0.49, and the average Taiwanese unit value of $0.55. Other comparisons in table 5 confirm

17 The nine chip categories distinguished by SIA in its 2022 Factbook are: Logic, Memory, Analog, Microprocessor Unit (MPU), Opto, Discretes, Microcontroller Unit (MCU), Sensor, and Digital Signal Processor (DSP). For the full list of 63 types, see the WSTS Semiconductor Industry Blue Book.

this result. Moreover, export unit values for chip sales by other suppliers to the United States are generally far lower than US export unit values. Self-sufficiency advocates might suggest that the United States should simply supply its own needs and curtail both imports and exports. Table 5 shows why this is a bad idea: Semiconductors are highly diverse and US trade follows the logic of comparative advantage, exporting high-value chips and importing low-value chips. US self-sufficiency is an illusion; increasing self-sufficiency would require the United States to prioritize basic chip production—a spectrum where it has a clear disadvantage—at the same time it is supposed to compete with China in producing the most advanced chips.

Table 5
Global semiconductor trade unit values, 2021 (US dollars)

Exporter	Exporting to					
	China	*Taiwan*	*South Korea*	*United States*	*Japan*	*Rest of world*	*Total*
China	n.a.	0.16	0.44	0.06	0.17	0.18	0.19
Taiwan	0.16	n.a.	0.72	0.38	0.55	0.54	0.32
South Korea	0.89	3.76	n.a.	2.23	0.49	1.45	1.08
United States	4.28	3.47	7.91	n.a.	1.16	1.71	2.16
Japan	0.13	0.31	0.22	0.24	n.a.	0.09	0.13

n.a. = not available; NAICS = North American Industry Classification System; HS = Harmonized System

Note: All figures are expressed in unit value and reflect HS commodity codes equivalent to NAICS code 334413, excluding HS commodity codes 381800, 854190, and 854290 (see table A.1 in appendix A for the full NAICS HS concordance file used). South Korean export figures are Chinese, Japanese, Taiwanese, America, rest of world, and total world imports of South Korean semiconductors. For political reasons, the United Nations is not allowed to show trade statistics referring to Taiwan; in the UN Comtrade database, Taiwan trade statistics are labeled "Other Asia, nes." For more information, see UN Statistics Wiki (https://unstats.un.org/wiki/display/comtrade/Taiwan%2C+Province+of+China+Trade+data).

Source: UN Comtrade database (https://comtrade.un.org/data/).

Tariffs and Penalty Duties. The Information Technology Agreement (ITA)—a plurilateral 1996 agreement negotiated under the World Trade Organization (WTO)—eliminates tariffs on select information and communications technology (ICT), including semiconductors. While basic semiconductors and semiconductor manufacturing equipment are covered under the original agreement, a 2015 "ITA Expansion" broadened coverage by eliminating duties on advanced semiconductors. To date, the ITA covers 97 percent of world trade in ICT products, and 84 WTO members participate in it.

Despite the ITA, the United States has levied a 25 percent tariff on imports of Chinese semiconductors since June 15, 2018 as part of President Donald Trump's Section 301 tariffs on China. Considering that 60 percent of US semiconductor imports from China are further fabricated in the United States, American chipmakers have largely borne the brunt of these tariffs, paying $750 million in duties between July 2018 and July 2020. In December 2021 comments to the Office of the United States Trade Representative, SIA called for the elimination of Section 301 tariffs on semiconductors and associated products, claiming that they were contributing to "inflationary price increases driven by the global shortage and rising demand." In summer 2022, President Biden was weighing a decision to lift some of the Section 301 tariffs to fight inflation but has recently defended Trump's China tariffs.

Given China's dominant position in producing basic chips, and the likelihood that China will remain a low-cost supplier for the next decade, few countries (apart from the United States) will limit their imports from China. Republicans are favored to win back control of the House of Representatives in November 2022, and as they tend to see China more negatively than Democrats, US proposals may soon spring up to restrict chip imports from China. Such restrictions might hamper US economic growth in the short run because alternative suppliers do not exist, and new US fabs will not come online for at least two years.[18] In the long run, such restrictions would put a range of US industries at a competitive disadvantage relative to European, Japanese, and other firms, owing to the higher cost of domestic chips, much as happened with barriers to steel imports, but on a larger scale.

Approximately half of the Trump administration's 25 percent steel tariffs passed through into US domestic steel prices, hurting downstream manufacturers of auto parts, farm machinery, military vehicles, and other products. A similar restriction on semiconductors would likely have a larger impact since US steel sales totaled about $92 billion in 2020,[19] while US semiconductor sales totaled $208 billion in the same year.

Over the past two decades, semiconductor countervailing duty (CVD) cases were few and far between. According to the World Bank's Temporary Trade Barriers Database, since the 1980s, only five semiconductor CVD cases have been brought to the WTO. Antidumping (AD) cases over the same period are more numerous, totaling 22. Of the CVD cases, three were initiated by the United States and one each by the European Union and Canada. Four of the five CVD cases targeted photovoltaic cells, modules, or other products from China. Of the AD cases, 13 were initiated by India, five by the United States, and one each by Australia, the European Union, Canada, and Turkey. Eight of the thirteen AD cases targeted photovoltaic cells, modules, or other products from China. Semiconductor CVD and AD cases are likely limited because of the concentrated nature of the industry, implying the prospect of industry-level retaliation when a firm brings a case.

Fabs as a Jobs Creator. Creating jobs was not a major reason for passing the CHIPS Act. Indeed, the Act was passed when US unemployment was hitting record lows, reaching 3.5 percent, and the Federal Reserve was boosting interest rates to quell demand. Nevertheless, the jobs impact deserves notice because opening a fabrication plant can significantly boost an ailing region.

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18 The CHIPS Act reserves $2 billion of grants for the manufacture of "legacy" chips, the basic chips used by automotive firms. However, new capacity may take two years to come online.

19 US production was about 80 million tons in 2020, valued at about $1,150 per ton. For more, see https://www.ft.com/content/29da816b-77bb-4cdb-a5e3-54c80bb94c2a.

In an important case study, *Regional Renaissance: How New York's Capital Region Became a Nanotechnology Powerhouse*, Charles Wessner and Thomas Howell give a detailed account of the New York Capital Region and the role of GlobalFoundries.

The Capital Region is a corridor of the Middle Hudson Valley, running from East Fishkill in the south to Saratoga Springs in the north and encompassing Albany (the state capital), Troy, and Schenectady. Late in 2009 GlobalFoundries started constructing its fab in Saratoga Springs, a 300,000 square foot clean room plus auxiliary buildings, and by 2017 had spent $15.8 billion on plant and equipment (largely financed by the Abu Dhabi sovereign wealth fund). Production of 12-inch wafers began in 2011 and ramped up over the next six years. Along the way, GlobalFoundries acquired a license from Samsung and IBM's chip operations in East Fishkill, making two GlobalFoundries fabs in the Capital Region.

In 2008, two consulting firms forecast that the GlobalFoundries Saratoga plant would create 5,000 to 8,000 direct jobs, forecasts viewed as optimistic at the time. Wessner and Howell estimate that direct employment at GlobalFoundries' two plants, plus a related nanotechnology center in Albany, actually approached 10,000 jobs by 2015. The authors accept the SIA multiplier of 4.89 to calculate indirect and induced employment, arriving at an estimate of 47,000 Capital Region jobs attributable to the fab plants. Even applying the more conservative Empire State Development (ESD) multiplier of 2.25, they say, some 22,000 regional jobs were attributable to the fab plants in 2015.

Wages for direct jobs at GlobalFoundries averaged $90,000 a year in 2015, very good pay for the Capital Region. State support for the semiconductor and nanotechnology industries largely took the form of generous grants to the state university system and specialized institutions, notably the Rensselaer Technology Park. Property tax abatements and sales tax exemptions were relatively minor. All told, public subsidies per direct job created were modest compared with wages.

Extrapolating from the GlobalFoundries experience in the Capital Region, fabs supported by the CHIPS Act will create a significant number of jobs in favored regions. However, the public subsidy per direct job will be considerably higher relative to wages.

DISTRIBUTION OF CHIPS ACT SUBSIDIES

Tax Credits and Grants. Distribution of the tax credit portion of the CHIPS Act—projected to cost $24 billion—will be straightforward. Semiconductor firms that build new plants or extend existing plants, including foreign-owned firms such as TSMC and Samsung, can claim a tax credit equal to 25 percent of the cost for plant and equipment placed in service after December 31, 2022 or for which construction starts before January 1, 2027. The 15 percent minimum corporate tax proposed in the Inflation Reduction Act will not erode the benefit of CHIPS Act (or other) tax credits. However, the 15 percent minimum tax will erode the benefit of accelerated (i.e., first year) depreciation of R&D outlays, a tax provision likely to be extended later in 2022 by Congress.

By contrast to tax credits, the distribution of semiconductor grants—some $52 billion through FY2026—will entail considerable discretion. By statute, some $39 billion is dedicated to manufacturing plant and equipment. The Act puts a $3 billion limit on grants to a single fab and dedicates $2 billion to the manufacture of "legacy chips" of special interest to the automotive industry. Some $11 billion is devoted over a five-year period to research endeavors, for which the National Semiconductor Technology Center gets the largest share. The Act principally entrusts the Commerce Department with distributing these pots of money. It remains to be seen how much emphasis is placed on R&D and manufacturing facilities for advanced chips. Those should be the priorities.

Support for TSMC. Taiwan Semiconductor Manufacturing Corporation plays a special role in terms of supply chain vulnerability. The BCG/SIA report estimates that 90 percent of advanced chips for military defense and corporate computing services come from Taiwan, where TSMC is the dominant supplier. Customers include Apple for iPhones, Qualcomm for smartphones, and Advanced Micro Devices for computer processors. Given its location, TSMC is especially vulnerable not only to Chinese invasion but also to typhoons and earthquakes. In May 2020, TSMC announced the construction of a new fab plant in Phoenix, Arizona, with a projected cost of $12 billion. Almost one year later, in April 2021, TSMC announced plans to invest $100 billion over the next three years "to increase capacity at its plants." Three TSMC sources familiar with the matter told Reuters that five additional fabs are being planned in the United States.

Under the CHIPS Act, TSMC can claim tax credits for capacity placed in service after December 31, 2022. But it will be up to the Commerce Department to determine how much grant money gets channeled to TSMC. Given TSMC's critical role in the US supply chain, and US determination to deter TSMC from selling advanced chips to China, generous but conditional allocation of grant money to TSMC seems in the US national interest.

Guardrails and Trade Initiatives. CHIPS Act grants prohibit expanding or upgrading advanced chip capacity in China for 10 years. The guardrail will encourage leading firms, such as TSMC, Intel, Micron, Samsung, and SK Hynix to expand capacity in the United States rather than China. But faced with realistic limitations on the power of subsidies alone to retard chip development in China, Congress asked the Biden administration to launch a new export control agreement with a small group of friendly nations. The Biden team has responded with two new initiatives: the "Chip 4" (or "Fab 4") alliance and the US-EU Trade and Technology Council (TTC).

"Chip 4" is a proposed alliance between the United States, Japan, South Korea, and Taiwan—apart from China, the world's four biggest semiconductor powerhouses—to increase cooperation on sophisticated semiconductor design and production as well as to counter China's growing influence in global semiconductor supply chains. Each country in the alliance plays a unique and critical role in the supply chain: The United States dominates advanced chip design, Japan supplies essential materials and equipment, and both South Korea and Taiwan dominate semiconductor manufacturing. The alliance's preliminary meeting was held on September 29, 2022, but the frequency of future meetings "were not addressed."

The TTC, founded in June 2021 by Presidents Biden, Ursula von der Leyen of the European Commission, and Charles Michel of the European Council, aims to secure critical technology supply chains, strengthen technology trade and investment, and "encourage compatible standards and regulations based on shared democratic values." At the TTC's second meeting on May 16, 2022, the two governments announced a joint effort to avert a semiconductor subsidy race, "provide early warning of semiconductor shortages," and promote "trusted suppliers"—namely suppliers other than China.

SEMICONDUCTOR TRADE AGREEMENTS

Existing Export Control Agreements. The United States is already a founding member of four export control agreements: the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies; the Nuclear Suppliers Group; the Australia Group on chemical weapons; and the Missile Technology Control Regime. New agreements are now being forged to address semiconductor trade.

During the US-Soviet Cold War, the Coordinating Committee for Multilateral Export Controls (Cocom) imposed mandatory end-use controls that limited exports of scheduled items to the Soviet Union and later China. Some of the post-Soviet Union export control agreements follow the same approach. In that spirit, it might be possible to agree on prohibited lists of chip-making equipment. However, similar strict lists of prohibited chip and end-use exports may not be feasible for semiconductor trade. Some countries may not be willing to curtail the export opportunities of their chip firms while monitoring the end-use of chips is difficult.

Instead, the current Wassenaar Arrangement, which calls for advance notification between participating countries, may be the preferred path. With 42 member countries, the Wassenaar Arrangement is too large for effective export controls on advanced chips and machinery. But much smaller semiconductor agreements could adapt Wassenaar precedents. Notification could be followed by a one-month period before questionable exports are contracted. After notification, concerned parties could try to persuade their counterparts not to export designated items. Something similar has already occurred in the realm of chip-making equipment. The United States persuaded ASML, a Dutch firm, not to export its chip-making machines to China.

New Semiconductor Export Control Agreements. The CHIPS Act provides $500 million to the State Department (as the lead agency) to forge a semiconductor alliance, called the CHIPS for America International Technology Security and Innovation Fund. Like-minded partners for this enterprise might include the United States, the European Union, Japan, Korea, Taiwan, and Singapore. Meanwhile, the United States and Korea (the second largest home base for chip manufacturers) have established a Semiconductor Working Group to discuss and coordinate export controls. The Chip 4 alliance will likely build on understandings reached in the US-Korea Semiconductor Working Group. The same is likely true of forthcoming semiconductor talks within the US-EU TTC.

Export controls are the heart of the new agreements. Emphasizing that aspect, on October 7, 2022, the US Commerce Department announced extensive limits on the export of advanced chips and chip-making machinery to China. Export controls are buttressed by guardrails in the CHIPS Act that prohibit recipient firms from expanding or upgrading advance chip capacity in China. But as the United States and its allies learned during the Cold War with the Soviet Union, export controls can delay access to advanced technology, but they cannot permanently deny access to adversaries. The same lesson will apply in the semiconductor realm. For example, China claims that it has designed a work-around technique to manufacture 7 nanometer chips, though the practical application of the technique remains in doubt. As David Hanke, a national security expert, observed, “When it comes to circumventing US regulations, China moves like water around rocks.”

More than Export Controls. New agreements should do more than curtail exports of advanced chips and chip machines to China and Russia. They should also ensure that members meet their supply commitments to purchasers based in partner countries; they should guarantee market access on a tariff-free basis to partners; and they should compel partners to notify their semiconductor subsidies. These additional roles remain to be enshrined in new initiatives.

Partners should promise not to unduly restrict exports between themselves for short supply reasons. When chip supplies must be rationed, purchasers in partner countries should be treated the same as purchasers at home. Agreement on this proposition should be easy.

More difficult will be to reach effective limitations on subsidies. Semiconductor subsidies are now standard practice among central governments and widely offered by local governments as well, for example, by US states and European Union member states.

The first step towards limiting the subsidy race should be comprehensive notification of past and planned subsidies. Notification of chip subsidies should be patterned after the Organization for Economic Cooperation and Development’s (OECD) template designed for agriculture, the Aggregate Measure of Support. In fact, the OECD has already published such a template for the semiconductor industry. The idea is to cover cash grants, free or bargain land and related infrastructure (electricity, water, roads), tax holidays and credits, long-term low interest loans, and kindred benefits.

To some extent, full notification may curtail future subsidies designed to capture future generations of physical plants. However, the lure of well-paying semiconductor jobs, ripple employment, and security concerns will be hard for public officials to resist. Nevertheless, notification might slow the subsidy race since participants will be less prone to exaggerate the subsidies of their partners.

CONCLUSION

The CHIPS and Science Act, export controls, and agreements with allied countries will accomplish many of their multiple objectives. More US fabs will be built, US R&D will be accelerated, and advanced chips and chip-making machines will be denied to China, Russia, and other adversaries.

However, the Act will not make a material difference to US chip supplies in the next two or three years. Slower economic growth has already tipped the chips market in favor of ample supplies. A possible recession could create a temporary chips surplus.

While collective measures have inflicted considerable short-term pain on China, causing a sharp drop in the fortunes of its high-tech firms, China will respond by redoubling its self-sufficiency programs. Within three to five years, Chinese chip firms will likely approach, or even meet, the proficiency of US firms, TSMC, and Samsung.

Finally, the United States should not mimic China in pursuing self-sufficiency, as US self-sufficiency is an illusion. As the United States currently exports high-value chips and imports low-value chips, increasing self-sufficiency would require the United States to prioritize basic chip production at the same time it is supposed to be competing with China in advanced chip production. Continuing to prioritize advanced chip production—where the United States has a clear advantage—is the most efficient course of action.

APPENDIX A

Table A.1 reflects the full NAICS HS concordance file (i.e., the full list of HS commodity codes equivalent to NAICS code 334413) used to create table 4 in this Policy Brief.

Table A.1
Commodities in NAICS code 334413

HS 6-digit code	Commodity
381800	Chemical elements; doped for use in electronics, in the form of discs, wafers or similar forms; chemical compounds doped for use in electronics
852352	Semiconductor media; smart cards, whether or not recorded, excluding products of Chapter 37
854110	Electrical apparatus; diodes, other than photosensitive or light-emitting diodes (LED)
854121	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of less than 1W
854129	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of 1W or more
854130	Electrical apparatus; thyristors, diacs and triacs, other than photosensitive devices
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, LED
854150	Electrical apparatus; photosensitive semiconductor devices n.e.c. in heading no. 8541, including photovoltaic cells, whether or not assembled in modules or made up into panels
854190	Electrical apparatus; parts for diodes, transistors and similar semiconductor devices and photosensitive semiconductor devices
854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits
854232	Electronic integrated circuits; memories
854233	Electronic integrated circuits; amplifiers
854239	Electronic integrated circuits; n.e.c. in heading no. 8542
854290	Parts of electronic integrated circuits

NAICS = North American Industry Classification System; HS = Harmonized System; n.e.c. = not elsewhere classified

Sources: Peter K. Schott data (https://www.dropbox.com/sh/y617r88ynedk2y8/AADs-EHEg3JDd6JrkuR7_Ii0a?dl=0); US Census Bureau (https://www.census.gov/foreign-trade/reference/codes/index.html).

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