Industrial Policy in the Global Semiconductor Sector*

Pinelopi Goldberg[†] Réka Juhász[‡] Nathan Lane[§]

Giulia Lo Forte[¶] Jeff Thurk[‖]

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[†]Yale University, BREAD, CEPR, CESifo, and NBER (penny.goldberg@yale.edu)*

[‡]University of British Columbia, CEPR and NBER (reka.juhasz@ubc.ca)

[§]London School of Economics, CESifo (n.lane@lse.ac.uk)

[¶]Board of Governors of the Federal Reserve System (giulia.loforte@frb.gov)

[‖]Amazon Web Services (jeff.thurk@gmail.com)

Abstract

The resurgence of subsidies and industrial policy has raised concerns about their efficiency and compatibility with multilateral principles. Critics argue that such policies may divert resources toward less efficient firms and trigger retaliation by other countries, potentially generating a wasteful "subsidy race." At the same time, subsidies may generate global benefits in sectors characterized by dynamic economies of scale and cross-border effects. Assessing these competing arguments requires accurate measurement of the policies governments actually pursue. This paper undertakes that task for the semiconductor industry – a key driver of economic growth and innovation, with potentially important dynamic economies of scale and strategic significance arising from its dual-use applications.

We document and quantify recent industrial policies in the global semiconductor sector and examine the economic rationale underlying them. Combining historical analysis, natural language processing, and a model-based approach, we measure the extent and composition of government support across countries and over time. We find that government support has played an important role in the industry's development, with subsidies constituting its predominant form. Although China provides substantial subsidies to its semiconductor sector, the scale of its support is not exceptional relative to that of other countries once differences in market size are taken into account.

JEL: F13, F61, L63, N60, O38

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1 Introduction

The recent resurgence of subsidies and other forms of industrial policy is widely perceived as a significant departure from the principles of multilateralism and international cooperation. Economists are generally skeptical of industrial policy as it can lead to inefficiency by diverting resources to less efficient firms. Internationally, industrial policies may have negative cross-border effects if resources are reallocated towards less efficient domestic producers, prompting retaliation and similar policies from other countries. The resulting "subsidy race" can become a "race to the bottom," a wasteful competition of resources that fails to achieve policy goals.

However, some subsidies, such as those for new goods, green technologies, or sectors with inherent cross-border effects, can have positive cross-border effects and benefit other countries. Assessing these cross-border effects is challenging when comparative advantage is dynamic. Subsidies today might have minimal immediate impact on other countries but could lead to significant future effects. Conversely, some countries may not currently use subsidies, yet their past subsidies have helped them secure a dominant position in the global market. This raises broader questions: (a) Can the new subsidies be economically justified? (b) Should current WTO subsidy rules be updated to address the complexities of new and rapidly evolving industries?

This paper is part of a larger project aimed at understanding these issues within key sectors of the global economy. It focuses on semiconductors, one of the most dynamic and globally integrated industries, heavily targeted by industrial policies worldwide. The semiconductor industry is a key driver of economic growth, enabling all facets of modern digital life and accelerating scientific innovation through high-performance computing. Learning-by-doing and dynamic comparative advantage are considered to be crucial features of the industry, leading to "infant industry protection" arguments in favor of government support. Additionally, the industry has strategic importance stemming from semiconductors being "dual-use" goods, with both civilian and military applications, prompting national security-based arguments for government intervention.

The objective of the present study is to document and, where possible, quantify the industrial policies recently implemented in the global semiconductor sector and to examine the rationale underlying them. Accurate measurement is a necessary first step toward assessing the effects of these policies and evaluating competing arguments about their merits. Yet, as our analysis demonstrates, measuring industrial policy in this sector is far from straightforward. Policymakers and industry experts frequently cite various figures in their statements and reports, but the sources of these numbers are often unclear, and the approaches used to measure government support are inconsistently applied across countries. An exception is the excellent study by the OECD (2019), which we incorporate into our discussion. To advance measurement, we combine three different approaches: (a) historical analysis of state support of the industry worldwide based on existing sources; (b) the natural language processing (NLP) approach pioneered by Juhász, Lane, Oehlsen, and Pérez (2025) to identify industrial policies in the *Global Trade Alert* (*GTA*) database between 2010 and 2022; (c) a model-based approach to identify (unobserved) production subsidies as a residual factor lowering the marginal cost of production after controlling for all other relevant cost determinants.

We compare our findings with those of the OECD study throughout our analysis. The two studies differ in many important respects, both conceptually and in terms of firm and year coverage, so it is unsurprising that our findings vary in some dimensions. Nonetheless, a common conclusion of both studies is that government support in the semiconductor industry is exceedingly difficult to quantify due to the diverse instruments and targets used by different governments across the value chain. Measurement difficulties are particularly pronounced in the case of China. The *GTA* database does not cover financial support provided by the Chinese government, much of which is provided by subnational governments. One exception is China's "Big Fund" in 2014. Estimates from other sources, such as *JW Insights* reported in the *Financial Times*, do not break down support by year or firm, making economic analysis of the policies challenging. This is partly why we also consider the model-based approach, inspired by Kalouptsidi (2018) and Barwick, Kalouptsidi, and Zahur (2025).

The model-based approach is described in detail in a separate paper (Goldberg, Juhász, Lo Forte, and Thurk, 2026), but we summarize here its implications for measuring subsidies. The model-based approach involves specifying a model of the semiconductor industry, estimating key demand and cost parameters using firm- or industry-level data, and then using the model structure to back out marginal costs for each product. In this framework, production subsidies are identified as a residual factor that reduces the marginal cost of all firms in a country, i.e., a factor that leads to lower marginal costs in a country relative to a benchmark country after accounting for all other relevant cost determinants. The disadvantage of this approach is that the estimates depend on modeling and identification assumptions, though it is possible to test their robustness against alternative assumptions. Nevertheless, a significant advantage of this approach is that it allows not only for measurement, but also for the evaluation of the subsidies' economic effects, which is impossible without a theoretical framework. From a measurement perspective, the model-based approach is particularly useful when its findings can be contrasted and potentially corroborated with evidence from other sources. In our context, we use confidential data from the Global Semiconductor Alliance (GSA) to implement the model-based approach. However, the overlap between this data, which covers 2004-2019, and the *GTA* data, which covers 2010-2022, is limited, making the comparison less informative.

Despite these caveats, the combined use of the three approaches leads to some clear takeaways:

First, government support has been critical for the semiconductor industry's growth, particularly during its initial development phase. This support is evident across all major segments of the value chain, benefiting established leaders at the technology frontier, such as Korea and Taiwan, countries seeking to advance their industry, such as China and the U.S., and countries attempting to enter the market, such as India. In more mature markets, governments have traditionally allowed the private sector to take the lead. However, since 2020, there has been a significant increase in government intervention, with China, the United States, Japan, Korea, and India notably ramping up financial support for the industry.

Second, subsidies are the primary form of government support, manifesting as financial grants, state aid, tax incentives, loans and loan guarantees, and equity injections. This trend aligns with the findings of the OECD report. These policies primarily target production improvement and research, development and innovation.

Third, China has been a prominent user of subsidies. However, our estimates do not pinpoint China as an outlier in its subsidy use; rather, its level of support is comparable to other countries, when considering the size of its market. This conclusion is supported by both our NLP-based analysis of *GTA* data and the subsidy estimates from our model-based approach.

Fourth, policymakers aim to achieve several goals through their support of the semiconductor industry, including economic growth and development, international competitiveness, resilience, and national security. Implicit in these objectives is the belief in strong learning-by-doing effects in chip manufacturing, which lead to dynamic comparative advantage, economies of scale, and high industry concentration. In the presence of learning-by-doing, subsidies have a multiplier effect, amplifying and accelerating cost reductions as experience accumulates. Even when firms internalize the benefits of learning spillovers, so that private production is socially optimal, governments may still have valid reasons to support their domestic semiconductor industry. This support helps counter the natural tendency toward industry concentration, diversify the supply chain, and enhance its resilience. These objectives become even more critical when considering national security concerns, given that crucial segments of the semiconductor supply chain are concentrated in a few geopolitically critical countries. Learning spillovers across technologies and firms may provide additional justification for subsidies if such spillovers are not internalized by the relevant market participants.

The remainder of the paper is structured as follows. Section 2 provides a brief overview of the industry. Section 3 summarizes the history of industrial policy in the semiconductor sector to offer context and background for the policies we analyze later. Section 4 presents the main findings from the NLP-based analysis of the *GTA* database and compares them with the results of the OECD report. Section 5 outlines the primary objectives pursued by policymakers as identified in the *GTA* database. Section 6 summarized the main insights from a model-based approach regarding the measurement of subsidies. Section 7 concludes.

2 The Semiconductor Industry

Semiconductor firms are firms engaged in the design and/or fabrication of semiconductors—any material whose electrical conductivity ranges between that of a conductor and that of an insulator. The bulk of industry revenue is accounted for by integrated circuits (ICs), which are networks of transistors fabricated on a surface to process binary data by switching them on and off. The semiconductor industry forms the backbone of the hi-tech industry and is considered a prime driver of economic growth.

2.1 The manufacturing process

Semiconductor fabrication begins with designing chips using software that lays out and simulates transistor networks on semiconducting material. Manufacturing occurs in a fabrication facility, colloquially known as a "fab." Transistors are etched onto a wafer via photolithography, a process akin to photographic development that repeats to form multiple chip copies. After layers are added, the wafer undergoes "wafer probe" testing to identify defects. Successful chips are then cut from the wafer, and each of these pieces is called a "die." The dies are then encased and prepared for integration with other components.

Technological advancements in fabrication manifest in a number of product characteristics; these include increased wafer sizes and reduced line widths, enhancing the number of chips per wafer, and the density of transistors on each chip. For instance, larger wafers reduce costs per die (a single chip cut from a wafer) by about 30%, while a 30% reduction in line width roughly doubles transistor density, making chips smaller, faster, and more efficient. Despite initial higher costs and the increased potential of defects, refinements in fabrication confer benefits such as increased output and performance.

2.2 The semiconductor supply chain

Table 1 summarizes the four broad categories of products within the semiconductor industry. First, firms such as Intel and Advanced Micro Devices (AMD) produce microprocessors, which amount to integrated circuits (ICs) containing one or more central processing units (CPUs). This first category of products are used in personal computers, tablets, and servers. The second category, system on a chip (SoC), is the newest type of semiconductor chip, which combines all the necessary components of an entire system on a single chip. These products are popularly used in small devices, such as smartphones, as they integrate CPUs with graphics, cameras, as well as audio and video processing. Key firms in the SoC market include names such as Nvidia, Broadcom, and Qualcomm.[1] The third category includes commodity integrated circuits commonly used in simple technological devices, such as barcode scanners. Finally, the fourth category includes memory chips, particularly flash memory, which are produced by large conglomerates such as IBM and Samsung.

Table 1: Categories of Semiconductor Products and Major Firms

Semiconductor Products	Example Firms	Example End-Products
1. Microprocessors	AMD, Intel	Computers, servers
2. "System on a Chip"	Broadcom, Nvidia, Qualcomm	Mobile phones
3. Commodity integrated circuits	Analog Devices, Xilinx	Barcode scanners
4. Memory	IBM, Samsung, Toshiba	Computers, flash drives

Comparative advantage comes through innovation, and innovation is a fast-paced, cumulative effort in which tomorrow's new product depends heavily on a broad set of today's products and ideas. In a 1965 paper, Intel co-founder Gordon E. Moore noted that the capabilities of the integrated circuit doubled roughly every 18 months.[2] This prediction is popularly known as "Moore's Law" and has held up remarkably well for over 50 years since its inception. Additionally, Moore's Law speaks to the short life span of any current product and the need to develop tomorrow's great idea today. Accordingly, R&D comprises a significant—and increasing—component of firm expenses.

There are four primary components of the value chain: design, fabrication, testing, and sales/distribution. During the design stage, skilled design engineers construct prototypes of next-generation chips using expensive, high-end electronic design automation (EDA) software. When completed, these plans are delivered to a (potentially external) fabrication facility, where the chip circuits are constructed in successive layers on the surface of flat silicon wafers. Firms engaged in the fabrication stage must incur a large fixed capital investment (≈$2 billion) to build a plant, or fab, which consists of a wide variety of expensive equipment capable of building the chips under extreme environmental requirements for cleanliness. During the assembly stage, the wafers are split into individual dies for distribution to customers.

During the 1970s and 1980s, the industry was dominated by vertically integrated device manufacturers (IDMs), which managed all components of the value chain (design, fabrication, testing, and distribution). The establishment of Taiwan Semiconductor Manufacturing Company (TSMC) in 1987 by the Taiwanese government marked the beginning of an alter-

1. To illustrate the importance of these products: In early 2018, Singapore-based Broadcom attempted a hostile takeover of Qualcomm ($120 billion), which was later blocked by the Trump Administration due to national security concerns. Intel has since expressed interest in acquiring Qualcomm to solidify its position to deliver 5G mobile services in the future.

2. At the time, he was referring to the number of transistors a firm could inexpensively place on a single silicon wafer. Today, advancement generally refers more generically to processor speed.

native business model, where production was outsourced to low-cost, third-party foundries. Firms choosing this business model lack an internal fabrication facility or follow a “fabless” model. Today, fabless firms account for roughly 90% of all semiconductor firms and generate one-third of industry revenue. The fabless business model provides two advantages to the traditional IDM. First, outsourcing fabrication enables these firms to avoid the substantial capital investment required to build fabrication facilities. Second, outsourcing—often overseas—enables these firms to take advantage of scale to lower input costs, pooling production with other fabless firms in third-party foundries. Outsourcing overseas also enables firms to benefit from lower foreign wages and weaker environmental standards. Thus, the fabless business model is thought to decrease upfront costs and ongoing production costs.

Outsourcing fabrication is particularly attractive in this industry as semiconductors tend to be high value, weigh little, and thus have low transportation costs. As many low-wage countries lack the technical expertise and capital infrastructure to establish viable foundries, the majority of foundries are located in a specific set of markets: mainly China, Europe, Japan, Taiwan, and the United States. The vast majority of outsourcing is done in Asia (Taiwan accounts for approximately 59% of all outsourced wafers produced), while U.S. foundries account for four percent of all third-party wafers produced. Hence, global supply chains have played an important, though not necessarily pivotal, role in facilitating growth of the fabless business model.

Today, the semiconductor supply chain is globally integrated, with different countries dominating different parts of the supply chain. Advanced economies such as the United States and the Netherlands lead in research and design. East Asia, particularly Taiwan and China, dominates fabrication, producing the vast majority of wafers in "pure play" foundries. Testing, assembly, and distribution are primarily controlled by East Asian countries (OECD, 2019; Bown, 2020). Each of these segments is highly concentrated, so that while manufacturing a chip requires cooperation among several firms across different countries, there is minimal competition at each stage of the process.[3] The global nature of the semiconductor chain has potentially important implications for the assessment of subsidies or any other form of government support by individual countries, as these actions resonate through global linkages across the entire supply chain.

3 A Brief History of Industrial Policy in Semiconductors

Historically, governments have played an important role in shaping the semiconductor industry. In this section, we describe the different ways in which governments have facilitated the

3. For instance, in the EDA software market, three US-based companies – Synopsys, Cadence Design Systems, and Mentor Graphics — control ca. 85% of the global market (Bown, 2020).

establishment of the industry, both at the technology frontier and in follower countries. The historical evidence suggests that the early phase of the industry's development may be the period where the government has the most important role to play.

We start with the U.S., the birthplace of the industry. Although most accounts of the industry's early days focus on the scientists and entrepreneurs who developed and commercialized the technology, the government was also involved in numerous ways. First, through the 1960s, the US military bought most integrated circuits produced (72% of all integrated circuits produced in 1965 (Miller, 2022, p. 31)). This major source of demand allowed producers to learn how to commercialize and mass produce a technology that was still in its infancy.

More subtly, large-scale government procurement meant that public agencies played an outsized role in shaping *how* the industry developed. As one example, the U.S. Army, Navy, and Air Force funded distinct approaches to solving the technical problem of soldering together more transistors before silicon integrated circuits emerged as the best solution (Berger, Khan, Schrank, and Fuchs, 2023). Importantly, the US military required that contractors share technology, a policy that promoted the flow of knowledge. This, together with rigorous antitrust policies pursued in the postwar period, allowed for the rapid dissemination of technology (Choi, 2008; Berger et al., 2023).

For technological follower countries, governments have used a variety of policy levers to foster a domestic semiconductor industry. Particularly in those economies where the technology gap was large, the state played a dominant and sometimes leading role in establishing the industry. This is seen to different degrees in all the economies which subsequently became major producers at the technology frontier (Japan, South Korea and Taiwan), in economies such as China that have pursued industrial policy in the sector for decades with mixed results, and also in economies such as Israel (Breznitz, 2007), which successfully entered the industry, but command a smaller share of the global market. This is important, as while we will focus our discussion on the establishment of the industry in East Asian economies, the economic forces at play seem to extend beyond "East Asia specific" factors.

We now turn to East Asian economies which have succeeded in catching up with the technology frontier. Although each pursued the objective of establishing a semiconductor industry differently, their policies also share broad similarities. Crucially, beyond making the industry more attractive to entrepreneurs by changing relative prices (through tariffs, subsidized loans, tax breaks etc.), each state was directly involved in the process of international technology acquisition, absorption, and diffusion. Put differently, developing a domestic industry seems to have required some infant industry promotion and, critically, also extensive international technology transfer facilitated by public agencies.[4]

4. Another important element was the availability of human capital. Taiwan established a semiconductor laboratory to study microelectronic physics when it only had semiconductor assembly capabilities (Liu, 1993).

In Japan, the famous pilot agency, MITI (Japanese Ministry of International Trade and Industry), directly controlled technology import policy. As Japanese firms began entering semiconductors in the 1950s, MITI determined which firms received a technology license and, once approved, the government guaranteed that payments would be made (Lynn, 1998). There were a number of potential advantages to Japan's coordination. First, in the 1950s, Japan was emerging from two decades of isolation from the world economy. Its firms were behind the technology frontier, had few foreign links, and limited experience with international agreements. Thus, by coordinating technology licensing directly, the government pooled knowledge and lent the credibility of the Japanese government to firms that were unknown to the West. The weight of the Japanese state arguably also helped firms' bargaining power; in 40% of all cases submitted for approval, the government intervened and forced changes to the agreement that favored Japanese firms (Lynn, 1998; Choi, 2008).

In Korea, the government began pushing the electronics industry to move beyond the assembly stage in its Fourth Five-Year Development Plan (1977-1981), when its per-capita income stood at $459, roughly on par with Guatemala's (Amsden, 1989). Semiconductors were one of the strategic products named in this plan; according to Amsden, beyond the usual incentive package for prioritized sectors, the government established an industrial estate for the production of semiconductors and computers, it protected the domestic market, and, most famously, it established the Electronics and Telecommunication Research Institute (ETRI).

In Korea, ETRI would play a key role in working together with the private sector to coordinate R&D efforts between public researchers and the private sector. In fact, the government accounted for the vast majority of the R&D spending in semiconductor technology through the 1980s, with private firms contributing a smaller share (Chen and Sewell, 1996, Table 5). At least as importantly however, through ETRI, the state pushed the *chaebol*, large conglomerates, to upgrade their production and move into more design-intensive, higher-return markets (Evans, 1992). In some cases, it did so by subsidizing and coordinating efforts by the private sector; in others, it undertook the basic research itself, working closely with the private sector (Evans, 1992).

One case in particular illustrates the extent to which public agencies took the lead in pushing the domestic technological frontier: electronic switching systems.[5] The Ministry of Communications (MOC) decided to develop indigenous switching technology, a hugely risky proposition that private firms would not have been willing to undertake on their own. The MOC however used its control of telecommunications public procurement to persuade foreign firms supplying the Korean market such as Ericsson to transfer some of their switching technology (a form of *quid pro quo*), and train ETRI personnel. ETRI then used this knowledge, as well as generous funding from the MOC, to design an electronic switching system that was better suited to developing country contexts with large rural populations.

5. This paragraph is based on the account in Evans (1992, p. 142).

Importantly, however, private firms were intimately involved with ETRI at the research stage, and production was undertaken by private firms from the very beginning.

As this case illustrates, much like Japan, Korea did not develop the technology in isolation. Instead, it relied extensively on technology alliances with foreign, mostly US, firms. Chen and Sewell (1996) document how each of the three *chaebol* involved in semiconductors (Samsung, Goldstar and Hyundai) had multiple technology alliances for a variety of products with foreign firms (the authors list twenty-two distinct alliances for three years between 1983-1985). Moreover, each acquired US based firms "providing them with direct access to highly qualified scientists and engineers, advanced technologies and major markets" (Chen and Sewell, 1996, p. 765).

While Korea entered the industry at a relatively low level of economic development, its concentrated industrial structure meant that there were large, incumbent private sector firms that the state could work with to develop the industry. Taiwan also entered the industry at a similar level of development, yet its economy was characterized by small and medium-sized firms. Thus, among the three cases we examine, the government's singular role in establishing the industry is most evident here. Much like Korea and Japan, however, Taiwan also relied extensively on foreign technology at the outset.

Liu (1993) denotes three stages in the initial development of the industry from the mid-1970s. First, through the newly founded Electronics Industry Research Center (reorganized later as Electronics Research and Service Organization, ESRO) the government set up a public pilot plant that developed technologies increasingly close to the frontier (in cooperation with RCA, a US-based firm). In this way, the government assumed the entirety of the risk of high-tech R&D. Over time, ESRO moved into all areas of the supply chain including computer-aided design (CAD) and IC mask making. Later, in the 1980s, it closed the technology gap further by moving into Very Large Scale Integration Technology (VLSI) – i.e., more than 100,000 elements in a chip.

In the second stage, the government transferred the technology it had developed at ESRO to the private sector through licensing, spin-offs (including both United Microelectronics Corp. and Taiwan Semiconductor Manufacturing Co.) and technology diffusion policies. In the third stage, the government provided a variety of incentives to encourage the private sector to enter the industry. Like Korea, the government set up an industrial park and also offered a large range of generous fiscal incentives (cheap loans, tax breaks, accelerated depreciation of R&D equipment and low-cost land).

These historical accounts suggest that the government was instrumental, and, in some cases, the driving force in the initial development of the industry in successful follower countries. However, observers agree that as the industries matured, government involvement took more of backseat to the private sector, "shift[ing] from that of father to friend" (Liu, 1993, p. 304). This is worth noting as we move to measuring more contemporary industrial policy in some of these same countries below in Section 4.

It is important to highlight the likely critical role US policymakers and firms played in making the technology available to these economies (all of whom were key US allies in the Cold War context). The technology became accessible to foreign firms partly because of U.S. antitrust policies (Choi, 2008), and partly because U.S. firms themselves were willing to share technology. This was not a given, and some authors note that Japanese firms shared much less technology with Korean firms in anticipation of future competitive threats (Chen and Sewell, 1996). Given the importance of international technology acquisition for all three economies, it is difficult to imagine them achieving similar success without some access to frontier technologies.

We conclude this section by examining the history of semiconductor industrial policy in China. Like other East Asian economies, China has sought to incubate a domestic semiconductor industry for decades, with the earliest efforts dating back to the 1960s.[6] Following Mao's death and the economic reform pursued by Deng Xiaoping, the Chinese leadership has consistently prioritized, guided, and generously financed the development of a domestic semiconductor industry, often using policy levers similar to other East Asian economies discussed above (Minnich, 2023, p. 194 Figure 6.1). Notably, from the 1980s onwards, Chinese industrial policy has sought to establish joint ventures or partner with foreign firms in an attempt to transfer the foreign technology that leaders understood was necessary to close the gap with the technology frontier.

Yet, unlike other East Asian economies above, China has not yet succeeded in reaching the technological frontier in any part of the semiconductor value chain. Based on data compiled by researchers at Georgetown University's Center for Strategic and Emerging Technology, China accounts for less than one percent of the market for software tools used to design chips, two percent of the market for core intellectual property, four percent of the market for silicon wafers and other materials used to make chips, one percent of the market for the tools used to fabricate chips, five percent of the market for chip designs, and seven percent of market share in fabrication (none of the latter capacity involves frontier technology). This has led one observer to conclude that "China is staggeringly dependent on foreign technology, almost all of which is controlled by China's geopolitical rivals" (Miller, 2022, p. 249).

China's modest progress in semiconductors, after decades of industrial policy, merits further discussion. Why has China's efforts yielded different results, particularly when China has been remarkably successful at absorbing foreign technology in other sectors. One compelling explanation comes from Minnich (2023), who argues that until the 2010s, due to low domestic final demand as opposed to production for exports, China lacked the bargaining

6. This summary draws from Minnich (2023). A full description of Chinese industrial policy is beyond the scope of this paper; we refer the reader to Minnich (2023) for an excellent discussion.

power to effectively use *quid pro quo* policies—such as trading market access for foreign technology—to facilitate technology transfer. The author provides multiple examples where China repeatedly failed to secure the desired foreign partners for its national champions. Moreover, consistent with their low bargaining power in semiconductors, Minnich shows that China did not formalize technology-sharing requirements in their semiconductor industrial policy in the post-WTO period. This is in stark contrast to other sectors, such as automobiles (Bai, Barwick, Cao, and Li, 2020) or wind turbines (Minnich, 2023), where China has made extensive use these policy tools.

Importantly, this argument is consistent with a potentially more successful industrial policy pursued by China recently. Researchers suggest that China's latest push, which many date to the launch of the National Integrated Circuit Investment Fund in 2014 (see Section 4.3), has appeared more promising (VerWey, 2019; Miller, 2022; Minnich, 2023). This is partly due to the fact that as China has developed, the domestic market has become more lucrative, increasing China's bargaining power *vis-à-vis* foreign firms. As a consequence, China has appeared more assertive in its efforts to acquire foreign technology (Minnich, 2023).[7]

Lessons from China's efforts are also consistent with lessons from earlier East Asian experiences. In particular, China's efforts only highlight the importance of technology transfer for successful industrial policy; outside of the U.S., our historical analysis has not uncovered a single instance where a domestic semiconductor industry developed without substantial foreign technology. This highlights that developing the industry, even with generous support, is difficult without foreign partners willing to share technology. The importance of foreign technology also provides insights into recent efforts by the Biden Administration to stymie China's technological advancement in semiconductors through export restrictions targeted at advanced software and advanced capital equipment.

4 Quantifying Recent Government Support in Semiconductors

Having reviewed the main government policies employed in the early phase of the industry, we now turn to more recent years. In this section, we discuss two approaches to measuring government support in the semiconductor value chain post-2010. The first, employed by the OECD in its 2019 report on semiconductors, applies the institution's longstanding work measuring *market distortions* to semiconductors (OECD, 2019). The second, which we

7. Due to the backlash surrounding the use of *quid pro quo* measures from foreign governments and firms, these policies have become more informal over time, making them harder to detect (Minnich, 2023). In addition, outward FDI (much of which was tied to state venture capital funds) emerged as one of the more visible forms of technology acquisition, although this has come under increasing scrutiny since the mid-2010s.

implement and refine in this paper for the semiconductor value chain, builds on Juhász et al. (2025)'s approach to identifying *industrial policy*, henceforth JLOP. The two perspectives take different, disciplined approaches to quantifying policy and use distinct concepts of government support and implementation. We first provide a short description of each, compare their relative strengths and weaknesses, and then describe their findings. We summarize the main features of each approach in Table 2.

Table 2: Comparison of OECD (2019) and this paper

	OECD (2019)	This paper
Aim	Quantify market distortions	Identify industrial policies
Years covered	Average for 2014-2018	2010-2022
Unit of analysis	Firms	Policies
Support reported for	21 firms	Countries
Input data	Companies' own publications and financial disclosures	JLOP (2023) for classifying industrial policies in *GTA*

4.1 OECD's (2019) methodology for quantifying government support

The OECD (2019) methodology aims to quantify *market distortions* relative to an unobserved *laissez-faire* counterfactual. More precisely, the OECD uses an expansive definition of government support, which includes "any financial or regulatory measures that can affect costs, prices or the profitability of market actors in any portion of the value chain, wherever they operate" (p. 62).

Practically, the report quantifies two main forms of government support for 2014–2018: i) budgetary government support (e.g., tax incentives, financial grants etc.), and ii) government support provided through the financial system. The former, budgetary government support, is primarily taken from firms' financial reports and disclosures. For the latter, the authors estimate below-market debt and the below-market provision of equity. Quantifying these requires comparing financial support to a hypothetical, unobserved market-based benchmark, which we discuss in Section 4.4.

Government support is then estimated from the "bottom-up," with firms as the unit of analysis. The report estimates the two forms of government support for twenty-one firms in the global semiconductor industry. These firms account for two-thirds of global industry revenue and cover different parts of the value chain. Given data limitations, this process excludes non-publicly traded firms (e.g., HiSilicon). Multinational firms play an important role in the sector and are common in the sample. Since multinationals receive government support from multiple jurisdictions, this complicates country-level calculations.

4.2 Our method: quantifying government support from Juhász et al. (2025)

This study takes a different approach to quantifying government support, building off the industrial policy dataset of Juhász et al. (2025). We do this in two steps: i) we use data from JLOP to identify industrial policies affecting the semiconductor industry; ii) we then systematically quantify the government spending for each, using a combination of policy text and source documents. We discuss both steps below, but first describe the JLOP dataset.

JLOP uses machine learning to identify industrial policies from policy text and produce counts of new industrial policies at the sector-country-year level for 2010-2022. The authors define industrial policies as those policies that "seek to change the relative prices across sectors or direct resources towards certain selectively targeted activities (e.g., exporting, R&D), to shift the long-run composition of economic activity" (p. 5). They take this definition to data using natural language processing (NLP) techniques to automatically classify industrial policies from the *Global Trade Alert (GTA)* database, an international inventory of commercial policy (Evenett, 2009).

By construction, the *GTA* database focuses on economic policies that meaningfully affect foreign commercial interests relative to domestic ones (capturing both positive and negative discrimination).[8] Hence, the policies identified by JLOP cover industrial policies that differentially impact domestic commercial interests, such as preferential subsidies and lending to domestic firms.

For this study, we identify and quantify semiconductor industrial policy in two steps. First, we select industrial policies from the JLOP dataset impacting the semiconductor sector. Although the source data provides Harmonized System (HS) industry codes, HS codes are insufficient to identify semiconductor industrial policies (**?**). Categories may be too broad; for instance, "semiconductor devices" (HS 8541) encompasses not only discrete semiconductors but also solar panels and light-emitting diodes (LED). Moreover, they may not account for complex, evolving supply chains, which span chemical inputs (photographic chemicals HS 370790) and machinery for manufacturing wafers (HS 848610). Additionally, the *GTA* is missing HS codes for about one-third of the policies.

Hence, we combine "dictionary-based" methods from text analysis with HS code to identify semiconductor industrial policies. Specifically, we identify policies from a dictionary of terms associated with the semiconductor industry, such as *"integrated circuit"*, *"chip"*,

8. Specifically, the *GTA* Handbook defines its scope as covering "credible announcement of a meaningful and unilateral change in the relative treatment of foreign versus domestic commercial interests" (Evenett and Fritz, 2022, p. 1).

or *"semiconductor wafer fab"* in the textual descriptions of the policies. This process produces an initial set of semiconductor industrial policies. We then manually verify that each industrial policy is related to the semiconductor sector and collect contextual information using additional sources (e.g., primary source statements, economic reporting, and trade industry associations). For all countries, we employ research assistants with local knowledge and language skills.

Second, we quantify government spending associated with each policy using source text and validate the data using research assistants with area expertise. This approach identified fifty-eight industrial policies affecting semiconductor manufacturing in seventeen countries. Table 3 contains the summary statistics.

Table 3: Summary statistics

	Mean	Std. Dev.	Min.	25p	75p	Max.
All policies ($n = 58$)						
Policies per country	4.00	3.52	1	1	7	11
Policies per country per year	0.31	0.64	0	0	0	3
Billions USD per country	12.79	22.19	0	0.10	16.06	77.77
Billions USD per country per year	0.98	6.72	0	0	0	76.82
National policies ($n = 35$)						
Policies per country	2.24	2.25	0	1	4	7
Policies per country per year	0.17	0.48	0	0	0	3
Billions USD per country	12.44	22.15	0	0	15.96	77.77
Billions USD per country per year	0.96	6.72	0	0	0	76.82

Notes: Count of policies and aggregate expenditure for the seventeen countries identified as having any semiconductor industrial policies for the period 2010 – 2022. National policies exclude policies targeting specific firms. European countries are reported individually. The value of policies jointly implemented by a group of countries is equally split across the participating jurisdictions. This table excludes the aggregate expenditure of Chinese provinces.

4.3 Chinese semiconductor policy

Chinese industrial policy is difficult to quantify (Kalouptsidi, 2018), and it is worth describing the details and limitations of accounting for Chinese semiconductor policy. In particular, our method does not allow us to ascribe monetary values to new Chinese industrial policy programs, with the exception of one policy: the National Integrated Circuit Investment Fund (typically referred to as the "Big Fund").[9] The core issue follows from the provincial nature

9. China's "Big Fund" is a public venture capital fund set up in 2014 with a capitalization of USD 47 billion and a mandate to invest in semiconductor firms (dollar value obtained from the Financial Times based on market intelligence from *JW Insights*).

of Chinese industrial policy governance. Specifically, in China, national policy *guidelines* are deployed by provinces, which design and fund provincial industrial policies. Thus, unlike other countries in the sample, in China there are typically no monetary values associated with national industrial policy announcements (which is what we capture through the *GTA*).

Figure 1 shows the importance of subnational policy in China and presents the number of provinces implementing each national policy among the semiconductor policies identified in our data. We see substantial take-up among China's thirty-one provinces across the various industrial policies. All three Five-Year Plans (FYPs) covered by our sample period include semiconductor policy, and around two-thirds or more of the provinces are implementing industrial policies to develop semiconductor capacity locally, with an increasing trend over time. The two dedicated integrated circuit development plans have more limited take-up, with about one-third of the provinces implementing industrial policies linked to national guidelines.

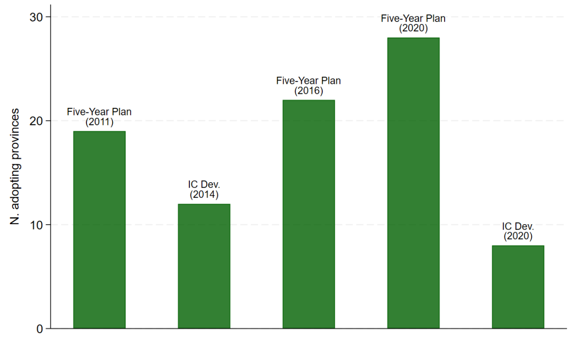


Figure 1: Take-up of national semiconductor industrial policies across Chinese provinces

Notes: The figure plots the number of Chinese provinces implementing each major national semiconductor industrial policy. Each province is coded as having taken up a particular national industrial policy if we could identify a specific provincial implementation plan. Source: authors' own research.

The provincial implementation of Chinese industrial policy means that we are almost certainly underestimating the value of semiconductor support if we do not include provincial spending. Figure 1 shows provincial spending is an issue; the question is how to quantify it.

We supplement our data with estimates of provincial spending on semiconductor policies, using information from the Financial Times based on market intelligence from *JW Insights*, a Chinese ICT market research firm.[10] A number of caveats are in order. We do not know

10. In the article titled "How Huawei surprised the U.S. with a cutting-edge chip made in China" dated November 29 2023, the Financial Times reports two types of data from *JW Insights* that we use to construct our estimates. First, they report spending by major provinces for 2016-2022. Second, for 2021-2022, they provide a breakdown of spending by the following categories: foundry, materials, testing, memory/storage, equipment, IDM, display panel, and others. We exclude the latter two categories (other and display panel) when disaggregated spending data are available.

how these estimates were constructed, nor what they include. Specifically, we do not know whether they include equity investments through the "Big Fund," which we do include in our initial, non-provincial estimates. Moreover, we do not know whether the estimates include spending beyond what was disbursed by implementing national-level industrial policies. Hence, additional information is required to make comparisons with other jurisdictions. For this reason, although we report numbers for China, we caution readers that they are uncertain and are not constructed like the other countries in our sample.

4.4 Contrasting our approach and OECD (2019)

It is important to highlight the differences between the OECD's approach and ours. The OECD takes the firm as the unit of analysis and builds its estimation from the bottom up. Its goal is to quantify distortions relative to the unobserved laissez-faire. This approach has the important advantage of yielding estimates for both budgetary support and below-market financing. However, this method comes with some assumptions and some practical challenges.

First, the OECD method assumes that the policymaker changes incentives for *individual firms* at the margin. Put differently, this method is not well-suited to quantifying market distortions from "big push," or "moonshot" type government interventions that seek to catalyze large-scale change in an industry. To illustrate the issue, consider the case of the government investing in a portfolio of firms in the semiconductor industry, similar to the mandate of China's public semiconductor venture capital fund launched in 2014 (the "Big Fund"). The OECD methodology evaluates ex-post, firm-by-firm, whether the required return on capital was met, and classifies those that did not as receiving below-market equity investment. Yet precisely because the methodology evaluates outcomes firm-by-firm, it misses the fact that the portfolio of investments needs to be evaluated jointly, with the potential losses of many firms covered by the large gains of a few.

Second, relatedly, by quantifying distortions relative to a laissez-faire benchmark, researchers make an implicit assumption that a purely market-based counterfactual exists. This is certainly a plausible assumption in some cases, but in the presence of market failures, certain socially desirable economic activities do not exist without government intervention (see Juhász, Lane, and Rodrik (2024)). Practically, the OECD method assumes these cases away by positing a required return on equity that is the same for all semiconductor firms, irrespective of which market that activity takes place in.

Third, in terms of practical challenges, this approach is inherently suited to capturing support for large and successful firms, particularly publicly listed ones required by law to release financial statements, the key data source for the OECD study. Consequently, the approach will miss quantifying the effects of government support for firms that failed or did not become large enough to be enumerated. These issues may mean government support is underestimated.

Fourth, a distinct practical challenge relates to estimating below-market financing, which requires imposing some strong assumptions. This is particularly true for estimating the provision of below-market equity. Given that this source of support is important for the report's findings, we consider it in more detail. Broadly, the OECD compares the estimated required rate of return in the semiconductor industry (RRR) to a firm's net operating profits each year.[11] A firm is said to receive below-market equity any year in which the estimated cost of capital is lower than operating profits. The approach requires the authors to estimate RRR, which they do using a capital asset pricing model (CAPM).

Most importantly, we note that returns are evaluated on an annual basis instead of a net present value (NPV) basis. Although flow-based evaluations may be more straightforward to calculate, they may not be well-suited to projects where cash inflows and outflows vary through time. High-capital investment projects (e.g., a chip fab) may require large upfront expenditures with the anticipation of eventual, long-run payoffs. Evaluating annual profits at early stages of a project's life cycle may bias returns downwards for firms undertaking investment projects in anticipation of large future profits. In fact, the government's ability to provide this type of "patient" capital is often invoked as a justification for government equity investment.

Likewise, the approach taken in this paper has its own advantages and disadvantages. Here, the state and, in particular, its industrial policies are the unit of analysis. The advantage is that this allows us to more accurately capture *ex-ante* what the state is trying to do, regardless of whether that effort is successful. Another distinct advantage of working at the policy level is that it allows us to capture national-level policies that do not entail spending (e.g., import tariffs) and those that require expenditure.

An obvious disadvantage of JLOP is that it relies on count-based measures rather than values. We deal with this in two ways. First, *GTA* source data contains both major national policy announcements and, for some countries, detailed, firm-level data documenting disbursements of support. As these two types of policies are typically very different in magnitude, we present a version of our count-based measure of policies with and without disbursements of support to individual firms. Second, we estimate the magnitude of government support by assigning monetary values to semiconductor industrial policies.

That said, one should keep in mind a number of issues in interpreting values. First, in the case of instruments such as tax credits, total government support depends on the take-up of the policy. As such, our measure captures ex-ante (intended) support for the semiconductor industry. This may differ from ex-post support measured at the firm level after take-up. If the policy is uncapped, ex-post support may be larger than the estimated ex-ante support. If,

11. For a full description, see pp. 81-85 of the report.

however, take-up is lower than what the government intends, ex-ante support may be larger than ex-post support. Related to take-up, a spending package announced in a particular year may be disbursed over many years. The U.S. CHIPS and Science Act is a good example. While the bill was passed in 2022, support is being disbursed at the time of writing (2024).

Second, for instruments such as public loans and equity, we do not attempt to isolate the implicit subsidy from the full value of the loan or equity injection. This is not feasible in our context, given we do not observe disaggregated information, nor is it necessarily the object of interest. The reason is the different aims of the two measures. The OECD seeks to quantify market distortions resulting from government support, while we seek to characterize the pattern of industrial policy spending. In that sense, a dollar of government support for semiconductors is a dollar not spent by the government elsewhere, holding total spending constant. Thus, for understanding patterns of industrial policy, taking the monetary value of the spending package is informative, though it measures a slightly different object than the OECD study.

There are also practical measurement challenges with our approach. One is that it is often difficult to pinpoint the budget allocated for supporting semiconductors when part of a larger spending package.[12] Moreover, spending may be adjusted or updated over time.[13] We deal with these cases through individual validation exercises and follow-ups.

Finally, we re-iterate the limitations surrounding Chinese industrial policies discussed in the previous section, specifically issues related to decentralized implementation. In these cases, our general approach is insufficient and requires supplemental data. Given the importance of China's semiconductor policy, we use external estimates of budgetary support for the sector to capture the possible magnitudes of the policy. These numbers should be taken as rough approximations.

Beyond the challenges of assigning monetary values to industrial policies, there are other limitations to consider with the JLOP data. First, by construction, JLOP captures policy flows. The *GTA* source data only tracks *new* policy announcements and does not capture the stock of pre-existing policies (e.g., any longstanding tax-incentives or budgetary support). Second, there is a risk of double-counting budgetary support in the *GTA*. For example, for China, the *GTA* includes disclosures of government support received by publicly listed firms. Thus, we may count support twice if we measure it once at the policy level and once at the firm level. Partly for this reason, we report two count-based measures below; one including all policies, and one including only national policy announcements (excluding firm policies). Finally, we

12. For example, in 2021 the Japanese government announced a large COVID-19 recovery plan with USD 489 billion in spending. However, the portion of funding allocated to semiconductors was only USD 6 billion.

13. For example, the *GTA* entry for the "Big Fund" set up by China in 2014 states that by September 2015, the fund had exceeded USD 16.3 billion. However, the estimates of *JW Insights* reported in the Financial Times assessed the overall spending of the fund to be USD 47 billion.

note that the *GTA* is a living dataset. Our sample period ends in 2022, meaning that we likely undercount policies in more recent years, as there is substantial backfilling of data.

4.5 Patterns of Government Support in the Global Semiconductor Industry

We now describe the basic patterns of support for the global semiconductor industry based on our methodology. Where possible, we compare our findings to those in the OECD study. We emphasize two points, which are detailed above (Section 4.4). One is that the OECD reports data at the firm level, while we report data at the country level. In general, there is no mapping from firms to countries in the OECD report. Second, while our data are annual, covering 2010 – 2022, the OECD data is not time-varying and instead captures averages for the 2014 – 2018 period.

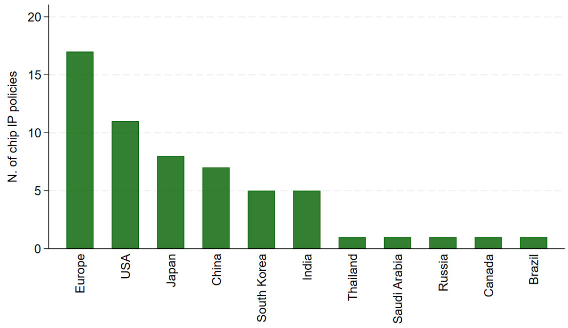
4.5.1 Supporting jurisdictions

Figure 2 shows the jurisdictions that implemented semiconductor industrial policies during our sample period. Given the measurement challenges described above, we provide three different measures: Panel A provides the counts of all policies, Panel B plots the counts of national policies (excluding policies for individual firms), and Panel C plots the estimated monetary value of support.

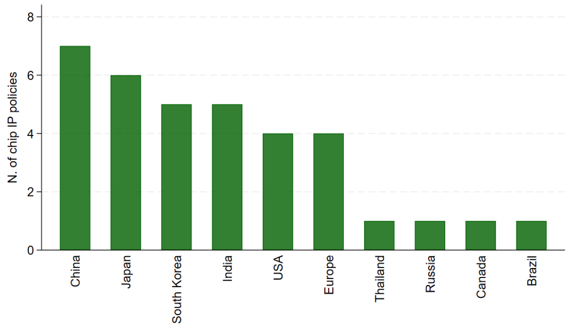
The number of distinct jurisdictions reporting *any* semiconductor industrial policy is small. Specifically, there are seventeen jurisdictions that implemented at least one new industrial policy during our sample period (eleven if we group European countries). This may be a result of the capital and R&D intensity of the sector, which leads to both high levels of concentration and high barriers to entry.

We find industrial policy concentrated predominantly among current major producers: China, Europe, Japan, South Korea, and the U.S. The notable exception to this is Taiwan, where we have identified no industrial policy. India stands out as a jurisdiction spending heavily to create a semiconductor industry without an established presence in the sector. This is notable; in terms of monetary value, India ranks fourth among all countries. Likewise, this result illustrates the advantages of an ex-ante measure of support, as the state appears to be trying to facilitate the establishment of the industry. Apart from India, we find no other country attempting to enter the industry with large-scale government involvement.

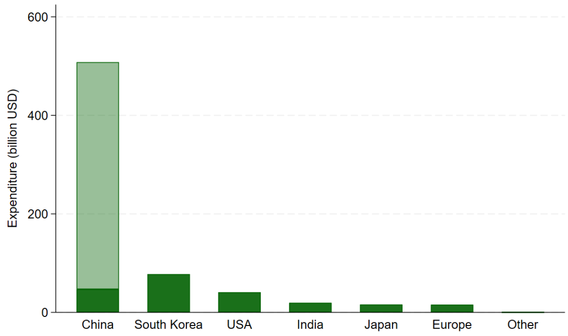
Which jurisdictions appear to provide the most support? Although not definitive, our analysis suggests the following tentative patterns. First, all measures point to six jurisdictions that provide the most intensive support: the five established producers (China, Europe, Japan, South Korea, and the U.S.) and India. Across all measures in Figure 2, industrial policy activity outside of the top-six jurisdictions is negligible.



(a) Counts (all)



(b) Counts (national policies only)



(c) Monetary values (billions nominal USD)

Figure 2: Industrial policy by country

Notes: Panel A includes the count of all semiconductor policies. Panel B excludes policies deploying funds to individual firms and only enumerates national-level policies. Panel C assigns monetary values to all policies. The monetary value for China should be interpreted as follows: the dark green shading is spending on the “Big Fund”. Light green shading refers to provincial spending on semiconductors for 2016-2022 as estimated by *JW Insights* and reported in the Financial Times. We group Europe together, which includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta, and the UK.

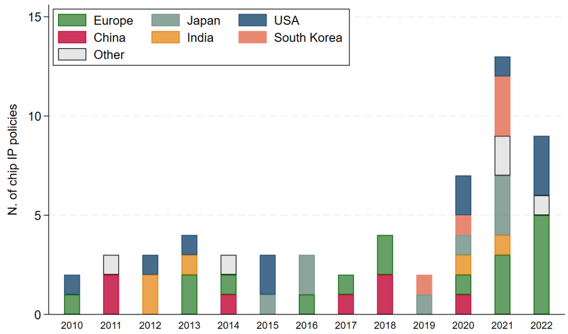
Second, our results are consistent with conventional wisdom that China has undertaken a substantial state-led push in the semiconductor industry over the past decade. China tops our list, marginally, if we compare the count of national policies across countries (Figure 2 Panel B). In absolute terms, for spending, our estimates suggest a substantial difference between China and other countries (Panel C). However, this does not take into account differences in the size of the economies. Although these results should be treated with caution, we believe they are broadly plausible. We explained in Section 4.3 that all three of China's latest Five-Year Plans have prioritized developing the semiconductor supply chain. Moreover, these national guidelines have been widely implemented across Chinese provinces (Figure 1). Alongside Five-Year Plans, there have also been two major integrated circuit policies, which have been taken up by many provinces. Taken together, these sources suggest substantial support for semiconductors in China over the past decade. Yet, is China an outlier?

Although these estimates support the popular notion that China's government is substantially funding its domestic semiconductor industry, it is harder to assess whether this level of support is extraordinary. Indeed, an absolute, dollar-for-dollar comparison suggests China's support is overwhelming relative to other countries. Yet, comparing monetary support relative to the size of the economy, South Korea dominates China's spending.[14]

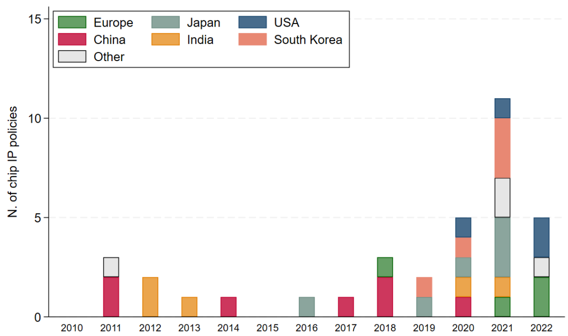
Thus, a judicious interpretation of this evidence suggests that while China provides substantial support to its industry, so do other major producers, with the notable exception of Taiwan (currently, according to our estimates). That is, most major producers actively support their domestic industries with large-scale national policies, especially when viewed as a share of total economic activity. Moreover, China's state-led effort in semiconductors is not historically unique. Our historical analysis above (Section 3) shows that every successful follower country we are aware of pursued aggressive industrial policy at the early stages of their domestic industry's development. In light of this, India's recent semiconductor push is also consistent with historical precedent.

Next, in Figure 3 we examine the time trend of support over the sample period using the same three measures. Panel A of Figure 3 reports the count of all industrial policies by country and year. Panel B reports the same but excludes firm-level policies, and Panel C reports monetary values. Note that for monetary values in Panel C, we do not have a temporal breakdown of Chinese provincial spending, and only the value for the "Big Fund" is reported. Panel C also highlights the lumpiness of major spending packages in our measure; we report the date the policy was announced, not when funds are disbursed. For major policy packages, the dispersal typically takes place over multiple years.

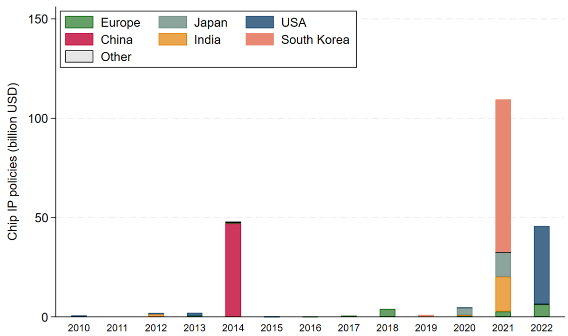
14. Over 2010-2022, South Korea and China had an average GDP of USD 1.5 trillion, and USD 12 trillion respectively. Thus, for every USD 1,000 in GDP, South Korea and China have each spent USD 51, and USD 42 on semiconductor policies.



(a) Counts (all)



(b) Counts (national policies only)



(c) Monetary values excluding Chinese provincial spending (billions nominal USD)

Figure 3: Industrial policy by country and year

Notes: Panel A includes the count of all semiconductor policies. Panel B excludes policies deploying funds to individual firms and only enumerates national-level policies. Panel C assigns monetary values to all policies. For China, we lack the temporal breakdown of provincial spending. Only the monetary value of the "Big Fund" is included for China. We group Europe together, it includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta and the UK. "Other" comprises Brazil, Canada, Saudi Arabia, Thailand, and Russia.

Figure 3 suggests semiconductor activism has increased post-2020. While all countries have offered support to semiconductor firms through the sample period, the post-2020 period is notable. Table 4 details that since the COVID-19 pandemic, multiple countries have introduced major national policy packages specifically aimed at their semiconductor industries.

We next consider which distinct parts of the semiconductor supply chain are targeted by industrial policy. We distinguish three parts of the value chain: i) inputs; ii) design and manufacturing; and iii) assembling, packaging, and testing.[15] Table 5 shows that each part of the value chain has received government support. While design and manufacturing seem to have received the most support, inputs, as well as the most downstream, assembly, packaging and testing have also been targeted. This last step is typically targeted by emerging economies (Brazil in 2011, Russia and Thailand in 2021), though more recently also by advanced economies (Japan in 2019, and the US and Canada in 2022).[16]

In comparison, the OECD findings can be summarized as follows. First, the OECD also find that almost all firms in their sample receive support, mostly in the form of budgetary support. Second, in terms of the absolute magnitudes of support received (which are most comparable to our estimates), they find large levels of support for some of the largest firms in their sample, such as Samsung and Intel.[17]

Third, a number of Chinese firms also receive large amounts of support, although these results are driven by below-market equity provision, which relies on the assumptions discussed in the previous sections (see Section 4.4).

Fourth, the report is able to identify the source of some budgetary support (though not consistently). Based on partial information, China, Singapore, Taiwan, and the U.S. were identified as major supporters. This completes the picture painted from our estimates; the OECD finds that Taiwan, the only major producer missing from our estimates, also provides major support for semiconductor firms. Moreover, another discrepancy between our estimates and the OECD's is the large-scale support we identify for Japan and South Korea. This is likely due to the fact that Japan and Korea announced their major support packages after the OECD sample period (post-2018).

Taking all the findings together, we argue that government support in this industry seems to be a fairly general feature. Government support can be identified at all major parts of the value chain. Support can be identified amongst established producers at the technology

15. We use the classification from **?**. We exclude ten policies that generically target the entire industry. These policies do not provide sufficiently granular information to assign monetary values to distinguish parts of the value chain. Among the ten excluded policies, six are Chinese policies and four are South Korean policies.
16. Appendix Figure A.1 plots the time trend of policies by the part of the value chain targeted.
17. In the case of Samsung, the jurisdiction of where the budgetary support came from could not be identified. For Intel, budgetary support came from a variety of jurisdictions, the major ones being the U.S. and China.

Table 4: Timeline of major policies

Year	Policy	Country	Value
2011	12th Five-Year Plan	China	-
2012	National Policy on Electronics	India	-
2012	Modified Special Incentive Package Scheme	India	$1.6 billion
2014	Integrated Circuit Development Outline	China	-
2014	National Integrated Circuit Industry Investment Fund (Big Fund)	China	$47 billion
2016	13th Five-Year Plan	China	-
2018	Microelectronics research and innovation project	France, Germany, Italy, and UK	$2 billion
2019	Artificial Intelligence Strategy	South Korea	$1 billion
2020	14th Five-Year Plan	China	-
2020	Integrated Circuit Development Outline	China	-
2020	Program for Promoting Investment to Strengthen Supply Chains	Japan	$3.5 billion
2021	National Recovery and Resilience Plan	Germany	$1.7 billion
2021	Modified Programme for Semiconductors and Display Fab Ecosystem	India	$17.5 billion*
2021	Specified Semiconductor Funding Program	Japan	$5.4 billion
2021	Economic Measures for Overcoming COVID-19 and Opening Up a New Era	Japan	$6 billion
2021	Korean New Deal	South Korea	$72 billion
2021	Export control licensing	USA	-
2022	Electronique 2030	France	$5 billion
2022	CHIPS and Science Act	USA	$39 billion

Notes: The table is not a comprehensive list of all policies, only major policies are included.
* This value includes $7.5 billion approved under the Production Linked Incentives for Large Scale Electronics Manufacturing, the Production Linked Incentives for IT Hardware, the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors, and the Modified Electronics Manufacturing Clusters Scheme.

Table 5: Industrial policy by part of the value chain targeted

	All	National
i) Inputs	**18**	**9**
Semiconductor manufacturing equipment	13	8
Specialized chemicals and materials	8	6
Electronic Design Automation software	7	5
ii) Design and Manufacture	**35**	**22**
Integrated Device Manufacturers	23	15
Semiconductor designers	15	14
Foundries	21	16
iii) Assemble, Package, and Test	**10**	**9**
Too generic	10	10

Notes: The same policy can target multiple parts and subparts of the value chain. "Too generic" refers to policies that contain no information on which part of the value chain is targeted (six Chinese and four South Korean). The first column reports all policies, the second column excludes firm-specific policies.

frontier (notably, Korea and Taiwan), in countries hoping to develop their industry (China and the U.S.), and in countries attempting to enter the industry (India).

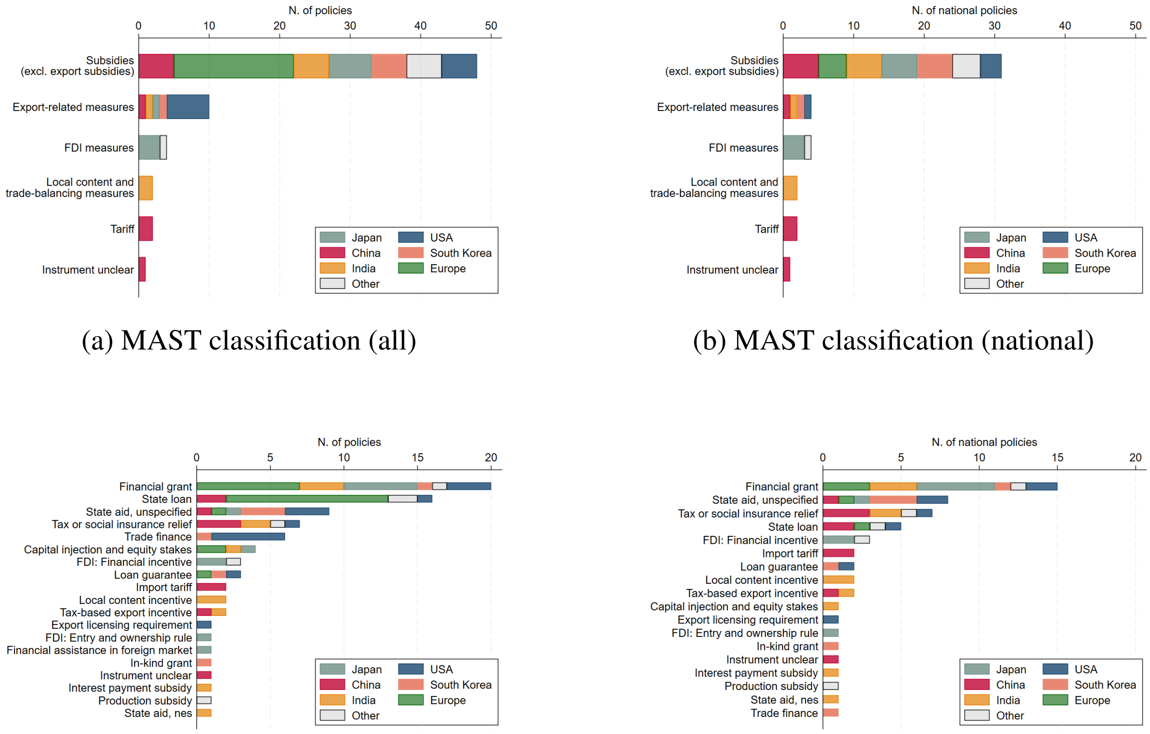
4.5.2 *Policy instruments*

We now turn to the question of how government support for the industry is provided. Unlike in the previous subsections, it is not possible to assign monetary spending at this level of disaggregation.

Subsidies are the dominant form of support. In Figure 4, we plot the policy instrument used to provide support.[18] We classify policy instruments using two taxonomies. Panels A and B break down policies by the UN MAST (Multi-Agency Support Team) Chapter classification for non-tariff measures. Panels C and D do so using *GTA*'s more disaggregated classification scheme.

Subsidies are by far the most common type of support offered by countries (see panels A and B), which aligns with OECD findings. Consistent with the main forms of government

18. We note that a single policy is often composed of many types of measures. For example, in 2021 India introduced the Programme for Development of Semiconductors and Display Manufacturing Ecosystem. This policy covers two UN MAST categories: subsidies, and local content and trade-balancing measures.



(a) MAST classification (all)

(b) MAST classification (national)

(c) *GTA* classification (all)

(d) *GTA* classification (national)

Figure 4: Type of support by country

Notes: Panels A and B show policies broken down by type according to the UN MAST Group. Panels C and D show policies broken down by type according to the *GTA* internal classification. Panels A and C include all semiconductor policies, while Panels B and D exclude policies deploying funds to individual firms and only enumerate national-level policies. We group Europe together, which includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta, and the UK. "Other" comprises Brazil, Canada, Saudi Arabia, Thailand, and Russia.

support covered by the OECD report, we find subsidies predominantly taking the form of financial grants, state aid, tax measures, loans, loan guarantees, and equity injections to be prevalent.

Alongside these, we can also see some other forms of support that may be harder to identify in firm-level data, including FDI incentives (Japan), local content incentives (India), as well as trade policy instruments such as import tariffs (China) and export licensing requirements (U.S.).

5 Policy Objectives

Why do governments target semiconductors with industrial policy? Having established that government support for the industry is ubiquitous among semiconductor-producing countries, we now turn to understanding more about the intentions of the policymakers.

An emphasis on growth, competitiveness, and, increasingly, resilience. For each policy, we have manually labelled both the stated *goal* of the policymaker, and the stated *means* to achieving that goal.[19] Table 6 shows that economic growth and development goals are by far the most prevalent. Indeed, this goal shows up across most jurisdictions and attests to the fact that domestic participation in the industry is widely seen as economically desirable. Similarly, the goal of enhancing international competitiveness is also widespread. Strikingly, resilience to supply chain disruptions was already an objective of the Indian and Chinese governments in the early 2010s. National security, not shown in Appendix Figure A.2, appears as a goal in European countries, the United States, Japan, and Canada starting in 2018 (Appendix Figure A.2 contains the time trends for the top three goals).

By what means do policymakers try to achieve these goals? Table 7 shows that policymakers are predominantly targeting the manufacturing process by subsidizing capacity expansion and the construction of new fabs, as well as supporting research and development across different parts of the value chain. We see fewer policies that try to achieve their goal by affecting international trade and investment decisions.

In comparison, the OECD finds that the vast majority of the budgetary support they identify is provided through research grants or the tax treatment of R&D spending (p. 9). They find smaller support for what they call investment incentives (production improvement in our terminology). This may be related to the fact that incentivizing investment is a more lumpy form of support, though it's also likely that production improvement policies became more important since the pandemic, and hence are not covered in the OECD report's time frame (for evidence of this, see Appendix Figure A.3, which shows the uptick in policies supporting production improvement since 2020).

Government documents may reveal growth, competitiveness, and resilience as the stated goals of policymakers, but government intervention in the semiconductor sector, and the use of subsidies in particular, require further justification. We turn to this next, with our model-based approach.

19. While there are fifty-eight total policy measures, a single measure can mention multiple means and multiple goals.

Table 6: Policies mentioning specific goals

Goal (broader aim)	All	National
Economic growth and development	38	25
International competitiveness	23	14
Resilience	10	8
National security	6	5
Green economy	4	3
COVID-19 support	3	3
No goal available	1	1

Notes: The first column reports the number of policies mentioning a specific goal. The second column excludes firm-specific policies, thus reporting only national-level policies. There are a total of 58 semiconductor industrial policies, 35 of which are national-level policies, as opposed to supra- or sub-national policies. Each policy can mention multiple goals. Economic growth and development include goals tied to industrial or technological development, economic growth, satisfying domestic demand, and addressing sub-optimal investment levels. International competitiveness includes the goals of expanding exports, becoming a global hub, catching up with the international frontier, or improving international competitiveness. Resilience includes the goals of self-sufficiency, supply chain resilience, and resilience to climate change or health pandemics. We use green economy for policies aimed at promoting the next generation of energy efficiency, resource saving, or the decarbonization and renovation of semiconductor production facilities. We further add the goal of providing economic support after the COVID-19 pandemic. (Note that we do not have enough information to identify the goal for one Korean policy.)

6 Model-Based Analysis

The model-based approach is pursued in a separate paper (Goldberg et al., 2026). Here we summarize the insights relevant to subsidy measurement and assessment.

The model examines the market for semiconductor fabrication, in which foundries such as TSMC in Taiwan and SMIC in China supply chips to fabless firms such as NVIDIA. We seek to identify and analyze production subsidies to the foundries, i.e., the transfers or other forms of implicit financial support that lower the cost of chip production. Of course, this is only a subset of policies that may be employed by the semiconductor sector. For instance, such subsidies do not include R&D subsidies. However, production subsidies are first order and arguably one of the more politically sensitive policy instruments targeted towards the sector. We can think of these subsidies as tools which lower foundries' marginal costs, leading to lower prices for buyers.

Table 7: Policies mentioning specific means

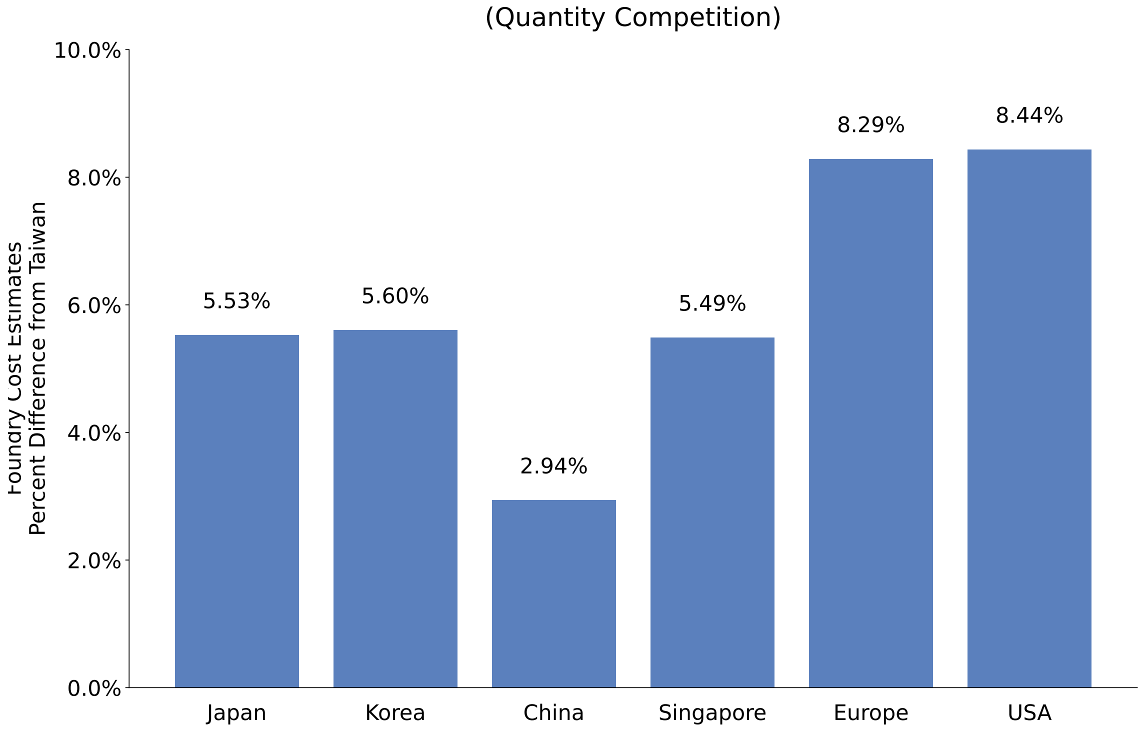
Mean (direct objective)	All	National
Production improvement	34	24
Research, Development, and Innovation	30	19
International Trade and Investment	10	5
Other	1	0
No means available	3	3

Notes: The first column reports the number of policies mentioning a direct objective, or mean. The second column excludes firm-specific policies, thus reporting only national-level policies. There is a total of 58 chips-related industrial policies, of which 35 are national-level policies. Each measure can mention multiple means. "Production improvement" includes capacity expansion, creation of new fabs, production subsidies, preferential market access, tax incentives, and capital injection. "Research, Development, and Innovation" includes product innovation, investment in R&D, development of high-tech machines, and training of the workforce. "International Trade and Investment" includes export tax rebates, export licensing requirements, loans to export, and restrictions or encouragements to inward FDI. The category "Other" includes a generic capital increase for a specific company. Of the measures with no available means, all are South Korean.

The model provides a way of identifying these production subsidies. Specifically, we interpret the supply-side country fixed effects as the *average* (across years) subsidies in each country. These fixed effects capture all factors, beyond those controlled for in the marginal cost specification of the model, that reduce (or, alternatively, increase) the marginal cost of production in a specific country relative to the benchmark country. The credibility of interpreting these fixed effects as subsidies depends on the extent to which all other factors affecting marginal cost are accounted for in the supply side specification. The marginal costs themselves are not observed in the data, but inferred based on the model structure and assumptions about the mode of competition. We examine the robustness of our results by estimating three alternative supply-side specifications: (a) quantity competition with product differentiation; (b) price competition with product differentiation; and (c) monopolistic competition.

The supply-side fixed effects for each of these specifications are shown in Figures 5-7. For ease of presentation, we do not report standard errors in the figures, but most fixed effects are highly significant. Assuming that the marginal cost function adequately controls for all determinants of variable costs, these fixed effects can be interpreted as capturing average subsidies at the country level, averaged over time and technologies. All fixed effects are relative to Taiwan. For example, in Figure 5, the estimate of 5.53% for Japan implies that, over our sample period (2004–2019), production costs in Japan were on average 5.53% higher than in Taiwan, for reasons not captured in our model; this cost difference can then be attributed to a difference in average subsidization between Taiwan and Japan. We emphasize that that our empirical specification controls for cost differences across technologies as well as sources of cost differences across countries. Labor cost is a significant cost component in semiconductor manufacturing, and our specification controls for wages. The second significant component of variable costs is the cost of inputs; these are internationally traded and absorbed by the time fixed effects. The empirical specification also controls for quality differences across suppliers that are associated with higher costs.

Figure 5: Estimated Country Fixed Effects Relative to Taiwan



The bars indicate that the *sign* of the country fixed effects is not robust across models of competition: under quantity competition, the estimated fixed effects are positive relative to Taiwan, whereas under price or monopolistic competition they are negative.[20] Importantly, however, the *ranking* of the country fixed effects – always measured relative to Taiwan – is robust across specifications. Europe and the United States consistently have relatively high fixed effects: they are more positive under quantity competition and less negative under price or monopolistic competition. This pattern, which is consistent with relatively limited use of production subsidies, is consistent with evidence that these regions have historically relied

20. Inspection of the remaining parameter estimates suggests that this difference reflects the interaction between the wage coefficient and the country fixed effects. These are the only estimates that vary meaningfully across models of competition; all other parameters, including those governing learning, are robust to the assumed mode of competition.

Figure 6: Estimated Country Fixed Effects Relative to Taiwan

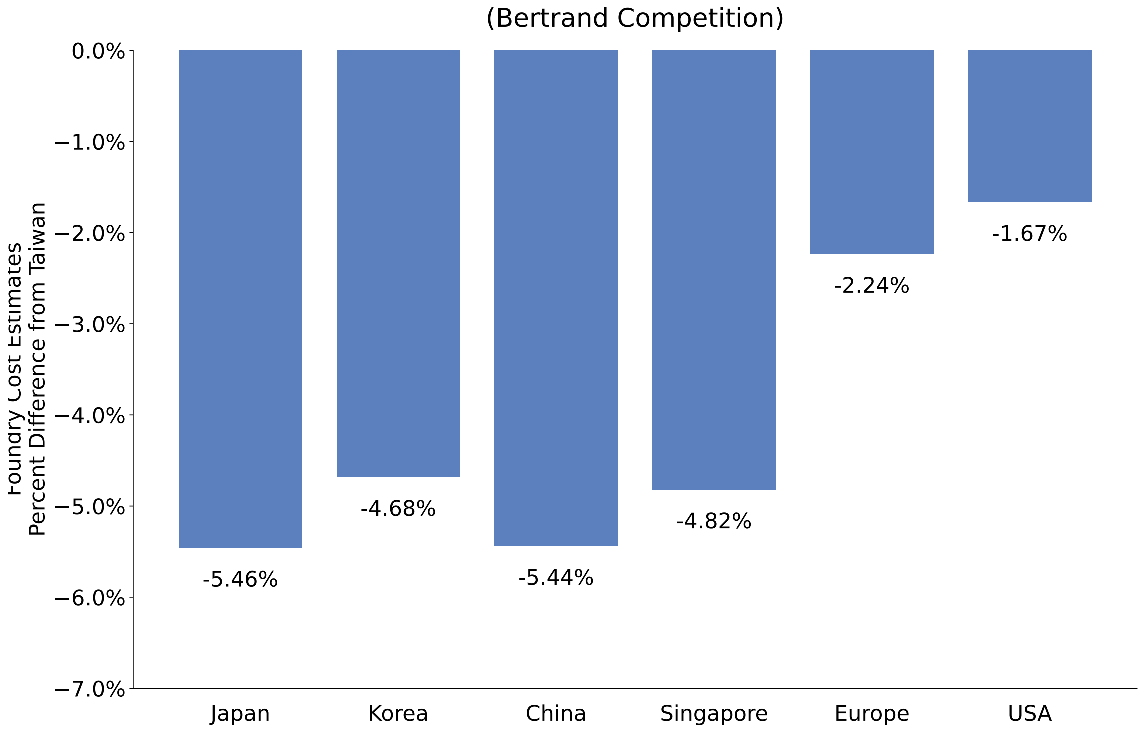
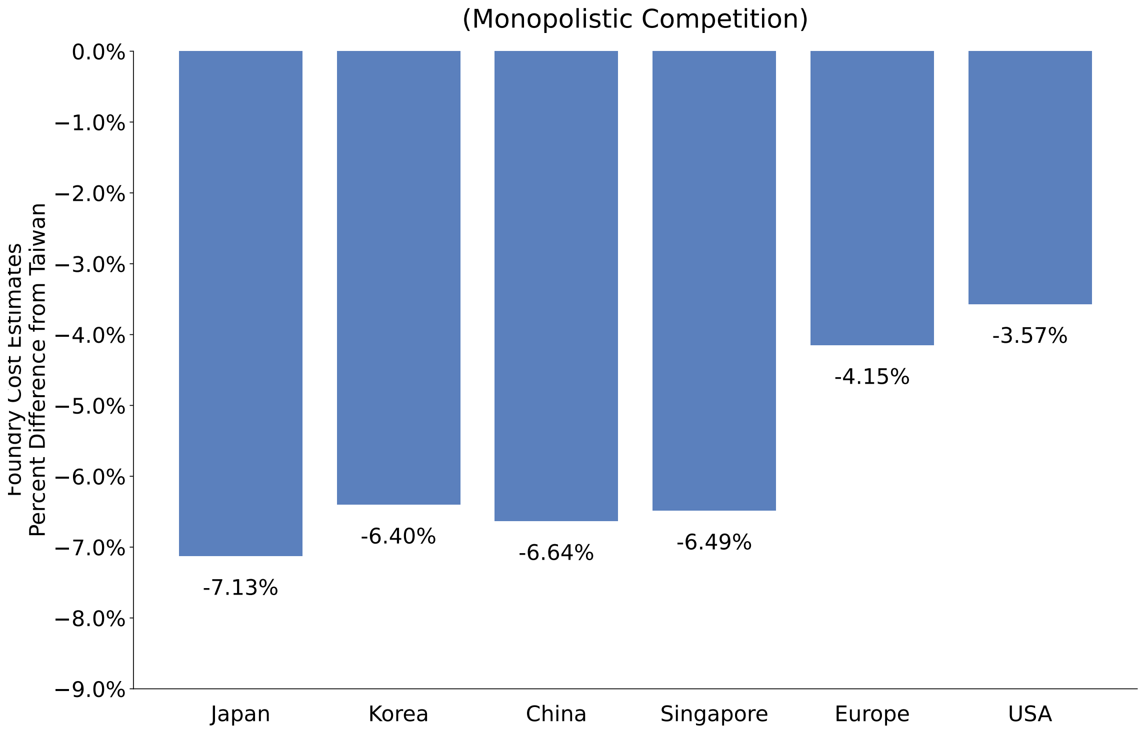


Figure 7: Estimated Country Fixed Effects Relative to Taiwan



more heavily on subsidies to research and development than to production (OECD, 2019). Consistent with the earlier *GTA*-based analysis, China does not emerge as an outlier, although we note that the sample periods covered by the two analyses do not coincide exactly. We stress that these fixed effects represent averages across time and technologies.

7 Conclusions

Our analysis highlights the important role of government support in the semiconductor industry's growth, especially during its nascent stages. Financial grants, tax incentives, loans, and equity injections have been fundamental in helping countries like Korea, Taiwan, China, and the United States enhance their semiconductor capabilities. Equally crucial is the role of technology transfer across countries, which has historically enabled firms in follower countries to reach the technological frontier.

Quantifying subsidies, the primary form of government support, remains challenging. Our comparative analysis with the OECD study highlights the challenges of measurement, particularly in the case of China. In light of these challenges, our model-based approach offers a promising alternative for identifying and evaluating subsidies in this pivotal global sector. However, we emphasize that our model-based approach is not yet a definitive tool. Importantly, data constraints limit our ability to explore recent industry developments and to provide a more granular analysis of technology-specific effects.

Nevertheless, the subsidy findings implied by our model broadly align with the patterns of semiconductor policy documented using *GTA* data. These parallels are notable, given the distinct methods and the lack of overlap (in years) between the two datasets. Furthermore, our analyses indicate that subsidies are employed by all countries active in the semiconductor industry. While China is a significant user of subsidies in monetary terms, it is not an outlier when accounting for the size of its market.

References

Amsden, A. H. (1989). *Asia's next giant: South Korea and late industrialization*. Oxford University Press, USA.

Bai, J., P. J. Barwick, S. Cao, and S. Li (2020). Quid pro quo, knowledge spillover, and industrial quality upgrading: Evidence from the chinese auto industry. Technical report, National Bureau of Economic Research.

Barwick, P. J., M. Kalouptsidi, and N. B. Zahur (2025). Industrial policy implementation: Empirical evidence from china's shipbuilding industry. *The Review of Economic Studies 92*(6), 3611–3648.

Berger, A., H. Khan, A. Schrank, and E. R. Fuchs (2023). A new policy toolbox for semiconductor supply chains. *Issues in Science & Technology 39*(4).

Bown, C. P. (2020). How the United States marched the semiconductor industry into its trade war with China. *East Asian Economic Review 24*(4), 349–388.

Breznitz, D. (2007). *Innovation and the state: Political choice and strategies for growth in Israel, Taiwan, and Ireland*. Yale University Press.

Chen, C.-F. and G. Sewell (1996). Strategies for technological development in south korea and taiwan: the case of semiconductors. *Research Policy 25*(5), 759–783.

Choi, H. (2008). Technology Importation, Corporate Strategies, and the Rise of the Japanese Semiconductor Industry in the 1950s. *Comparative Technology Transfer and Society 6*(2), 103–126.

Evans, P. (1992). The state as problem and solution: Predation, embedded autonomy, and structural change. *The politics of economic adjustment 3*(3), 138–181.

Evenett, S. J. (2009). Global Trade Alert: Motivation and Launch. *World Trade Review 8*(4), 607–609.

Evenett, S. J. and J. Fritz (2022). The Global Trade Alert database handbook. Technical report.

Goldberg, P. K., R. Juhász, G. Lo Forte, and J. Thurk (2026). How knowledge crosses borders: Evidence from semiconductor manufacturing. Working paper.

Juhász, R., N. Lane, and D. Rodrik (2024). The New Economics of Industrial Policy. *Annual Review of Economics*.

Juhász, R., N. J. Lane, E. Oehlsen, and V. C. Pérez (2025). Measuring industrial policy: A text-based approach. Technical report, National Bureau of Economic Research.

Kalouptsidi, M. (2018). Detection and impact of industrial subsidies: The case of Chinese shipbuilding. *The Review of Economic Studies 85*(2), 1111–1158.

Liu, C.-Y. (1993). Government's role in developing a high-tech industry: the case of taiwan's semiconductor industry. *Technovation 13*(5), 299–309.

Lynn, L. H. (1998). Japan's technology-import policies in the 1950s and 1960s: did they increase industrial competitiveness? *International Journal of Technology Management 15*(6-7), 556–567.

Miller, C. (2022). *Chip War: The Fight for the World's Most Critical Technology*. Scribner.

Minnich, J. D. (2023). *Re-Innovation Nation: The Strategic and Political Logic of Technology Transfer Policy in Rising China*. Ph. D. thesis, Massachusetts Institute of Technology.

OECD (2019). Measuring distortions in international markets: The semiconductor value chain. (234).

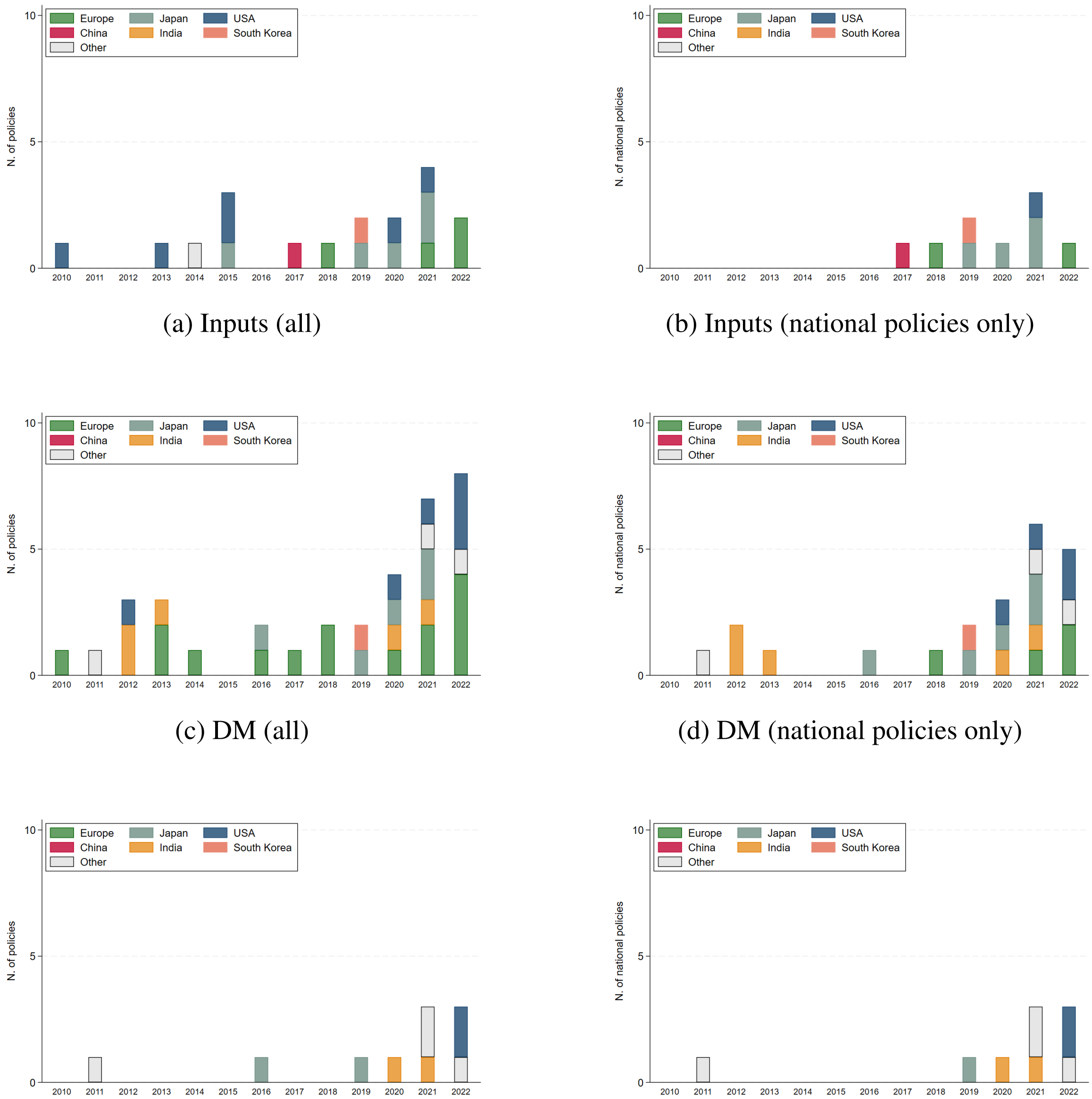
VerWey, J. (2019). Chinese semiconductor industrial policy: Past and present. *J. Int'l Com. & Econ.*, 1.

Online Appendix

Industrial Policy in the Global Semiconductor Sector

Goldberg, Juhasz, Lane, Lo Forte, and Thurk

A Additional Figures



(a) Inputs (all)

(b) Inputs (national policies only)

(c) DM (all)

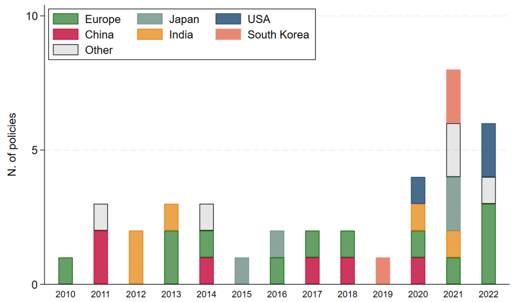
(d) DM (national policies only)

(e) APT (all)

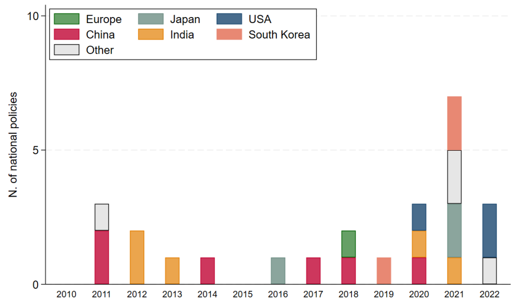
(f) APT (national policies only)

Figure A.1: Supply Chain targeted over time

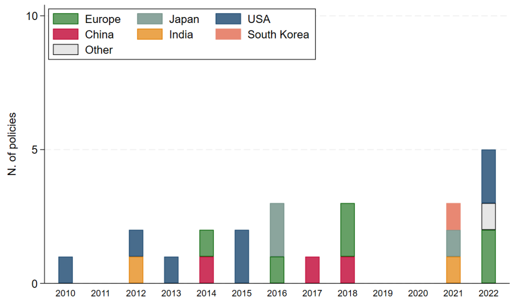
Notes: Panels A, C, and E include the count of all semiconductor policies. Panels B, D, and F exclude policies deploying funds to individual firms and only enumerate national-level policies. Panels A and B show policies targeting Inputs. Panels C and D show policies targeting Design and Manufacture (DM). Panels E and F show policies targeting Assemble, Package, and Test (APT). We group Europe together, it includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta, and the UK. "Other" comprises Brazil, Canada, Saudi Arabia, Thailand, and Russia.



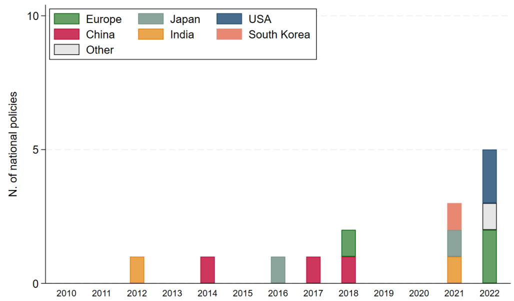
(a) Growth (all)



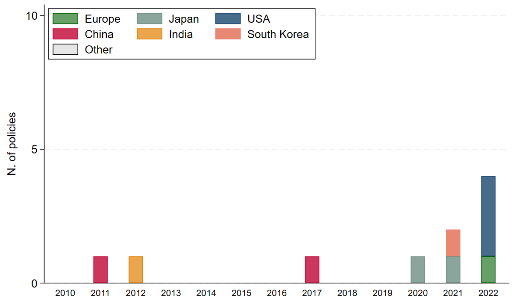
(b) Growth (national policies only)



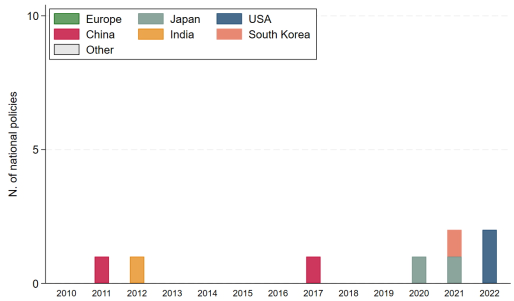
(c) Competitiveness (all)



(d) Competitiveness (national policies only)



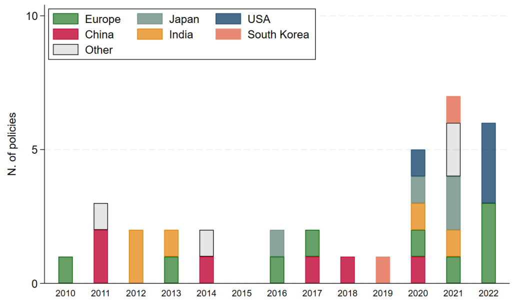
(e) Resilience (all)



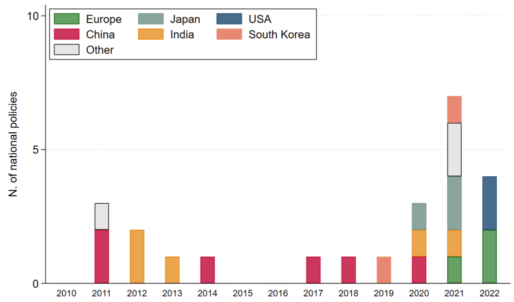
(f) Resilience (national policies only)

Figure A.2: Goals over time

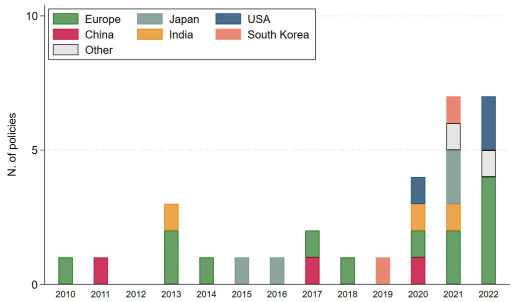
Notes: Panels A, C, and E include the count of all semiconductor policies. Panels B, D, and F exclude policies deploying funds to individual firms and only enumerate national-level policies. Panels A and B show policies with the goal of promoting economic growth and development. Panels C and D show policies with the goal of fostering international competitiveness. Panels E and F show policies aimed at improving resilience. We group Europe together, it includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta, and the UK. "Other" comprises Brazil, Canada, Saudi Arabia, Thailand, and Russia.



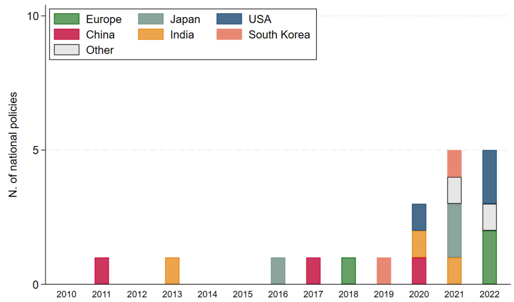
(a) Production (all)



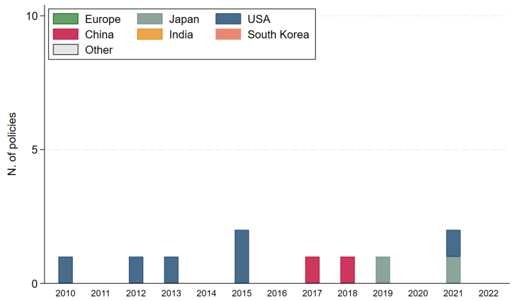
(b) Production (national policies only)



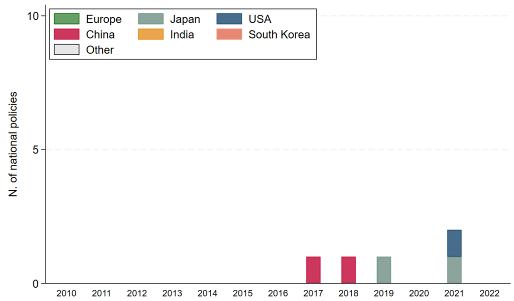
(c) RDI (all)



(d) RDI (national policies only)



(e) ITI (all)



(f) ITI (national policies only)

Figure A.3: Means over time

Notes: Panels A, C, and E include the count of all semiconductor policies. Panels B, D, and F exclude policies deploying funds to individual firms and only enumerate national-level policies. Panels A and B show policies with the direct objective of improving production. Panels C and D show policies with the direct objective of supporting Research, Development, and Innovation (RDI). Panels E and F show policies with the direct objective of supporting International Trade and Investment (ITI). We group Europe together, it includes policies implemented by the following countries: Czechia, France, Germany, Italy, Netherlands, Malta, and the UK. "Other" comprises Brazil, Canada, Saudi Arabia, Thailand, and Russia.