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BETWEEN SANCTIONS AND SUBSIDIES:
RESHAPING THE SEMICONDUCTOR ECOSYSTEM

by Lilia Patrignani*, Michele Savini Zangrandi* and Alessandro Schiavone*

Abstract

Semiconductors are crucial to the modern economy, enabling economic and social interactions and supporting future growth and national security. Amid growing geopolitical tensions, the industry has become a focal point for policy intervention. This paper provides a comprehensive assessment of these policies, discussing their potential economic and international impact. Over the next 5-10 years, the US, the EU, China, Japan, South Korea and Taiwan will inject over $400 billion into the industry, catalyzing more than $700 billion in private investment. At the same time, an unprecedented bout of export controls is fragmenting the market. These policies will likely reshape the sector profoundly. Given the complexity of the semiconductor value chain, these measures reduce but do not eliminate external dependencies. Additionally, heavy-handed government intervention could unintentionally jeopardize the sector's economic health, with significant economic and security implications. The issues discussed highlight the challenge of managing security risks in an interconnected global economy without undermining its foundation.

JEL Classification: F13, L52, L63, N60, O38.

Keywords: semiconductors, industrial policy, supply chains, subsidies, export controls.

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* Banca d'Italia.

1. Introduction[1]

Semiconductors are critical inputs to much of the modern economy. In the context of rapid digitalization, semiconductor devices have surged to a central role. Today, semiconductors enable nearly all downstream technologies as well as most economic and social interactions. Powering research and boosting productivity, including through AI, semiconductors are also critical to future growth and wellbeing. Due to their applications in the military sphere, finally, semiconductors are also critical to a country's security and power-projection capabilities.

Two events contributed to draw attention to the critical role of semiconductors. First, the rapid rise of China in the digital and telecommunication sector – exemplified by the inroads made by Huawei in telecommunication devices and infrastructure – raised concerns related to the security of digital communications. Rapid advances of other Chinese operators in the high-tech sphere, in conjunction with the country's efforts to boost military-civil cooperation, also raised concerns regarding the deployment of new technologies in the military domain.[2] This overlaps with China's territorial claims over Taiwan, which plays a central role in the production of advanced semiconductors. Second, the 2021 shortage of semiconductors that followed the COVID19 pandemic brought to the fore their critical role by impairing activity in key sectors, with broad economic repercussions.

As a result, the industry became subject of intense policy scrutiny. The objectives of policy interventions vary significantly across countries, with increasingly intertwined security and economic goals. For instance, the US aims to maintain the technological edge by bolstering domestic production of advanced and security-critical devices, while denying such technologies to foreign adversaries. The Chips and Science Act adopted by the US in 2022 epitomizes the return of a strategic approach to industrial policy; coupled with unprecedented export controls, the two actions are at the core of the pincer strategy deployed by the US to maintain control over the most advanced segments of the sector. In the EU, the main objective of the European Chips Act adopted in 2023 is to secure the supply of semiconductors, by enhancing domestic capacity and diversifying imports, and to re-gain global market share. Finally, China has deployed vast resources to reduce its dependence on foreign chips and reach the technological frontier.

This paper sets off to answer two questions: how is the policy landscape changing, and what impact might this have on the industry – and on the broader economic and international landscape. While too many factors might be at play to provide a holistic assessment of the impact of the impending shift, this paper aims at least to define the contours of the problem.

This paper contributes to the narrow, but rapidly expanding literature on the economics and policy aspects of the semiconductor industry. Existing research examines the main trends in the semiconductor industry, describing the globally integrated nature and geographic concentration of semiconductor supply chains (Khan, 2021; BCG SIA, 2021). Other studies focus on the policy landscape, but often analyze measures in isolation. For instance, through a firm-level perspective, the OECD (2019) estimates that leading chipmakers received subsidies exceeding USD 50bn during the 2014–2018 period. Complementing this, Goldberg et al. (2024), uses data from the Global Trade

[1] Corresponding author: Michele Savini Zangrandi. The views expressed are personal and do not necessarily reflect the views of the Bank of Italy or the European Central Bank. We are grateful to: Claudia Biancotti, Alessandro Borin, Riccardo Cristadoro, Michele Mancini, Julia Trehu, Giovanni Veronese.

[2] Kania and Laskai (2021).

Alert database to estimate that major economies—namely China, Europe, Japan, India, South Korea, and the US—collectively spent over USD 800bn on semiconductor policy support between 2010 and 2022. The bulk of this amount (500bn) is attributed to China, while no industrial policy is identified for Taiwan. The Hufbauer and Hogan (2025) and Varadarajan et al (2024) reports illustrate the main subsidy policies being implemented globally. Varadarajan et al (2024) projects USD 2.3tn in new wafer fabrication investments between 2024 and 2032, with the US expected to capture 28% of it. Export controls have also received attention (Crosignani et al., 2024), with Khan (2020) and Chorzempa et al. (2024) analyzing how the US uses these measures to limit China's access to critical semiconductor technologies, while Voetelink (2023) focuses US rules that extend beyond their border to foreign-made products involving US technology. Bown and Wang (2024) provide a broader perspective on the evolution of industrial policies in semiconductor manufacturing, highlighting critical challenges such as China's expanding semiconductor industry, fragmented supply chains, and escalating geopolitical risks.

This paper makes several contributions. First, we bring together two closely related aspects of economic security policy in the semiconductor space that are normally examined in isolation: restrictive measures, such as export controls and investment screening; and government incentives and subsidies. Second, we distinguish countries' subsidies and incentives to the industry by instrument, providing a novel angle to headline-figure policy comparisons. In so doing, we estimate that over the next five to ten years, governments will plough over USD 400bn in the sector: the US prioritizes direct grants and tax credits, the EU focuses on direct grants, China relies on share purchases, while Taiwan mostly leverages tax incentives. Third, we estimate the scale of private investments these policies are likely to generate in the medium term. Leveraging an announcement-level dataset compiled by the German Marshall Fund,[3] supplemented with publicly available news and announcements, we estimate these policies are catalyzing private investments for over USD 700bn.[4] Finally, we discuss the likely impact and risks associated with these policy measures.

The rest of the paper is structured as follows. In section 2, we provide background on semiconductors and the semiconductor industry. In section 3, we discuss the complex relationship of the sector with security, and document the recent tightening in US export. In section 4, we survey the policies that the US, China and the EU deployed in support of the sector, and the investment announcements spurred by policy incentives.[5] Finally, in section 5 we discuss how such investment and restrictive measures might reshape production, and how that might affect economic and international landscape.[6]

[3] The GMF Technology Semiconductor Investment Tracker.

[4] This estimate aims to capture investment that is linked to policy incentives based on public announcements. Taking into account ongoing trends, Varadarajan et al. (2024) estimates that between 2024 and 2032, capital outlays in the industry will sum to USD 2.3tn.

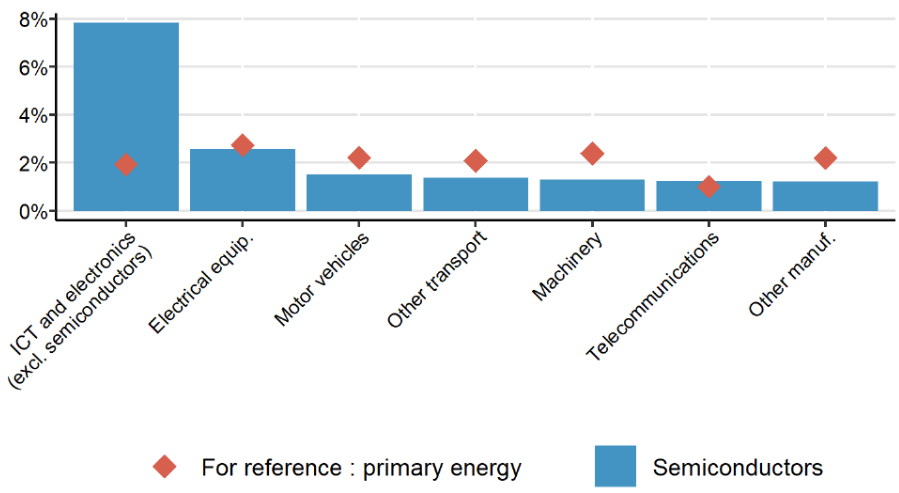
[5] The incentives, and investments of other very important countries in the semiconductor industry, Japan, South Korea and Taiwan, are detailed in Appendix 1.

[6] The two appendixes, which constitute an integral art of the paper, provide deep dives into the mechanics of export controls and the policies of relevant countries in the value chain that due to space constraints we were unable to address in the main body of the paper.

2. Background on semiconductors

The semiconductor industry is widely recognized as a critical input to the rest of the economy. According to the Semiconductor Industry Association, semiconductor sales neared USD 600bn in 2022.[7] As the enabling element for any electronic device, however, semiconductors play a much larger role than what industry turnover suggests. In many sectors, semiconductors are as important an input as raw energy (Fig. 1).[8] Indeed, the post-pandemic global chip shortage showed that the lack of fairly unsophisticated devices can cause disruption in large sectors of the economy. Looking ahead, the growth of the digital sector and the mass deployment of AI and connected devices are likely to make the sector even more central for the economy and security.[9] Consistently, semiconductor firms and equipment makers have recently surged amongst the most valuable companies on the market.

Fig. 1: Semiconductors vis-à-vis energy as an input



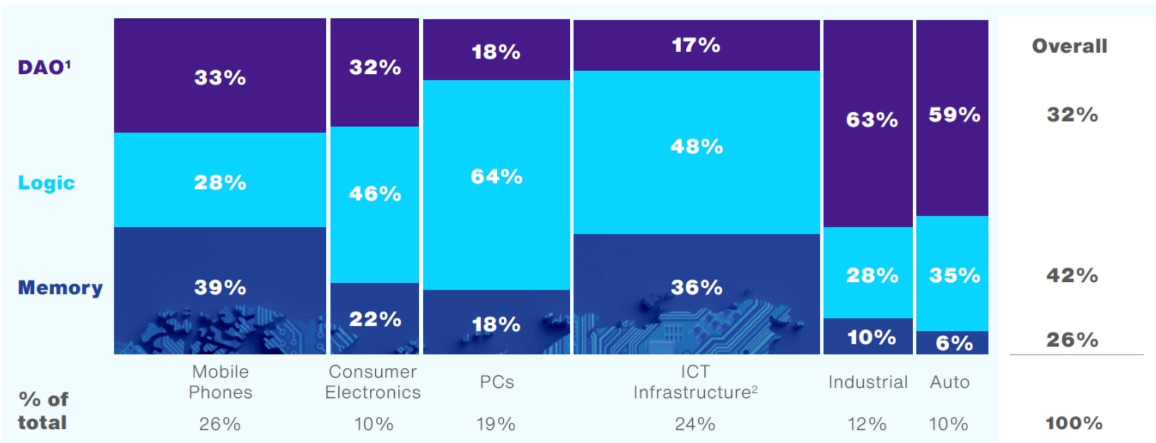
Source: OECD (2023).
Note: Share of value added in final demand, 2018.

The industry is highly segmented, reflecting the complexity of the manufacturing process, and the diversity of outputs.[10] By most classifications, there are three broad families of semiconductors: logic chips, memory chips, and DAOs devices (discrete, analog and others). Logic chips include central processing units (CPUs), Graphic Processing Units (GPUs), Micro-Controller Units (MCUs), and other programmable or task-specific devices.[11,12] These devices perform high-frequency binary operations and are at the core of computation. Memory chips allow for storage of information, and

[7] The words "semiconductor" and "chip" will be used interchangeably throughout the document.
[8] For a discussion of on the definition of strategic sectors, see Ding, Dafoe (2021).
[9] Aschenbrenner (2024).
[10] OECD (2024a).
[11] CPUs are the primary processors that handle a wide range of computing tasks, from running software applications to managing system operations. GPUs specialize in rendering images and videos, making them crucial for gaming, graphic design, and other visually intensive applications. MCUs are smaller, specialized processors typically found in home appliances, automotive controls, and smart devices.
[12] These include Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuits (ASICs).

include volatile[13] and non-volatile[14] memory devices. High grade GPUs and High Bandwidth Memory (HBM) chips, a particular type of volatile memory, have recently gain prominence because of their central role in the training of AI models. Finally, DAOs include discrete chips, which typically perform a single electrical function, and analog chips, which convert and modify signals from the physical world (such as sound or temperature) into digital signals or vice versa. These are used as sensors, in power management and in radio transmission. While certain devices find predominant use in selected applications (such as GPUs in training of AI models and DAOs in the industrial sector), other are used across the board. Further, different semiconductor types generally work as complements in final products. Smartphones, for instance, incorporate the three types in almost equal part (Fig. 2).

Fig. 2: Semiconductor type, by end market



Source: Varas et al. (2021).
Note: Share of 2019 industry sales.

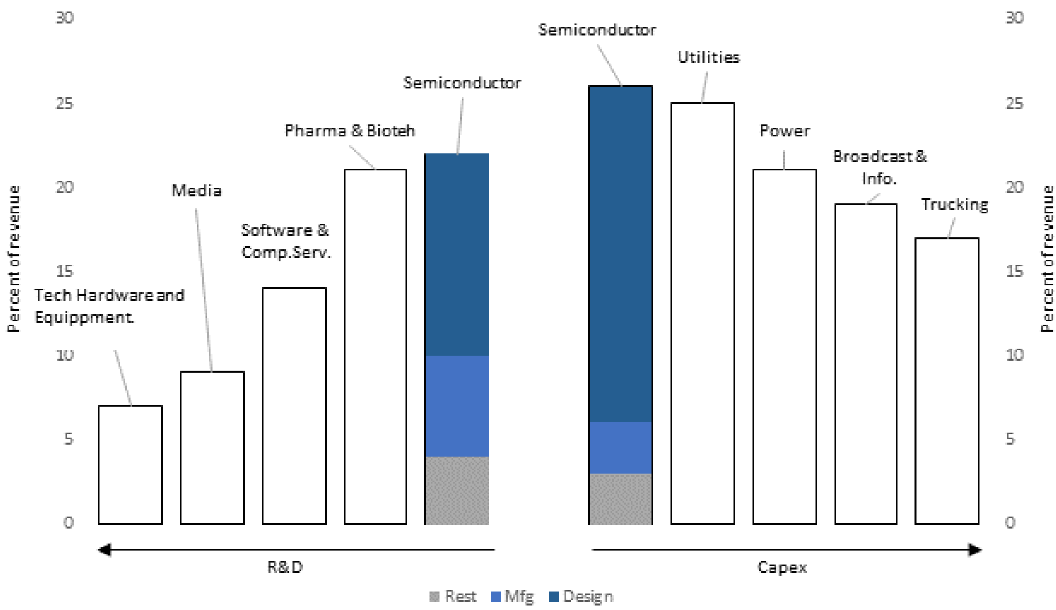
Chips are extremely sophisticated devices, in many aspects. Transistor size plays a predominant role in public discourse. Smaller transistors increase power-efficiency and computational speed, enabling cutting edge application. Training of AI models, for instance, requires single-digit nanometer-scale devices, which are extremely complex and expensive to produce. Not all devices need to be cutting edge however, simpler electronics can work perfectly well with larger transistor-size logic devices. Further, transistor size is not the only defining feature in semiconductor manufacturing. Other elements of complexity include materials and design. Logic and memory devices are generally made of silicon. DAOs can be made of different compounds, depending on the application. For instance, Silicon Carbide (SiC) chips find use in power applications, while Gallium Nitrate (GaN) in telecommunications. Whereas these devices are less sophisticated in terms of transistor-size, the materials involved require complex processing. Finally, performance per transistor-size can also be improved through design or manufacturing, as in the case of Systems on

[13] Devices that store data store data temporarily and require a source of power to retain information, including Dynamic Random Access Memory (DRAM) and Static Random Access Memory (SRAM) devices.
[14] Devices that do not require a source of power to store information, such as flash memory, including Not And (NAND) and Not Or (NOR) devices.

a Chip (SoC) or in 3D stacking.[15] Chip fabrication, in addition, requires extremely sophisticated machinery and trained workforce.

The industry structure is complex.[16] Semiconductor production is generally described as comprising three stages: design, fabrication, and assembly testing and packaging (ATP). The design stage consists of setting the requirements of the chip, designing its architecture, and validating its design. This stage requires sophisticated software applications (Electronic Design Automation, EDA) and intellectual property (IP). The fabrication stage consists of printing the integrated circuit on a silicon wafer. This entails complex manufacturing processes (like the Extreme Ultraviolet Lithography, EUV). The design and fabrication stages display very high levels of R&D and capital expenditures, making the industry amongst the most knowledge and capital intensive (Fig. 3). Finally, ATP involves dicing the wafers into individual chips, packaging them into frames or shells, and testing them. Parts of this stage are lower-skill-labor-intensive, and thus often outsourced to lower unit labor cost countries.

Fig. 3: R&D and Capital intensity



Source: Adapted from Varas et al. (2021).

Economies of scale and scope drive concentration and specialization. Firms in the industry follow one of two different business models. In the Integrated Device Manufacturer (IDM) model, one company carries out all stages of production—design, manufacturing and assembly, testing and packaging. The IDM model reflects the original industrial set up, and derives efficiencies from vertical integration. The model has however come under pressure from an alternative arrangement that demands further specialization. In the "fabless-foundry" model, a first set of firms specializes

[15] SoCs are integrated circuits that combine all essential components of a computer on a single chip, improving efficiency and reducing size. 3D stacking involves vertically stacking multiple semiconductor layers to form a single chip, increasing memory capacity and performance while saving space.
[16] OECD (2023).

in chip design (fabless is a contraction of fabrication-less), while a second set of firms – foundries – specializes in fabrication. Today, only two major firms (Intel and Samsung) follow the IDM model.

Recent OECD work shows the semiconductor industry to be amongst the most concentrated industries providing upstream inputs to the rest of the economy.[17] This is also the result of the high number of mergers and acquisitions in the last two decades, half of which were cross-border with US and China firms among the main buyers. The concentration is also pronounced in terms of revenues, with the top 20 firms accounting for more than 80% of the total, compared to 20% for the broader manufacturing sector.[18] The degree of concentration is also extremely high in two crucially important afferent industries: that of chip-design software and that of Semiconductor Manufacturing Equipment (SME).

Concentration along the value chain is also geographic, although the industry is extremely interconnected. Chip design capabilities are concentrated in the US and South Korea. Fabrication capacity is concentrated in the US, South Korea and Taiwan, with the production of cutting edge logic devices almost entirely concentrated in Taiwan. Software design tools and core IP are concentrated in the US and Europe, while the production of SME is concentrated in the US, Europe and Japan. China plays a significant role in ATP and is rapidly gaining ground in design and fabrication capacity (Tab. 1). South East Asia has growing role in ATP. As a consequence of the high degree of geographic specialization, the industry is extremely interdependent. The production of a logic chip for a smartphone, for instance, involves at least six different countries.

Tab. 1: Market share by industry segment

	Segment Value add	Market shares						
		U.S.	S. Korea	Japan	Taiwan	Europe	China	Other
EDA	1.5%	96%	<1%	3%	0%	0%	<1%	0%
Core IP	0.9%	52%	0%	0%	1%	43%	2%	2%
Wafers	2.5%	0%	10%	56%	16%	14%	4%	0%
Fab tools	14.9%	44%	2%	29%	<1%	23%	1%	1%
ATP tools	2.4%	23%	9%	44%	3%	6%	9%	7%
Design	29.8%	47%	19%	10%	6%	10%	5%	3%
Fab	38.4%	33%	22%	10%	19%	8%	7%	1%
ATP	9.6%	28%	13%	7%	29%	5%	14%	4%
Total value add		39%	16%	14%	12%	11%	6%	2%

Source: Khan (2021).
Note: Europe includes the UK.

The current geography of the production is also a reflection of industrial policies and of the outsourcing strategies adopted by the leading chipmakers over time. With the rise of consumer electronics, demand for semiconductors grew exponentially over the 1980s. Along with demand,

[17] OECD (2023).
[18] OECD (2019).

the investments required to set up and run cutting-edge production facilities also grew. Both factors put a heavy premium on scale and specialization. Against this backdrop, most of the leading US firms focused on chip design, outsourcing downstream production to East Asia.[19] A textbook example is Taiwan, that since the early '70s supported the creation of a network of specialized and innovative firms, attracting foreign investment and financing R&D activities. Licensing of foreign technologies was another important channel trough which Taiwan enhanced its role in the production of cutting-edge chips.

3. Semiconductors and security, a shifting balance

The US historically led semiconductor innovation, leveraging government support to secure military and strategic dominance. The United States pioneered early breakthroughs in semiconductor technology in the 1950s and 1960s, with the invention of the transistor and the integrated circuit, establishing itself as the global leader. This was sustained by strong government support, mainly through contracts for defence and space programs. Government support for the sector was part of strategy which saw the deployment of semiconductors in the military and intelligence domain as an offset to the increasing – though technologically less advanced – military might of the USSR. Developments such as precision-guided munitions and signals intelligence proved critical in shifting the balance of forces to the US advantage. Given their vital role in the US security strategy, maintaining leadership in the sector constituted a strategic prerogative; semiconductor technology thus remained closely controlled.[20]

As globalization intensified, the US embraced open trade, confident that it could retain its leadership through a combination of intense and export controls. During the 1990s and 2000s, US chipmakers started advocating for open trade and reduced government involvement. A consensus formed in Washington around the idea that the best strategy was to "run faster" than America's rivals, imposing the minimum possible level of restrictions. This strategy was based on the innovation-leadership-control cycle, whereby opening the sector to the mass market would provide a much greater source of funding for R&D, which would in turn ensure US technological leadership. This lead would be reinforced by selective export controls aimed at keeping adversaries behind in technology by one or two generations – a gap considered sufficient in the light of the US' role as the sole global superpower. Controls on older technologies would be regularly relaxed in order to tap the mass market to fund the R&D that would keep the cycle going.

However, practice defied theory and the US progressively lost its edge. Despite the appealing logic of the "run faster" paradigm, which neatly reconciled market and security requirements, its application failed to deliver. Weak protection of leading technologies, weak enforcement of controls on exports, slower than anticipated innovation in the US one hand, and the ingenuity and vast resources deployed by competitors on the other, conjured to progressively erode the US lead in many segments of the industry.[21]

[19] Miller (2022).
[20] Miller (2022).
[21] CRS (2023).

Meanwhile, China's technological prowess grew dramatically, sparking security concerns. During the 2000s and 2010s, China spent more on semiconductor imports than on oil, while at the same time carving itself an increasingly important role in certain areas of the industry.[22] In 2014, the Chinese government launched the "Big Fund" to reduce dependency on chip imports and boost domestic production of advanced semiconductors. By the late 2010s, Huawei had not only replicated technologies from South Korea's Samsung and Japan's Sony but also made significant strides in designing cutting-edge devices. In 2015, Intel's CEO raised concerns about China's aggressive expansion into the semiconductor sector, highlighting massive state subsidies and urging the US government to respond. These moves intensified fears that China's state-backed investments would weaken America's strategic edge in semiconductors, heightening security risks related to cyber warfare, signals intelligence, and the development of advanced (including AI-powered) weapons systems.[23]

In the subsequent years, the US government began to take a more aggressive stance towards China's growing technological ambitions, taking steps to restrict Chinese companies from acquiring US intellectual property and cutting-edge technology. In 2018, the Trump administration blocked semiconductor exports to Chinese telecom giant ZTE. In 2019 it was Huawei's turn. Found in violation of US export controls, the company was subject to increasingly tighter controls, which would eventually sever almost entirely its access to US semiconductor-related technology. Many other top Chinese tech companies were also affected by the same measures.

Amid escalating geopolitical tensions, the Biden administration shifted to a more restrictive policy stance, moving from a "run faster" approach to the "small yard – high fence" strategy. With the Chinese government's deep involvement in its economy and the ease with which restrictions were bypassed, the run faster approach proved insufficient to maintain a sufficiently reassuring technological gap. In response, the Administration, led by US security adviser Jake Sullivan, introduced a new paradigm in 2022. Certain technologies, including semiconductors, were deemed "force multipliers"[24] and could no longer be shared with adversaries under any circumstance.[25] This "small yard – high fence" strategy aimed to preserve the largest possible lead in critical technologies to secure a lasting competitive advantage. The result was a significant expansion of US export controls and investment screening measures in the semiconductor sector. Alongside the 2022 CHIPS and Science Act, these are among the key drivers of the ongoing transformation in the industry.

3.1. The resurgence of export controls

Export controls are a key tool of foreign and security policy, which limit the export, re-export, or transfer of specific goods and services to certain countries, end-users, or to serve certain nefarious uses, in order to achieve national security objectives. These controls, rooted in history, evolved from wartime measures such as the Trading with the Enemy Acts (1914–1917). Over time, multilateral peacetime arrangements like the Wassenaar Arrangement (focused on dual-use technologies,

[22] Miller (2022).
[23] ODNI (2024).
[24] A capability that, when added to and employed by a combat force, significantly increases the combat potential of that force and thus enhances the probability of successful mission accomplishment. US Department of Defense (2009).
[25] Sullivan (2022).

including semiconductors), and others like the NSG, AG, and MTCR, emerged to coordinate global controls.[26]

The US leads with the most comprehensive and impactful export control system. Governed by the Arms Export Control Act (1976) and the Export Control Reform Act (2018), US export controls are implemented through the International Traffic in Arms Regulations (ITAR) for military items and the Export Administration Regulations (EAR) for dual-use and commercial goods. EAR controls impose licensing requirements based on items (Commerce Control List), countries (Commerce Country List), end-users (Entity List), and end-uses, with licenses issued according to policies which reflect rationale for which the specific item is controlled, and its destination. Notably, US controls have extraterritorial reach, covering foreign-made goods with US-origin content or technology under rules like *de-minimis* content and the Foreign Direct Product Rule (FDPR).[27]

Up until 2022, only a portion of semiconductor (and semiconductor-manufacturing) technologies were subject to controls, and the related licenses were generally approved. Various types of semiconductors, and inputs to the semiconductor manufacturing process featured on the Commerce Control List.[28] Controls also covered technical data associated with those technologies and required US employers to apply for “deemed export licenses” for certain foreign nationals who could access controlled technical data or source code in the United States during their employment. These controls applied to all Chinese entities, and license exception, made on a case-by-case basis, generally resulted in approvals unless the entity was a military end-user.

Between 2022 and 2024, the reach and depth of controls on semiconductors to China increased substantially. Building on Sullivan’s commitment to restrict access to force multiplier technologies to US adversaries, the US implemented a first set of stringent controls in October 2022 specifically targeted to China.[29] This country-wide approach marked a major shift to the regime, which had until then attempted to discriminate on an end-use and end-user basis within the country. The 2022 controls were designed to limit China’s access to AI and high-performance computing by restricting its access to advanced chips, hinder its ability to acquire or produce viable alternatives, all this with the smallest possible impact in on US industry revenue and profitability by allowing sales of less advanced technologies to China.[30] These controls systematically restricted direct access to advanced semiconductors, SME, and to inputs to the production of SME. The controls achieve a significant extraterritorial reach through a combination of 0 *de-minimis* and FDPR.[31]

[26] See Appendix 1 for detail.

[27] See Appendix 1 for details.

[28] Among manufacturing equipment, controls covered some types of lithography, deposition, ion implanting, testing, and wafer handling tools, but not etching, process control, assembly, and wafer manufacturing tools. Among high-end semiconductors, controls covered field-programmable gate arrays (FPGAs), partly covered CPUs, but not GPUs, and their coverage of other AI-chips remained unclear. Among materials, controls covered certain types of masks, resists, consumable gases, wafers, and materials. Among software, controls covered software related to manufacturing equipment, but not EDA to design chips. For details see Khan (2020).

[29] Department of Commerce (2022). The controls on flows of semiconductors and semiconductor related technologies to Russia where also vastly expanded on occasion of Russia’s invasion of Ukraine. These developments are however unrelated to the US-China competition for technological supremacy and are therefore not discussed here.

[30] Allen (2024).

[31] These are mechanisms used to control exports of US technology. The *de minimis* rule prohibits exports of a foreign-made products that contains any amount (0%) of controlled US content. The FDPR, on the other hand, expands US jurisdiction by applying controls to foreign-made products that are the direct result of US technology or software, even if they are produced entirely overseas. While the *de minimis* rule focuses on content thresholds, the FDPR targets items derived from U.S. intellectual property, regardless of physical US components.

The regime was subsequently tightened as misspecifications, legal and illegal circumvention dampened its effects.[32] As it rapidly emerged, the effectiveness of the new regime was mired by technical gaps in the regulations, which still allowed China to compensate restrictions on top performing chips with larger quantities of lower performing ones. This was compounded by chip producers gaming the technical thresholds in the regulation, or producing chips at or near-threshold explicitly for the Chinese market. Finally, as controls only targeted entities in China, Chinese entities were still able to source chips through foreign subsidiaries of affiliates. The regime was thus amended in October 2023[33] to tighten the technical requirements for advanced chips, and to extend China specific restrictions to 43 additional countries.[34]

The 2023 update however still proved insufficient to achieve the US objectives. As a consequence, the controls were revised in multiple occasions through 2024.[35] In essence, the newly-revised controls: (i) enact worldwide controls on a set of advanced chip manufacturing tools and technologies,[36] while creating a license exception for countries that implement similar controls; (ii) add High Bandwidth Memory (HBM) chips to the controls, a high performance type of memory device that is critical to AI development; (iii) expand end-user controls adding over one hundred Chinese entities to the entity list; and, (iv) created extremely restrictive extraterritorial controls for SME, again waived by means of a license exception for selected few countries. These controls, have been argued to be broad enough to capture the whole SME market, including SME domestically produced in China.[37]

The 2025 AI diffusion rule further tightens controls on advanced semiconductors. In early 2025 the Biden administration issued a sweeping regulation aiming to control the diffusion of Artificial Intelligence.[38] Building on the 2022-2024 controls, the AI diffusion rule sets global licensing requirements on advanced AI chips, previously only controlled for a narrow set of countries including China. Recognizing the importance of already trained AI models, the regulation also sets restrictions on the export of AI "model weights" – that is, the technical parameters that result from the training of AI models. Consistently with the 2022-2024 controls, license exceptions on the export of advanced AI chips are available for certain validated end-users and low risk destinations, subject to a certain level of security screening and country-specific quantitative restrictions on the number of advanced devices that can be imported. License exceptions for allies and partners that implement similar controls reflect efforts to align export regulations for maximum effectiveness.

In sum, the 2022–2025 controls significantly reshape traditional U.S. export control strategy. First, they end the attempts to discriminate among end-users within China (and other countries), imposing a restrictive country-wide licensing requirement. Second, for specific items, they shift from an allowed-save-exceptions to a barred-save-exceptions approach, imposing worldwide licensing

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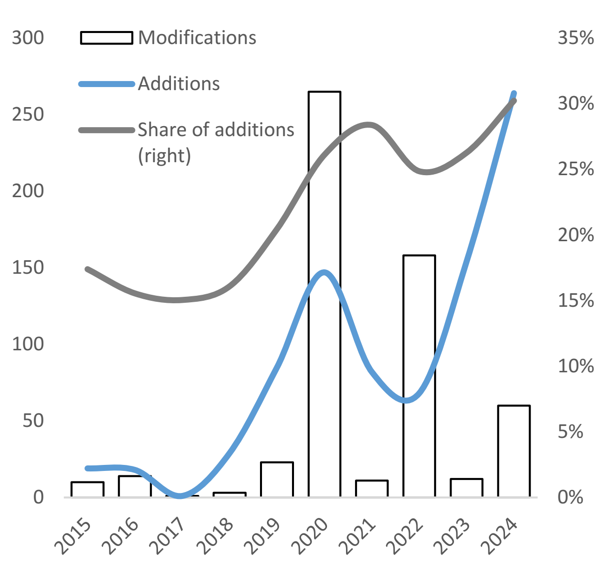
[32] Harithas and Schumacher (2024).
[33] Department of Commerce (2023).
[34] Dohmen and Feldgoise (2023).
[35] US Department of Commerce (2024a, 2024b, 2024c).
[36] This includes a wide range of advanced technologies, equipment, materials, and software with specific uses in manufacturing, electronics, and military applications. They include tools for making precision components, software for developing or using high-tech devices, materials like specialized wafers and chemicals for electronics production, and transmit/receive modules for communication systems. Many of these items are designed for sensitive or military-related purposes, focusing on high accuracy, advanced features, and specialized applications in fields like semiconductor manufacturing, pattern generation, and digital computing.
[37] Allen (2024).
[38] Department of Commerce (2025).

requirements. Third, they vastly expand US jurisdiction through the foreign direct product rule. Fourth, they codify international cooperation by instituting license exemptions for countries that implement similar controls.

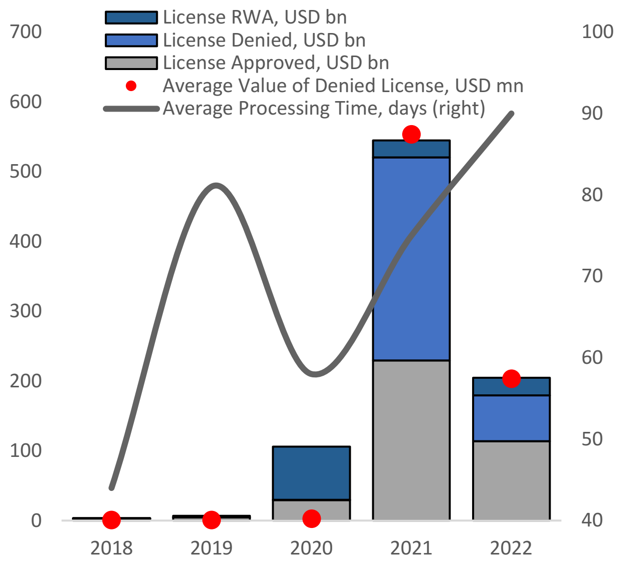
Stricter US controls are accompanied by an extensive expansion of the entity list, and a tightening in licensing. As a result of the tightening of export controls, since 2019 the number of Chinese entities on the entity list (which captures restricted end-users) increased exponentially, jumping from over 250 to over 900 (Fig. 4). Additions to the entity list comprise key players in China's tech space (Fig. 6). The expansion of the entity list was also accompanied by a tightening in licensing policies towards China: between 2018 and 2022, license approvals to China fell by 10 percent in number and 20 percent in value (visible in the increased share of licenses denied in Fig. 5), while processing time doubled (Fig. 5).[39]

Fig. 4: China additions to the entity list



Source: Authors elaboration from BIS entity list.
Note: Additions indicates the number of entities added to the entity list each year. Modification indicates the number of changes in the regime applicable to entities on the list.

Fig. 5: Outcomes of license requests to China



Source: Authors elaborations from BIS (2023).
Note RWA=Returned Without Action.

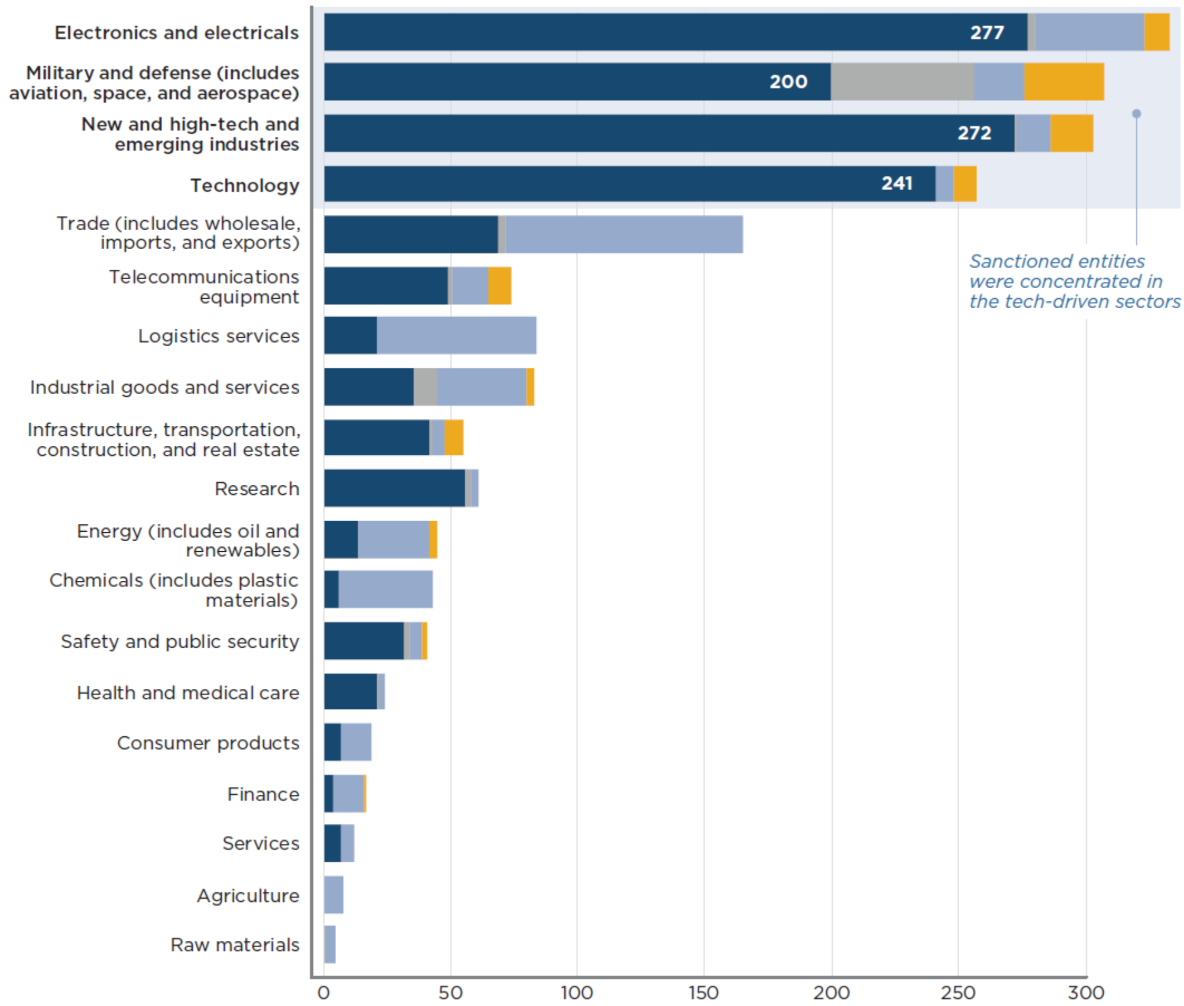
The implementation of tighter controls is associated with a sharp drop in US exports to China. Since the implementation of the 2022 controls, US exports of integrated circuits and Semiconductor Manufacturing Equipment (SME) to China dropped sharply (Fig. 7); in particular, between 2021 and 2023 (the last full year of data available), exports of integrated circuits dropped by 75 percent and exports of SME fell by 35 percent. Given the complexity of the regime, its extraterritorial nature and coordinated international efforts, a full evaluation of the impact and effectiveness of the US export controls will require further research. At present, expert commentary suggests that despite the progress of Chinese firms in producing advanced devices (7nm with low but increasing yield,[40] against a 2-3nm at the cutting edge), such progress is likely limited by the SME equipment utilized,

[39] Note that this predates the introduction of the 2022 regime. Data for 2023, which will likely show further tightening, was not available at the time of writing.
[40] Huawei improves AI chip production in boost for China's tech goals, Financial Times, 2024.

and by the tightening in SME controls. Export controls appear thus to pose substantial constraints to China's stock of computational capacity and its ability to increment it through domestic production.[41]

In response to US controls, China imposed controls on critical materials, such as gallium and germanium, of which it the world's main supplier. These materials play an important role in the manufacturing of certain semiconductors, particularly with defense applications.[42] A total ban on the exports of such materials has been estimated to cost up to USD 9bn to the US economy (0.03 percent of GDP), most of which in the semiconductor sector.[43]

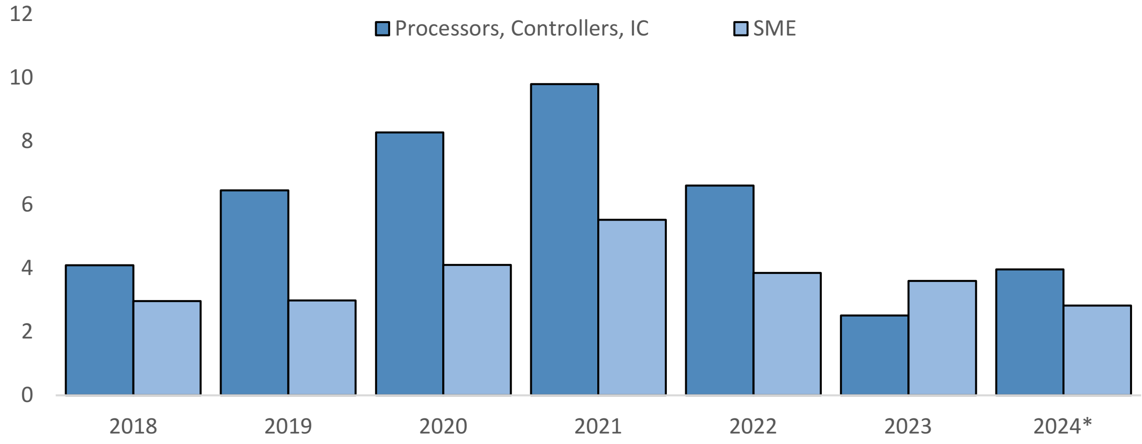
Fig. 6: Number of Chinese entities on sanctions lists, by sector



Source: Adapted from Chorzempa et al. (2024).

[41] Hathias (2024).
[42] Baskaran and Schwarz (2024).
[43] Nassar et al (2024).

Fig. 7: US exports to China (USD bn)



Source: Author's elaboration from TDM data.
*Note: SME = Semiconductor Manufacturing Equipment; * January to September.*

3.2. Investment screening

Despite the high level of capital mobility in advanced economies, countries have made efforts to safeguard their critical assets from being acquired by foreign adversaries. Since 1975, the US and Australia, followed by Canada, have implemented legislative frameworks to review foreign investments in strategic sectors including microelectronics, on a case-by-case basis. Other major advanced economies, such as France and Germany, adopted similar measures in the early 2000s.

Investment screening regimes in sensitive sectors such as semiconductors, became significantly tighter in the wake of the COVID-19 pandemic in 2019 and of recent geopolitical tensions. Several advanced economies began enforcing stricter scrutiny of foreign transactions from the late 2010s onwards. In 2018, the US enacted the Foreign Investment Risk Review Modernization Act. By 2020, Australia, Canada, and the largest European countries imposed tougher restrictions on foreign direct investment (FDI) to protect distressed national assets from opportunistic foreign takeovers.[44] G7 governments have made extensive use of these authorities in the semiconductor sector in recent years.[45] While drawing an extensive list of blocked transactions is beyond the scope of this paper, recent examples are indicative of the trend.

As a result of tighter controls, in the United States, several high-profile semiconductor transactions have been blocked due to security concerns. For instance, in 2016, the *Committee on Foreign Investment in the United States* (CFIUS) intervened to block the acquisition of Global Communications Semiconductors, a semiconductor manufacturer, by China's San'an Optoelectronics.[46] In 2017, acting on CFIUS recommendation, President Trump blocked the acquisition of Lattice Semiconductor, a specialized semiconductor design company, by China-backed

[44] Bencivelli, Faubert, Le Gallo, Negrin (2023).
[45] As for China, the 2020 Foreign Investment Law imposes restrictions on foreign investments in sectors listed in the "Negative List". While semiconductors are not part of this list, investments in the sector may still be subject to National Security Review, which also covers critical technologies related to national security.
[46] CFIUS Filing Withdrawn, Deal Abandoned: San'an Optoelectronics and GCS Holdings, Trade Practitioner, 2016.

Canyon Bridge.[47] The following year, President Trump also halted Broadcom's hostile takeover of Qualcomm, a major semiconductor intellectual property player, emphasizing the threat to US technological leadership and national security.[48] In 2018, CFIUS blocked the acquisition of Xcerra, a semiconductor testing company, by Hubei Xinyan Equity Investment, a Chinese government-backed fund.[49] The global nature of semiconductor firms and the increasing assertiveness of US authorities is also leading to an increase in CFIUS action to block transaction outside of the US borders.[50]

Other G7 countries also increased their level of vigilance. In the UK, the government blocked the acquisition of Newport Wafer Fab, a semiconductor production company, by Chinese company Nexperia in 2022 on national security grounds.[51] In 2021, the Italian government blocked the acquisition of LPE, a semiconductor equipment manufacturer, by Shenzen Investment Holdings.[52] In 2022 the German government blocked the sale of Elmos Semiconductor, which makes chips for the automotive industry, from selling its factory in Dortmund to Silex, a Swedish subsidiary of China's Sai Microelectronics.[53]

4. Support policies and investments

Recent years have seen a dramatic increase in government support to the sector. Government action in the sector dates back to the 1960s, when the US started funding research on microelectronics primarily for defense purposes during the Cold War. In East Asia, economies like Taiwan and South Korea implemented industrial policies starting in the 1970s, to strengthen their positions in the global supply chain, attracting foreign investment and helping domestic firms to gain competitiveness. Recognizing the capital intensity and R&D requirements of the sector, governments worldwide deployed a mix of grants, tax breaks, subsidized loans, and facilitated public-private consortia. These interventions serve three broad purposes: (i) ensuring supplies to power a wide range of downstream industries, including ICT, electronics, and motor vehicles; (ii) retaining or bolstering positions of leadership in the sector particularly in the light of the impending AI revolution; and (iii) strengthening security, as semiconductors are fundamental inputs for defense-critical sectors.[54]

Government support to the sector is projected to increase by 10 fold compared to the 2005-2019 period. Based on government budgets, we estimate that the key global players plan to inject over **USD 400bn** into the sector over the next five-to-ten years, catalyzing private investments exceeding **USD 700bn**. These are large numbers. For perspective, the OECD estimates that the semiconductor industry received 0.7 percent of revenue in subsidies over the 2005-2019 period.[55] In 2022, with

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[47] Presidential Order on CFIUS Filing: Canyon Bridge Capital Partners, China Venture Capital Fund, and Lattice Semiconductor, Trade Practitioner, 2017.
[48] CFIUS Deal Abandoned, Presidential Order: Broadcom and Qualcomm, Trade Practitioner, 2018.
[49] CFIUS Filing Withdrawn, Deal Abandoned: Unic Capital Management, China Integrated Circuit Industry Investment Fund and Xcerra, Inc., Trade Practitioner, 2018.
[50] See Van Grack and Brower (2021).
[51] Newport Wafer Fab's sale to Nexperia blocked by UK ministers, Financial Times, 2022.
[52] China Targeted Milan Semiconductor Firm Before Draghi's Veto, Bloomberg, 2021.
[53] Germany blocks sale of chip factory to China over security fears, CNN, 2022.
[54] For instance, weapons systems require specific devices whose production process needs satisfy particularly stringent security requirements. In addition, cyber, drone and AI-powered capabilities might require particularly advanced technologies. See also: Scharre (2023).
[55] OECD (2024b).

industry sales at USD 600bn, this would correspond to just over USD 4bn in subsidies worldwide. Thanks to current support the industry will receive an average of USD 40bn per year over the next ten years – a 10-fold increase over the 2005-2019 period. In this section, we dive into the details of the policies and investments of the US and China – the main geopolitical contenders – and of the EU. Policies and investments of other relevant countries for the sector are detailed in Appendix 2.

The US leads the push in support of the semiconductor industry. Comparing national programs is not easy as funds rely on different combinations of federal, national and subnational budgets, widely different instruments, and have been appropriated or executed to diverging degrees. Based on the main government programs, the US is leading the effort, with the Chips and Science Act allocating nearly **USD 140bn** (0.5% of US GDP) in incentives to the semiconductor industry in 5 years, in addition to up to **75bn** in subsidized private sector credit. Most of the US support comes in the form of tax breaks for investments in manufacturing facilities (Tab. 2). In response to the stimulus, the private sector pledged large investments. By 2030, firms' announcements indicate that more than USD 370bn will be invested in the US (Fig. 8), with over 90 projects announced since 2021. According to Varadarajan (2024), with these investments the US could propel its advanced logic semiconductor market share from nearly zero to almost 30 percent of global production.

Tab. 2: Government incentives in semiconductors by country and type (USD bn)

	US	EU[i]	Korea	Taiwan	Japan	China
Direct grants	46.7	48.1	6.4	-	22.7	-
Tax incentives	85	0.5	21[ii]	15.8	N/A	N/A
Subsidized credit	6	-	12.4	-	-	-
Share purchase	-	0.2	0.8	-	-	76.5
Unclear/unspecified	-	-	1	9.9	4.1	66[iii]
Total	**138[iv]** *(0.5% of GDP)*	**49** *(0.3% of GDP)*	**42** *(2.4% of GDP)*	**26** *(3.4% of GDP)*	**27** *(0.6% of GDP)*	**142.5** *(0.8% of GDP)*
Time horizon	5 years (2022-27)	9 years (2021-30)	7 years (2023-30)	10 years (2023-33)	9 years (2021-30)	10 years (2019-29)

Source: Authors' elaboration based on: Varadarajan et al (2024), Chorzempa (2024), and public news and announcements.
(i) This reflects the budgets of the EU's main economies: Germany, France, Italy and Spain.
(ii) Authors' estimate based on announced investments and applicable government incentives.
(iii) Author's elaboration, based on Varadarajan et al (2024) estimates of municipal funds for semiconductor projects, and national funding trends.
(iv) The figure excludes up to USD 75bn in subsidized credit from the private sector.

China's incentives, though less transparent, are similarly ambitious. According to available data, we estimate China's direct support to the sector in the decade starting in 2019 to be about **USD 140bn** (0.8% of GDP). The fiscal multiplier – that is, the private sector response – of the incentives however is unusually low, at 0.5, against the 1.8-2.8 range of other countries (Tab. 3). While this may reflect the extraordinary level of government support to the sector, it may also be a result of lower transparency in private investment plans. Either way, with these levels of investments, China seems poised to strengthen its position in less-advanced but ubiquitous technologies. On the other hand, it remains unclear if China will manage to reach the cutting edge.

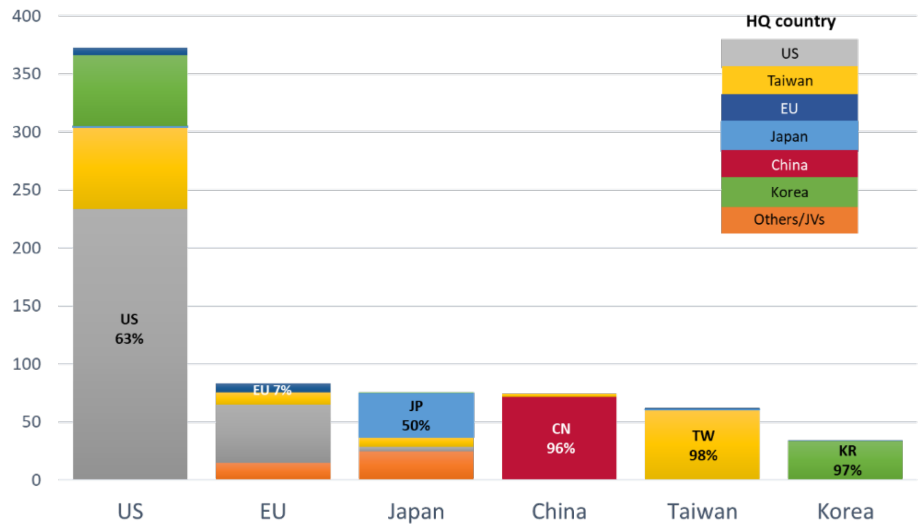
Meanwhile, the EU's results are mixed. Despite almost **USD 50bn** allocated through national budgets, mainly in the form of direct grants to companies, private sector response has been less enthusiastic than in the US. The fiscal multiplier in the EU is the lowest after China. The difficulties that EU encountered in leveraging private capital are compounded by the fact that several large projects have been put on hold, as disappointing financial results led some investors to de-prioritize on investment in the Union.

Tab. 3: Semiconductor investment and fiscal multiplier

Country	Public incentives (USD bn)	Private investments (USD bn)	Multiplier
US *(2022-27)*	138	373.1	2.7
EU *(2021-30)*	49	87.4	1.8
Korea *(2023-30)*	42	105	2.5
Taiwan *(2023-33)*	26	62	2.4
Japan *(2021-30)*	27	75.2	2.8
China *(2019-29)*	142.5	74.5	0.5

Source: Authors' elaboration.

Fig. 8: Semiconductor investments announced since 2021, by HQ country (USD bn)



Source: Authors' elaboration based on GMF Semiconductor Investment Tracker and public news and announcements.
Note: Figures refer to investment in projects to be completed by 2030.

4.1. A deeper look at national plans and investment outturns: US, EU and China

<u>The US</u>

A look back. In the early days of the semiconductor industry, the US Department of Defense and NASA were key customers for microchips, driving industry growth and technological advances.[56] The formation of organizations like DARPA (Defense Advanced Research Projects Agency) fostered innovation, ensuring the US maintained a technological edge over its rivals. This era saw the emergence of Silicon Valley as a global hub for semiconductor innovation, driven by a combination of government contracts, university research, and entrepreneurial activity.

[56] The Department of Defense procurement policies significantly shaped the semiconductor industry by awarding contracts to newer firms, like Texas Instruments, and by requiring technology transfer to ensure multiple domestic sources for components. This policy encouraged diversity, innovation and knowledge sharing within the industry.

By the 1980s, US semiconductor policy shifted toward addressing competitive threats from Japan, whose industry had captured a significant share of the global market, particularly in DRAM. In response, the US government and private sector collaborated to create Sematech (Semiconductor Manufacturing Technology), a public-private consortium aimed at revitalizing domestic manufacturing capabilities and fostering innovation. Around the same time, the rise of the fabless-foundry model allowed US firms to specialize on design while outsourcing production, increasing flexibility and efficiency. These efforts, coupled with trade agreements and anti-dumping measures, helped the US regain market shares in the 1990s, pioneering new product categories like GPUs and challenging Japanese leadership as competitors like South Korea emerged.

The Chips and Science Act. Today, the US is the world leader in the most R&D-intensive components of the value chain such as chip design, chip design software, semiconductor manufacturing equipment and is home to leading global chipmakers, but lacks significant advanced fabrication capacity which has been mostly outsourced to Asia. The fabrication of the most advanced logic chips is currently located in Taiwan and South Korea, and 97 percent of ATP is performed outside the country.

In order to bolster domestic semiconductor capabilities and mitigate supply chain vulnerabilities, the US committed **USD 138bn** in incentives to the semiconductor industry over the 2022-2027 period (Table 4). This figure increases to 213bn once subsidized private sector lending is included. In detail, the Chips and Science Act allocates 39bn in direct grants for capital expenditures and 13.7bn for R&D and workforce development programs. Of the 39bn allocated to capex: 6 can be leveraged to support loans and loan guarantees, facilitating up to 75bn in financial assistance for the semiconductor industry; and 2bn are designated specifically for the production of mature semiconductor technologies (28 nanometers and above).

The Act also provides a 25 percent tax credit for investments in semiconductor manufacturing facilities.[57] The Congressional Budget Office originally estimated that the tax credits would cost USD 24bn, but reputable projections suggest that the actual figure could exceed 85bn.[58] States such as Texas, Arizona, and Oregon have supplemented these federal efforts with their own grants and tax credits.[59]

In order to guarantee the safe use of US funds, companies receiving subsidies under the Chips and Science Act are prohibited from increasing the production of chips below 28nm in “countries of concern”, including China and Russia, for the subsequent 10 years.[60] As part of the US' friend-shoring strategy to move supply chains away from China, the country also promoted the ‘Chip 4 alliance’, which comprises the US, Taiwan, Japan, and South Korea. The alliance aims to enhance cooperation between the members on design and production of sophisticated semiconductors.

[57] The tax credit is available to any facility whose primary purpose is the manufacturing of semiconductors and semiconductor manufacturing equipment (thus excluding administrative areas of fabrication facilities). This includes facilities for producing chips, chipmaking equipment, and wafers, but excludes those that manufacture underlying materials such as polysilicon.

[58] Chorzempa (2024)

[59] The Texas CHIPS Act establishes a USD 1.36bn fund to provide grants for semiconductor R&D and manufacturing projects, and the creation of advanced R&D centers. The Oregon CHIPS Fund has approved USD 190 million in loans and grants to support chipmakers' capital investments. Arizona has allocated USD 100 million to stimulate growth in its semiconductor industry. Colorado has introduced a USD 75 million CHIPS Refundable Tax Credit program.

[60] NIST (2023)

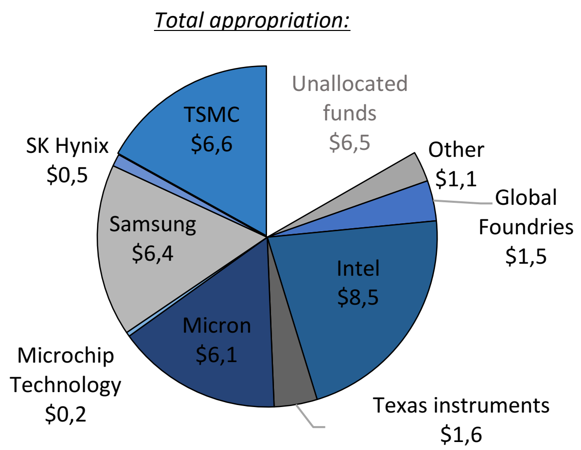
Table 4: US subsidies to chipmakers

Overall funding	**137.7 bn**
o/w	
Capex	124 bn
R&D and workforce	13.7 bn
o/w	
Direct subsidy	46.7 bn
Tax incentive	85 bn
For up to 75bn in subsidized credit	6 bn

Source: Authors' elaboration.

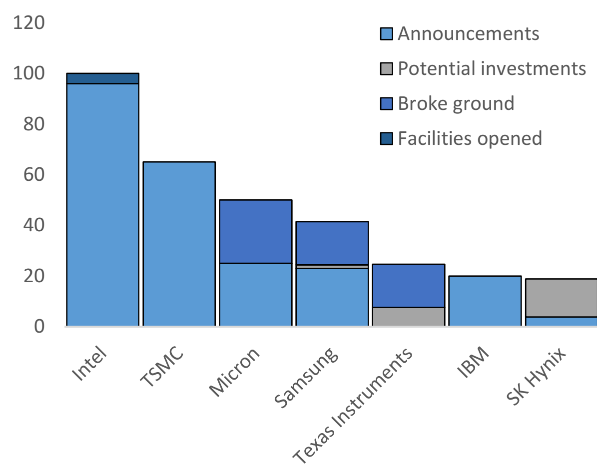
Investment outturns. The US leads in semiconductor investment, with nearly **USD 370bn** in planned outlays over the next few years. The Chips and Science Act has been highly successful in crystallizing investment in the country. This is already visible in hard economic data, with construction spending for computer and electronics manufacturing increasing fourfold since its enactment.[61] Since 2021, chipmakers have announced over 90 projects across 25 States, aimed at improving manufacturing capabilities and driving R&D. While the bulk of these investments (USD 300bn) are still in the planning stage, several broke ground or started production testing (about 70).

Fig. 9: Allocated funds under the Chips and Science Act



Source: Chips for America News & Releases.
Note: "Other" includes: Absolics, Amkor Technology, BAE Systems, Entegris, GlobalWafers, Polar Semiconductor, Rocket Lab, and Rogue Valley Microdevices.

Fig. 10: US top semiconductor investments announced since 2021, by company (USD bn)



Source: Authors' elaboration based on GMF Semiconductor Investment Tracker and public news and announcements.
Note: For Micron, Samsung and Texas Instruments the investment figures represent planned expenditures by 2030, rather than the investment planned over the entire two-decade period.

Leading investors in the US include Intel and Micron, along with Taiwan's TSMC and Korea's Samsung, collectively receiving more than two-thirds of direct grants allocated under the Chips and Science Act (Fig. 9). **Intel** has committed to investing USD 100bn over five years to build advanced

[61] Notstrand et al. (2023)

chip manufacturing plants, including a regional cluster in New Albany, Ohio (Fig. 10). For these projects, the company will receive 33.5bn in government aids – the largest awarded under the US Chips Act, of which 8.5 in direct grants and 25 in tax breaks, in addition to 11bn in subsidized credit.[62] **TSMC** has secured almost USD 23bn, of which 6.6bn in grants plus 5bn in subsidized credit to support its 65bn investment in three cutting-edge fabs in Arizona, expected to be completed by 2030. Similarly, **Micron**, the largest American maker of computer-memory chips, is set to receive 16bn from the government to fund its 50bn investment in three Dynamic Random-Access Memory (DRAM) fabs.[63] Meanwhile, **Samsung** plans to invest nearly 200bn in the construction of 11 new chip-making plants in Texas over the next two decades. Of this, 40bn will be spent in the coming years, with 16.4bn in government subsidies facilitating the initial phases.

The EU

A look back. In contrast to the US, the semiconductor industry in Europe did not benefit from large-scale government support and military contracts during its early development. In the 1970s and the 1980s, European governments primarily focused their attention on other technological sectors, particularly computer electronics, leaving the semiconductor sector relatively underfunded compared to its US and Asian counterparts. However, during the 1990s, European governments launched several initiatives to promote public-private partnerships, including the MEDEA (Micro-Electronics Development for European Applications) program and the JESSI (Joint European Submicron Silicon Initiative), a collaborative R&D effort involving key semiconductor firms like Philips and Siemens. National efforts also played a role. After its unification, Germany supported the "Silicon Saxony" semiconductor hub in Dresden, attracting firms such as Infineon and GlobalFoundries. France and Italy's national chipmakers, SGS Microelettronica and Thomson Semiconducteurs, were both partly state-owned. In 1987, the governments decided to merge the two companies to form STMicroelectronics, a strategic initiative aimed at consolidating resources and create a competitive European presence in the semiconductor industry.

The EU Chips Act. Today, the EU is a global leader in specific segments of the value chain and has fabrication capacity to cater for domestic downstream manufacturing. In particular, the EU leads in the advanced lithography technology, particularly through ASML, which is the sole world producer of Extreme Ultraviolet (EUV) lithography machines (in the Netherlands), and it is home of prominent research centers such as the Interuniversity Microelectronics Center (IMEC, in Belgium). Europe is also home to several chip manufacturers that cater for automotive and other domestic manufacturing industries. However, its share of global fabrication capacity stands below 10 percent, and – most importantly - the EU lacks production capacity with regard to cutting-edge chips. To boost the EU's global position, the *European Commission Digital Compass*, published in 2021,[64] sets

[62] Intel will also receive more than USD 2bn in incentives from Ohio, for a total public subsidy of around 35bn (35% of planned investment).
[63] Of the 16bn in support, 6bn comes from direct grants while 10bn is estimated tax credits (as not all of the company's planned investments qualify for tax breaks). Additionally, the state of New York has committed up to 5.5bn in incentives through tax credits on capital investments and labor costs. Micron will also benefit from an incentive package in the state of Idaho, bringing total public subsidies to over 20bn (40% of its planned investment).
[64] European Commission (2021).

the target of increasing global production share to 20 percent by 2030.[65] The 2021 EU *Chips Act*[66] aims to inject around USD 50bn of public subsidies and catalyze private investments for a similar amount. It remains unclear if these funds are sufficient to meet the EU's ambitious objectives; according to some estimates the EU would need to deploy over 100bn in additional resources.[67]

Building on the EU Chips Act, Member states earmarked nearly **USD 50bn** in support of the industry. Unlike in the US, where funding for the sector comes from the federal budget, the EU chips act relies mainly on national budgets. EU funds are tapped only for R&D activities. This creates issues of comparability, as national budgets do not necessarily earmark funds over consistent timespans, and might be subject to revisions. Nonetheless, to the extent to which a comparison is possible, the largest EU Member States budgeted for USD 49bn in support of the industry (Tab. 5). Specifically, Germany allocated nearly USD 21bn in incentives (of which 16bn for capital expenditures) under its *Microelectronics for Digitalization program,* to be spent between 2024 and 2030. Spain launched the ambitious *PERTE Chips program*, with USD 13bn of allocated funds available between 2022 and 2027.[68] France allocated USD 5.2bn in direct aid for the semiconductor industry as part of its France 2030 program, aiming to double domestic production capacity.[69] Italy designated nearly USD 4bn to be spend between 2022 and 2030, with USD 3.4 billion allocated to its *Fund for Microelectronics* to encourage new investments, USD 570mn for tax credits supporting semiconductor R&D programs, and USD 230mn for the *Chips IT Foundation*.

Tab. 5: EU incentives in semiconductors by country and type (USD bn)

	Germany	Spain	France	Italy
Direct grants	21	12.5	4.9	3.6
Tax incentives	-	-	-	0.5
Share purchase	-	0.2	-	-
Total	**21** *(0.5% of GDP)*	**13** *(0.8% of GDP)*	**5** *(0.2% of GDP)*	**4** *(0.2% of GDP)*
Time horizon	6 years (2024-30)	5 years (2022-27)	9 years (2021-30)	8 years (2022-30)

Source: Authors' elaborations.

Finally, EU resources come from various funding programs which include the EU Chips Fund (USD 1.9bn) and the two large innovation oriented programs (Horizon Europe and Digital Europe, each contributing for USD 1.5 bn). The overarching goal is to facilitate the transfer of laboratory research into industrial innovation and on-shore manufacturing, by encouraging R&D investments and supporting innovative firms.

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65 This objective reflects the wish to return Europe to a dominant role in semiconductor manufacturing. Varas et al. (2021), shows that in the 1990s Europe held 44 percent of global manufacturing capacity. This estimate, however, has recently been questioned as more accurate accounting appears to indicate that Europe historically only held a 10 percent share. (see Europe didn't have 44percent of global chip production capacity in the 90s. Sorry., J.P. Kleinhans, 2021).

66 European Parliament and Council of the European Union (2023).

67 Timmers (2022).

68 The bulk of the Spanish program (USD 10.2 billion) goes toward building manufacturing facilities. Additionally, USD 1.3 billion is allocated in advanced research, USD 1.5 billion for boosting Spain's microprocessor design capabilities, and USD 440 million for stimulating the ICT manufacturing industry (including a USD 220 million capital fund to finance startups and innovative SMEs in the national semiconductor sector). Despite the ambitious program, no major chipmakers have yet announced plans to invest in Spain.

69 Key initiatives include a "mega-fab" project led by STMicroelectronics and GlobalFoundries, developing low-power and high-power electronic technologies, and establishing Intel's design centers in France.

Investment outturns. Despite significant announcements, pledged investments in the EU are struggling to break ground. Catalyzed by national subsidies, semiconductor firms pledged investments for **USD 87bn** in Europe over the coming years. However, the vast majority of European investment plans remain at the announcement/potential level (Fig. 11), and 40bn in pledged investments have been recently put on hold.

Intel is a key player in Europe's chip strategy (Fig. 12). The company pledged to invest USD 50bn. Of this, 32bn for the construction of two cutting-edge fabs in Germany, backed by approximately USD 11bn in grants from the German government. Other investments by the company include 13bn for expanding operations in Ireland, and 5bn for a state-of-the-art assembly and test facility in Poland. Investments in Germany and Poland were however recently put on hold as disappointing financial results led the firm to de-prioritize investments in the Union.[70] Germany will also see a **TSMC** 11bn investment backed by a 5.5bn grant, an **Infineon** 5.3bn investment on the back of 1bn in grants, and a 3bn investment by **Wolfspeed**. Like Intel's however, Wolfspeed's investments has also recently been put on hold due to financial difficulties.[71] France committed 3bn in support of **STMicroelectronics'** and **GlobalFoundries'** 8bn joint venture in Crolles. Italy granted a total of over 3bn in support of STMicroelectronics silicon carbide wafer production initiative in Sicily and Silicon Box's advanced packaging facility in Piedmont (Fig. 13).

Fig. 11: EU investments announced since 2021 (USD bn)

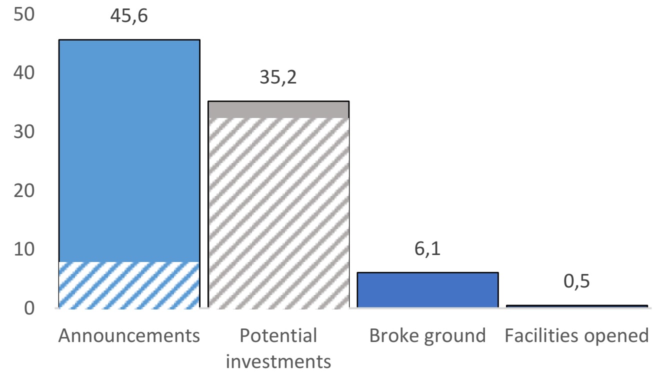
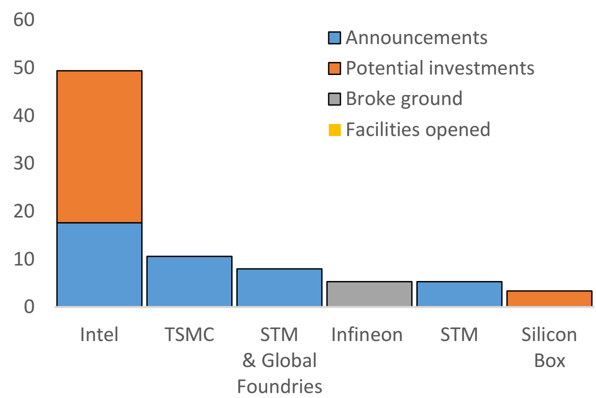


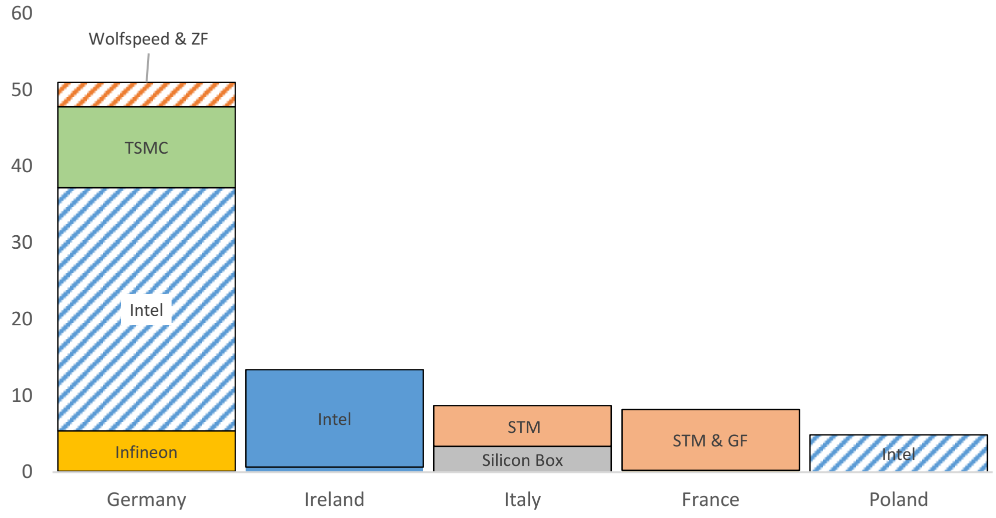
Fig. 12: EU investment progress, by company (USD bn)



Source: Authors' elaboration based on [GMF Semiconductor Investment Tracker] and public news and announcements.
Notes: "Announcements" refer to public statements or disclosures made by companies, while "Potential investments" refer to projects under consideration or industry rumors about upcoming investments that have not yet been formally confirmed. Shaded areas indicate investments currently on hold.

[70] Intel outlines plans to cut costs and boost chip business in turnaround push, Financial Times, 2024.
[71] Germany's chip ambitions hit after US tech group shelves plans for plant, Financial Times, 2024.

Fig. 13: EU investments announced since 2021, by country (USD bn)



Source: Authors' elaboration based on [GMF Semiconductor Investment Tracker](#) and public news and announcements.
Note: shaded areas indicate investments currently on hold.

<u>China</u>

A look back. China's semiconductor development began in the 1960s with the establishment of state-owned enterprises as part of the country's broader industrialization plans. Due to political isolation, progress in semiconductor technology was slow. The industry faced significant challenges such as outdated equipment, limited technical expertise, and poor integration into global supply chains.

After China's opening-up policies in the late 1970s, the government introduced several initiatives to attract foreign technology and capital, helping China gaining access to semiconductor production know-how. By the late 1980s and throughout the 1990s, the government set up dedicated industrial zones and provided favorable policies like tax breaks and subsidies to semiconductor manufacturers. However, China's semiconductor industry still faced significant challenges during this period, particularly with regard to technological lag and reliance on foreign imports. Projects like 908 and 909 aimed to develop domestic chip manufacturing faced delays, technological gaps, and market challenges. Despite setbacks, China's growing demand for semiconductors spurred new efforts in the 2000s, leading to the rise of firms like SMIC, which leveraged government support and foreign expertise to compete internationally.

China's Big Fund. Today, China leads the world in ATP capacity and wafer fabrication for mature chips and raw materials, but its semiconductor industry lags in sophistication. China's domestic industry lacks leading firms in high-end logic, advanced analog, and cutting-edge memory markets; in advanced semiconductor manufacturing equipment; and in chip-design software. This creates "chokepoints" where the country remains heavily dependent on imports.

To address these dependencies and accelerate the development of a robust domestic semiconductor ecosystem, China launched the "National IC Promotion Guidelines" in 2014 and the "Made in China 2025" plan in 2015. These initiatives set ambitious goals for establishing a world-leading integrated circuit industry. Quantifying Chinese semiconductor investment is challenging, as national policy guidelines lack specific monetary values and are implemented by provinces, each designing and funding its own industrial policies. An exception is represented by the "Big Fund", established to provide targeted support through direct investments in Chinese chipmakers. The *Big Fund* raised USD 23bn during its first phase in 2014, investing in 81 projects by 23 listed companies, and 29bn in its second phase in 2019. It financed China's two biggest chip foundries, SMIC and Hua Hong, memory manufacturer YMTC, and a number of smaller companies. In May, China launched the third phase of the Big Fund, aiming to raise USD 47.5bn in state-backed financing for fabrication and design activities.

Alongside the National IC Fund, at least 15 provincial and municipal funds have been established since 2015, for an estimated combined capital of USD 50bn.[72] The Chinese government also provides other forms of support to the semiconductor sector, including concessional loans, reduced utility rates, and subsidized land prices.[73] In 2023, it further enhanced support by increasing the pre-tax deduction for R&D expenses to 220 percent for Chinese chipmakers, a policy set to remain in effect through the end of 2027.[74]

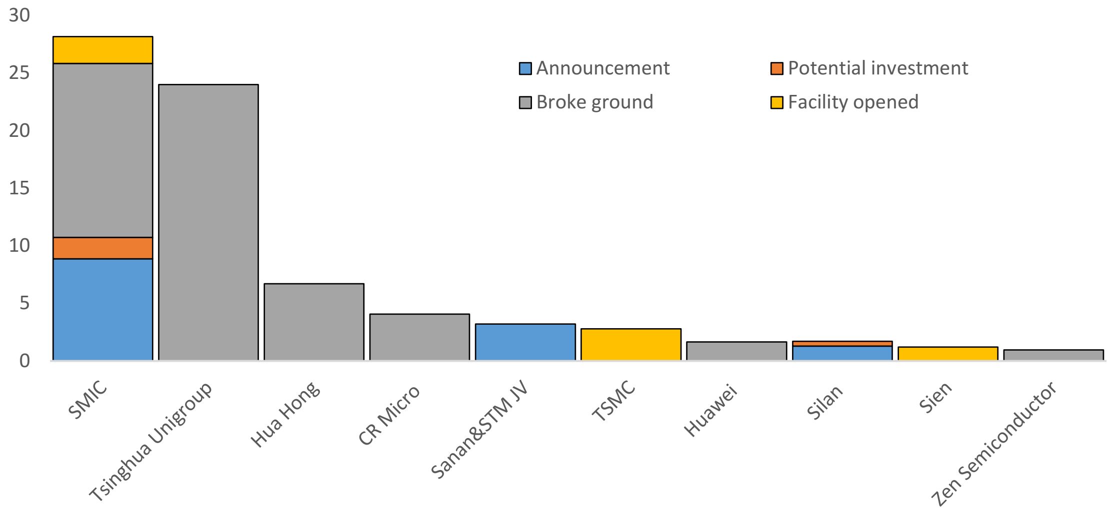
Investment outturns. Since 2021, chipmakers in China have committed over USD **75bn** in new investments, primarily focusing on legacy technology nodes. Domestic companies account for 95 percent of these investments, for a total of 16 projects, many of which are already under construction (Fig. 14). Key examples include **SMIC**'s 28bn investment to expand the production of 28-nanometer and larger integrated circuits, and **Tsinghua Unigroup**'s decision to resume its 24bn memory chip fab construction plan, previously suspended due to financial difficulties. Among foreign firms, Taiwanese company TSMC is investing 2.3bn to expand its 28-nanometer production in Nanjing, while Micron Technology is planning a 600mn investment in its chip packaging facility in the city of Xi'an.

[72] In addition, Huawei has reportedly received an estimated USD 30 billion in state funding from the government and the Shenzhen city since it moved into chip production in 2022, according to the Washington-based Semiconductor Industry Association. However, Huawei denied that the government is giving it support to develop semiconductor technologies.

[73] OECD (2019) revealed that, from 2014 to 2018, the benefits from below-market loans for China's four major state-backed semiconductor firms (Tsinghua Unigroup, SMIC, JCET and Hua Hong) amounted to USD 4.85 billion. Tsinghua Unigroup alone obtained USD 22 billion in favorable loans from Chinese state banks in that period. The study also estimates that, in terms of benefits for firms, total public support over the period amounted to more than 40percent of SMIC's revenues, 30percent for Tsinghua Unigroup, and over 20percent for Hua Hong (compared to 10percent of revenues for STMicroelectronics, and less than 5percent for TSMC, Samsung Electronics, Infineon and Intel).

[74] Chip technology R&D expenses are eligible for a 120percent deduction on top of the 100percent general R&D credit, resulting in a total deduction of 220percent. Additionally, up to 80percent of outsourced foreign research costs can be deducted, provided that these costs do not exceed two-thirds of the total R&D expenses. This approach reflects China's focus on increasing the long-term technological capabilities of its domestic companies, regardless of where the know-how originates.

Fig. 14: China semiconductor investments announced since 2021 (USD bn)



Source: own computations based on public news and announcements.

5. Perspectives and considerations

In this paper, we discussed the structure of the semiconductor industry and the main policy levers being pulled to reengineer it for a world of increased tensions, revamped economic and national security concerns and selective de-risking.

Government action is profoundly reshaping the structure of this critical sector. Restrictive measures, such as pervasive and extraterritorial export controls and investment screening are fragmenting the market. At the same time, unprecedented cash-injections are reconfiguring production across geography and technology. While too many factors are at play to tell with a reasonable degree of confidence where the sector is heading, we can attempt some considerations.

First, the boost in investment is likely to lead to a significant increase in productive capacity. According to industry association SEMI, between 2022 and 2024, 71 additional fabs have started production. Of these, 18 in the US, 13 in China, 12 across Europe and the Middle-East, 9 in Taiwan, 8 in Japan and 4 in South Korea. The impact of these additional fabs should be felt in the course of the next 5 years. As government incentives stretch much further into the future, however, even more capacity is expected to come online. By 2032, it is estimated that up to 150 additional fabs might be in operation.[75]

Second, we can expect a significant shift in the geography of production. According to Varadarajan et al. (2024), assuming announced investments come to bear, the US could see a major increase in its market share by 2032. This would be particularly notable in the advanced logic segment, where the US share could jump from virtually naught to nearly 30 percent of global production. China's large investment would lead to significant gains in the non-edge logic semiconductors, where Chinese demand is still heavily import-dependent.[76] Finally, due to the limited size of public

[75] SEMI (2023).
[76] Varadarajan et al. (2024).

resources made available, and the comparatively lower level of leverage they seem to achieve, it appears unlikely that the EU will achieve its target to double its market share by the 2030. Nonetheless, the EU will continue playing a critical role in segments of the industry where it holds dominant positions

Third, this is likely to bear significant economic and international consequences. Gaining a substantial share of the advanced logic sector, the US appears poised to reinforce its leading position in the industry. From an economic standpoint, this will put the US in a leading position to benefit from the impending AI transformation, while from a security standpoint it will reinforce the US's strategic advantage. The vast expansion in China's non-edge logic capacity will increase China's autonomy in the segment. While the bulk of China's additional capacity appears to be catered to domestic demand, such capacity may overflow – directly or indirectly – in international markets, depressing prices of commodity chips. Analysts seem to consider the direct weaponization of this production unlikely; increased domestic capacity in this segment however will further entrench China's leading position in the manufacturing of downstream electronics, and learning-by-doing dynamics increase the chances of breakthroughs into advanced logic production despite the increasingly stringent export controls.[77] Finally, it is worthwhile to stress that despite the increased onshore production, the industry will remain tightly interdependent, with no country poised to achieve self-sufficiency. Indeed, Varas et al. (2021) estimates that complete manufacturing self-sufficiency in the US would require over USD 400bn in government incentives and cost more than USD 1tn over ten years.[78]

While the US would appear to come out as the major winner, several words of caution are due.

First, restrictive measures are only as good as the enforcement capacity the US can bring to bear, and the degree international cooperation it can elicit. It remains to be seen how effectively countries will be able to enforce the extremely complex controls they have deployed, and the extent to which the private sector and other international actors will cooperate. Further, sanctions and export control are likely to elicit countermeasures, causing the weaponization of adjacent sectors, such as critical minerals.

Second vast government and private sector capital outlays are no guarantee of success. Transferring or starting from scratch the production of advanced technologies is notoriously complex, and the economic viability of the projects is far from ensured – particularly in the context of the broader transformation of the industry.

Third, the economic viability of the sector will depend on the balance of supply and demand. Government interventions are likely to alter the supply demand balance in the sector, in ways that may not be conducive from its long run health.

On the supply side, heavy government intervention will boost production in advanced economies, where the cost of inputs may lead to higher end-market prices.

[77] For a discussion of China's role in non-edge logic semiconductors, the risks of weaponization and overcapacity see: Goujon et al. (2024), Benson et al. (2024) and Ebrahimi (2024).
[78] Varas et al. (2021).

On the demand side, restrictive measures may fragment the market in a context where demand projection are characterized by a profound uncertainty – particularly in the advanced logic segment. The recent Introduction of DeepSeek – a highly capable and very cost-effective[79] Large Language Model developed in China – cast doubts over trillion-dollar investment plans in datacenters by US players.[80] While increased efficiency of AI models may reduce the amount of computational power required, the overall impact on semiconductor demand is unclear as several concurring factors may push in the other direction. For instance, in the race for the control of Artificial Intelligence, more computational power will be required, even at higher levels of efficiency; lower cost of training may also draw new AI model developers – previously discouraged by the prohibitive costs of datacenters – into the market; finally, lower cost of AI at the user level might increase the demand for inference datacenters.

The combination of increased costs, fragmented markets and increased costs of compliance may trim profits in parts of the sector, undermining its ability to sustain the extremely high capital outlays and research budget necessary to maintain the technological edge. Loss of competitiveness in the sector may have significant economic and strategic implications.

More broadly, developments in this sector point to the need for an articulated economic security doctrine. Governments have paid increasing attention to the industry, dedicating resources to understand its functioning and needs.[81] Governments however need to balance the benefits of free trade and competition with security concerns, not just in the semiconductor industry but also across a growing number of sectors of the economy, like critical raw materials and energy. This will require a clear definition of economic security, distinguishing it from competitiveness and national security. Additionally, it will be important to evaluate the costs and benefits of economic security measures and to foster international cooperation to address inevitable spillovers.[82]

[79] Through a combination of architectural choices, efficient training methodologies, and a focus on data optimization. DeepSeek managed to cut significantly training and inference costs. This breakthrough, which is widely considered as part of the natural evolution of the technology, was released in open source and quickly replicated, contributing to improve the efficiency of AI across the hard.

[80] On 21 January, President Trump announced "The Stargate Project", a "physical and virtual infrastructure to power the next generation of advancements in AI", with investments for USD500bn over the coming four years.

[81] This is testified by the increasing number of semiconductor units within governments, and international efforts of the G7 and OECD.

[82] Muzinich (2024).

Appendix 1: A deep dive into export controls

Export controls are a tool of foreign and security policy. In their broadest definition, export controls are limits that countries impose on the export, re-exports or transfers of certain goods or services to specific countries, end-users or for specific uses to achieve national security or foreign policy objectives.

Export controls have a long history. The control of technology flows towards foreign adversaries[83] has long been part of international relations. In the middle ages, the Republic of Venice closely guarded the shipbuilding secrets which lay at the heart of its military and commercial power. The roots of modern export controls can be found in the *Trading with the Enemy Acts* (TWEA) instituted by the UK in 1914 and the US in 1917. Wartime measures evolved, at the end of World War 2, into peacetime controls, such as the US 1949 Export Control Act. NATO countries kept such measures closely aligned through the informal *Coordinating Committee for Multilateral Export Controls* (CoCom) – an arrangement designed to bar technology transfers to the Eastern Bloc – which remained in place until the fall of the Soviet Union in 1994. Between the late 1960s and the 1990s four wider multilateral arrangements emerged. The Nuclear Suppliers Group (NSG) concerning nuclear material and related technology; the Australia Group (AG) concerning biological and chemical weapons and related material; the Missile Technology Control Regime (MTCR) concerning missiles and related technology; and the Wassenaar Arrangement (WA), the broadest of the four and most relevant for the semiconductor industry, on conventional arms and, most importantly, on dual use goods and technologies.[84]

The scope of export controls increased substantially in recent years. The four multilateral agreements form the basis of national export control regimes, which countries often supplement with additional measures. Despite their central role in international security, the limited number of items controlled kept the overall footprint of export controls on international commerce reasonably small.[85] Over the last decade, however, export control regimes expanded significantly, as international tensions grew and the number of technologies considered dual use increased. Expansions of controls happened mostly at the national rather than multilateral level,[86] with only a limited degree of coordination across the G7+ countries.

The US has the world's most articulated and pervasive regime of controls. The expansion of national export controls regimes is particularly evident in the US, which has the world's most articulated system of controls and – owing to its unique position as leading tech, economic and military power – the most impactful regime at a global scale. The main legal frameworks for export controls in the US are the *Arms Export Control Act* of 1976 and the *Export Control Reform Act* of 2018. The first covers a narrow set of sensitive military items, is implemented through the International Traffic in Arms Regulations and administered by the Directorate of Defense Trade Controls of the Department of State. The second – much broader in scope – covers commercial, dual-use items and some military items of lesser sensitivity, is implemented through the Export

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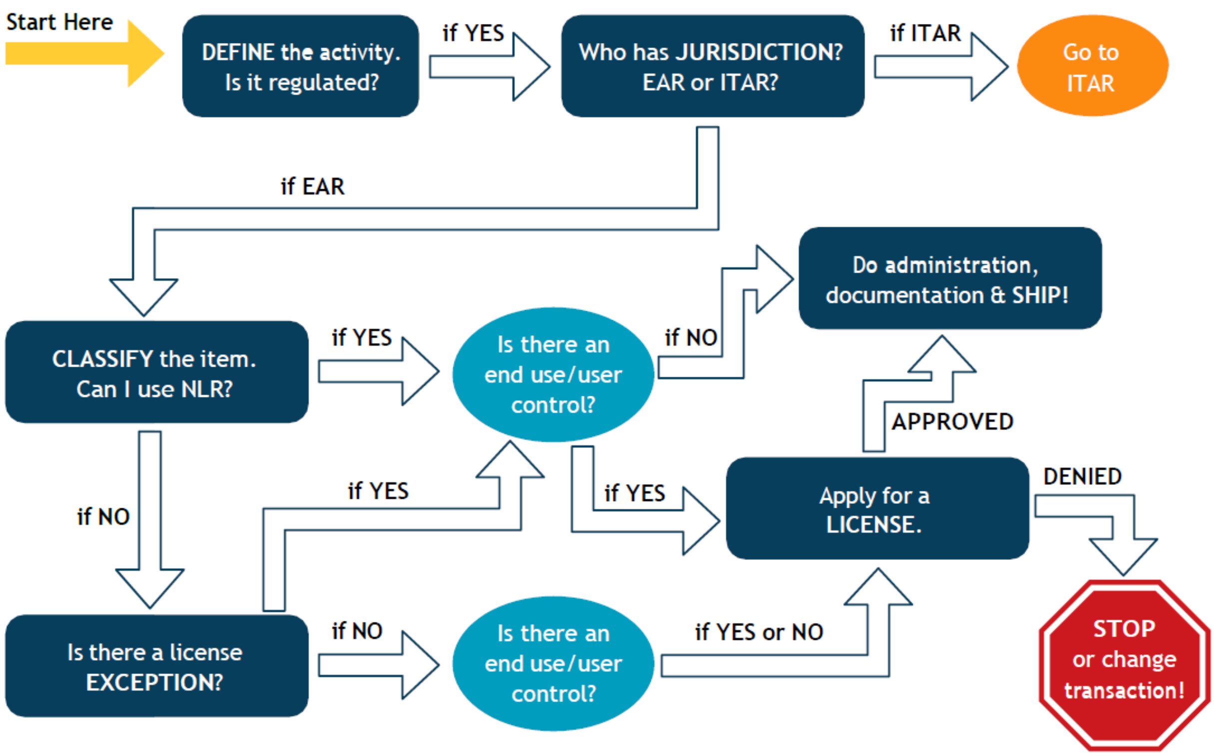
[83] The US defines foreign adversaries as "any foreign government or foreign non-government person determined by the Secretary to have engaged in a long-term pattern or serious instances of conduct significantly adverse to the national security of the United States or security and safety of United States persons".
[84] CRS (2023) and CRS (2021).
[85] According to the BIS (2021), 0.4 percent of US take place under BIS license, and 0.9 percent under license exceptions. No estimate is available for exports for which the license is denied.
[86] Notably, Russia is part of the NSG, MTCR and WA, China of NSG.

Administration Regulation (EAR) and administered by Bureau of Industry and Security (BIS) of the Department of Commerce. These frameworks are based on US international commitment under the four multilateral agreements, supplemented with additional US-specific controls.

US export controls are structured as overlapping licensing requirements. To the untrained eye, the US export control framework looks extremely complex. Understanding the key elements of its functioning however is critical to get a sense of the recent policy shift. In essence, the US export controls are structured as overlapping sets of licensing requirements. The EAR sets licensing requirements on (i) a broad array of goods and services, captured by the Commerce Control List, (ii) a set of countries, captured by the Commerce Country Chart, (iii) specific end-users, as detailed in the Entity List, and (iv) specific end-uses. Trade that involves flagged items, countries, subjects or end-uses is only permitted with a license, which is granted on the basis of the reason why the item is controlled and of its destination.[87] Licenses are issued according to predetermined polices, and the administration can issue temporary of general license exceptions (Fig. 15). Finally, controlled items are reviewed periodically in order to limit controls to the most sensitive items.

Fig. 15: Export Controls Flowchart



Source: Quick reference flipchart, Export Compliance Training Institute, 2022.
Notes: EAR = Export Administration Regulation; ITAR = International Traffic in Arms Regulation; NLR = No License Required.

US controls are extraterritorial. At least two features of the US export control regime extend its effects well beyond transactions that involve US subjects. First, US export controls apply to goods and services that contain a *de-minimis* US content. This is typically set at 10-20 percent, but it can go much lower for foreign-made items if they contain certain high-end US-origin content. Second,

[87] Licenses can be either general, or specific. Licensing policies vary according to the item object of the transaction, reason for control, country of destination, end-use and end-user.

under the recently introduced Foreign Direct Product Rule (FDPR), certain items that are produced abroad, remain under US jurisdiction if they are the direct product of US-origin technology, software or equipment.[88]

Appendix 2: A deeper look at national plans and investment outturns: Japan, South Korea and Taiwan

Japan

A look back. From the 1960s to the 1980s, Japan gradually increased its global share of semiconductor production, supported by substantial government investment. By 1977, semiconductor manufacturing equipment accounted for 26% of Japan's total R&D spending, up from 2% in the early 1970s. During this period, the Japanese government invested in public-private partnerships involving Japan's leading computer companies, like Fujitsu, Hitachi, and NEC, focusing on researching fundamental technology for semiconductors.

As Japan's semiconductor industry expanded, the US grew increasingly concerned about Japan's competitive threat, with fears that Japan's export-subsidized firms were "dumping" chips into the US market. This led to the 1986 US-Japan Semiconductor Agreement, which set minimum chip prices in the US market and increased foreign access to Japan's domestic market. These concessions weakened Japan's competitive edge both at home and abroad, allowing companies in the US and South Korea to capture a larger share of the global market. Later, in the 1990s and 2000s, despite government efforts to shift towards specialization, many Japanese companies struggled to adapt to global shifts from vertical integration to a fabless model. In response to Japan0s relative decline, the Japanese government has recently redoubled its efforts to steer the national semiconductor industry towards a more globally competitive business model.

Revitalizing Japan's semiconductor industry. While Japan remains a global leader in semiconductor materials and equipment, its global market share has declined significantly: from 50 percent in the 1980s to 9 percent in 2022.[89] According to government estimates, the Japanese semiconductor industry currently lags about ten years behind the world's technology leaders.[90] To bridge this gap, the Japanese government committed almost **USD 27bn** to semiconductor projects under its Semiconductor Revitalization Strategy. Key initiatives include: (i) 11.6bn for advanced manufacturing (5G Promotion Act); (ii) 8.5bn for R&D, including funding for the Rapidus Consortium's 2nm chips,[91] and (iii) 6.8bn for mature-node chips, equipment and materials

[88] The Foreign Direct Product Rule (FDPR), which was introduced in 1959 to place controls on the transfer of certain items made abroad with the benefit of U.S. technologies. In simple terms, the FDPR allows the BIS to regulate the reexport and transfer of foreign-made items if their production involves certain US technology, software or equipment. It does this by defining that technology, software and equipment as subject to the EAR. Understanding the Foreign Direct Product Rule, Export Compliance Training Institute, 2022; BIS (2024); Voetelink (2023).

[89] Analysts attribute the decline in Japan's market share to three main factors: (i) the industry's focus on memory chips at the expense of logic chips; (ii) the offshoring of production and the global shift to a fabless model of chip design and manufacturing; and (iii) the 1986 US-Japan Semiconductor Agreement, which negotiated a 20percent market share for the US industry in Japan and committed Japan to allowing greater foreign competition in its market.

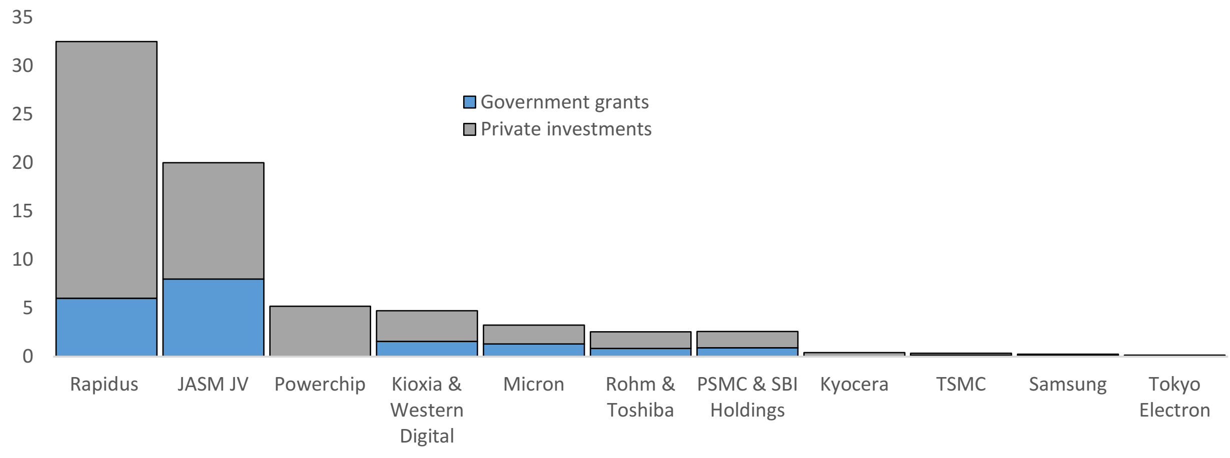
[90] "Japan Ministry of Economy, Trade and Industry (202)(

[91] Rapidus is a consortium of Japanese firms (including Toyota, Sony, NTT, NEC, Kioxia and Denso) established in August 2022 for the production of cutting edge chips in collaboration with IBM, the European research hub Interuniversity Microelectronics Centre (IMEC), and the LSTC (a government-supported R&D center). Rapidus received USD 2.3 billion from the Japanese government over 2022 and 2023, with the aim to start producing 2-nanometre chips by 2027.

(Economic Security Act). In addition to these projects, Japan's fiscal year 2024 tax reform offers up to a **20 percent break** on corporate income tax to semiconductor firms. The tax credit will be available for a period of ten years, but there are currently no estimates of its cost to the government.[92]

Investment outturns. Government incentives are yielding results. Since 2022, chipmakers have announced nearly **USD 70bn** in investments in the country. The majority (70 percent) of the investment stems from the Rapidus consortium and the Japan Advanced Semiconductor Manufacturing (JASM) joint venture, primarily funded by TSMC. Specifically, **chip foundry venture Rapidus** is investing more than 30bn to create a "Hokkaido Valley" for mass production of cutting-edge chips starting from 2027, in partnership with IBM and Belgium-based research organization IMEC. The government is contributing 6bn to support this initiative. Additionally, **TSMC** is in collaboration with Japanese Sony, Denso, and Toyota in a 20bn investment for the establishment of two semiconductor plants. These facilities will focus on producing wafers tailored for automotive, industrial, consumer, and High-Performance Computing applications, with 8bn in support provided by the government. Besides TSMC, other foreign companies are looking to increase their presence or enter the Japanese market. Taiwan's Powerchip obtained government subsidies to set up a 5bn foundry. Samsung will receive up to 130mn in support of a new R&D facility for advanced semiconductors near Tokyo. Additionally, Japan is enhancing collaboration with the US, with Micron Technology planning a total investment of 3bn in Japan over the next few years. To date, the Japanese government has announced a total of USD 20bn in grants to chipmakers investing in the country (Fig. 16).

Fig. 16: Japan investments announced since 2021 (USD bn)



Source: own computations based on public news and announcements.

South Korea

A look back. South Korea invested early in its semiconductor industry, helping Samsung and SK Hynix become global leaders in memory chips. In the 1970s, Korea's semiconductor policy was shaped by

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[92] Moreover, in line with recent export restrictions by the United States and the Netherlands, Japan has listed 23 types of semiconductor technology now subject to export restrictions, effective July 23, 2023. These restrictions include advanced microchip manufacturing equipment, such as machines for depositing films on silicon wafers, and devices for etching microscopic circuits. For China, this amounts to a ban similar to the US export restrictions.

a top-down, government-led strategy, focusing on rapid industrialization and leveraging semiconductors as a key pillar of economic modernization. The government was successful in attracting foreign investment with laws like the Foreign Capital Inducement Law (1969), offering tax incentives to companies like Fairchild and Toshiba. These foreign partnerships brought essential semiconductor technologies and enabled local firms to gain production knowledge. The Eight-Year Plan for Electronics Industry Promotion (1969-76) outlined goals for exports and domestic production, particularly targeting memory devices and silicon wafers. The government also encouraged large family-owned conglomerates (so called chaebols), such as Samsung, to enter the semiconductor market. By 2022, Samsung and SK Hynix together held 70 percent of the global Dynamic Random Access Memory (DRAM) market and 50percent of the global NAND flash market.

The K-Chips Act. In response to the US Chips and Science Act and increasing international subsidies, in 2023 South Korea enhanced its semiconductor support through the K-Chips Act. The Act raises the tax credit for semiconductor investments to 15 percent for large companies and 25 percent for SMEs investing in the country.[93] The tax credit is up to 50 percent for R&D activities.[94] These tax incentives are expected to provide **USD 55bn** in support for companies over the next 7 years.[95] In addition to the K-Chips Act, in May 2024, the Korean government announced a **19bn** package primarily aimed at providing low-interest loans to chipmakers.[96] Of this package, 2.8bn are allocated for infrastructure construction for a semiconductor "mega-cluster" outside of Seoul, intended to be the core of the country's chip industry and to attract 450bn in private investment by 2047. To position itself as a major player in the field of AI, South Korea has also approved a 1bn fund to support domestic AI chipmakers, to be spent by 2027.

Investment outturns. South Korea's incentives are proving effective, favoring investments from domestic firms. The country is investing heavily in the construction of the world's largest semiconductor cluster in the Gyeonggi province, with the goal of attracting a total of USD 470bn in private investment over the next two decades.[97] Construction is set to begin in 2026, and the long-term vision includes establishing 13 production facilities and 3 R&D fabs by 2047. In the short term, 105bn will be invested in projects to be completed in the coming years. Of this amount, 82bn will be allocated by **Samsung** for a new fab in Yongin, expansions in Pyeongtaek, and the establishment of 3 R&D facilities within the mega-cluster. Meanwhile, **SK Hynix** is investing USD 22bn in the first fab within the cluster, which is expected to start production by 2027, as well as in a new memory chip facility in Cheongju (Fig. 17).

[93] The K-Chip Act was first passed in December 2022 and offered an 8 percent tax credit for investments aimed at expanding facilities in strategic industries, including semiconductors. To be more in line with the support provided by other nations, an amendment was passed in April 2023, increasing the deduction. However, the tax credit still falls short of the level offered by the US.

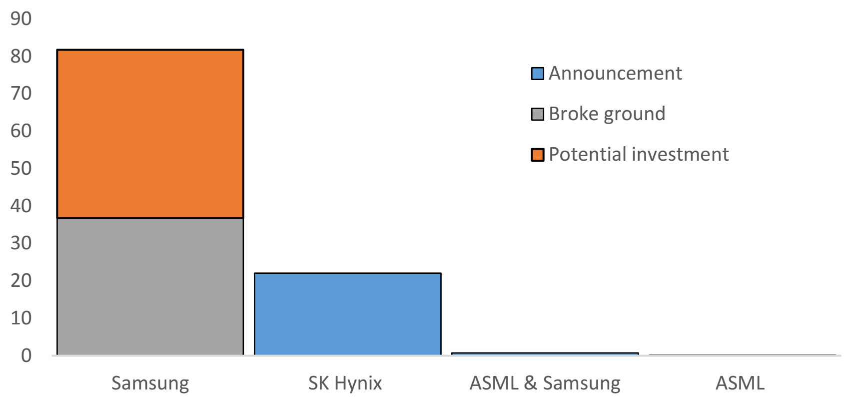
[94] The K-Chips Act's tax incentives apply only to specific high-tech semiconductor technologies, including (i) 15nm or lower DRAM, (ii) 170-layer or higher NAND flash, (iii) 7nm or less System-on-Chip (SoC) foundries, and (iv) chips for vehicle and energy efficiency improvements. This focus on advanced technology means that few companies other than Samsung and SK Hynix qualify for these funds.

[95] Based on Varadarajan et al. (2024)

[96] Of the USD 19 billion package, USD 12.4 billion will be allocated as low-cost loans to support chipmakers, USD 3.6 billion as grants for research, USD 2.8 billion for infrastructure construction, and USD 800 million in capital funds to invest in local chipmakers. South Korea will not be providing any direct subsidies for chip manufacturing.

[97] The two-decade plan includes a USD 375bn investment by Samsung, while SK Hynix is set to invest 91bn in memory chip production in Yongin (Gyeonggi). The government said the region will also house smaller chip design and materials companies.

Fig. 17: : Korea investments announced since 2021 (USD bn)



Source: Authors' elaboration based on public news and announcements.
Notes: For Samsung and SK Hynix the investment figures represent planned expenditures by 2030, rather than the investment planned over the entire two-decade period. "Announcements" refer to public statements or disclosures made by companies, while "Potential investments" refer to projects under consideration or industry rumors about upcoming investments that have not yet been formally confirmed.

Taiwan

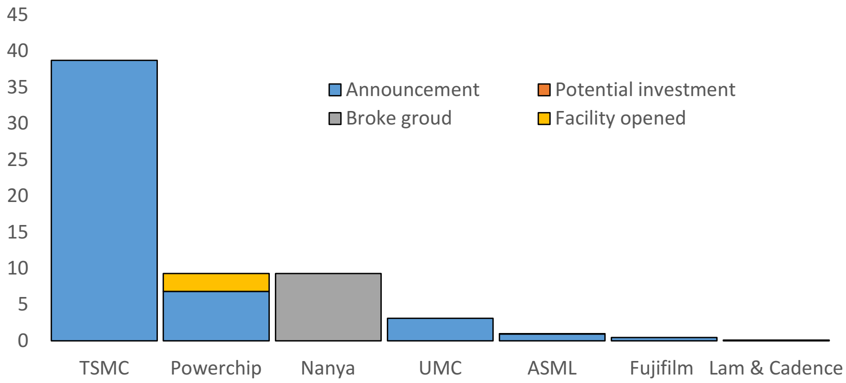
A look back. Taiwan's rise as a global semiconductor leader began in the mid-1970s, spurred by government-led initiatives like the "*RCA Project*", aimed at acquiring IC manufacturing technology and reducing local electronic industries' dependence on imported components. Through the Industrial Technology Research Institute (ITRI), Taiwan trained its engineers in cutting-edge techniques, achieving significant progress in IC production by the late 1970s. ITRI became the birthplace of Taiwan Semiconductor Manufacturing Company (TSMC), founded in 1987 as the world's first pure-play foundry, focusing on manufacturing chips for other companies. This business model revolutionized the industry, enabling fabless design companies to flourish globally.

Backed by government subsidies, infrastructure investment and talent development, Taiwan rapidly developed a robust semiconductor ecosystem. By the 1990s, Taiwan's semiconductor sector had grown rapidly, positioning the country as a leader in advanced manufacturing and a cornerstone of the global technology supply chain. Today, Taiwan accounts for 18 percent of global production capacity and dominates the logic IC segment. In 2022, the country accounted for 70 percent of the global production capacity for advanced chips (under 7nm), led by TSMC.

Recent government policies. To further strengthen its semiconductor sector, the Taiwanese government is encouraging investment in the domestic semiconductor industry through tax incentives. The 2023 "*Statute for Industrial Innovation*" increased tax deductions to 25 percent for R&D and to 5 percent for expenditures on new equipment for advanced process technology in the semiconductor industry. These tax credits apply to investments from 2023 to 2029, and are valued around **USD 16bn**. Additionally, the government proposed the "Taiwan Silicon Valley" project in February, aimed at enhancing the country's semiconductor industrial clusters, with a projected 620mn investment from the 2024 budget. Following this, in May 2024, Taiwan launched a chip-based Industrial Innovation Program office, supported by **9.27bn** in funding for the period from 2024 to 2033.[98]

Investment outturns. Government incentive programs are driving over **USD 60bn** in semiconductor investments in Taiwan, primarily from domestic chipmakers. **TSMC** plans to invest nearly 40bn to expand its advanced Tainan facility and build a new chip plant in Miaoli County.[99] Meanwhile, Taiwan's memory chipmakers Powerchip and Nanya each plan to spend 9bn in new fabs (Fig. 18).

Fig. 18: Taiwan investments announced since 2021 (USD bn)



Source: Authors' elaboration based on public news and announcements.
Note: "Announcements" refer to public statements or disclosures made by companies, while "Potential investments" refer to projects under consideration or industry rumors about upcoming investments that have not yet been formally confirmed.

[98] In addition to these incentives, Taiwan allocated a total of USD 26.6 billion in government-backed loans from 2019 to 2024 through the "Investing in Taiwan" program, aiming to attract investments in innovation industries such as semiconductors, green technologies, and biotech.

[99] TSMC is also planning to invest in two new advanced packaging facilities in the city of Chiayi and a 2nm fabrication plant in Kaohsiung, though the exact investment amount has not yet been disclosed.

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