The Chip Race and Chip Trade Flows: Reshaping the Semiconductor Ecosystem Across Major Chip-Making Countries

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Abstract

Rising concerns over semiconductor supply chain resilience during the 2020–2021 pandemic and the imposition of U.S. export control restrictions against China in 2022 have exacerbated technological competition between major powers, turning it into a chip race that is reshaping the semiconductor industry and influencing international trade and even geopolitics.

To assess how the chip race affects the semiconductor ecosystem, this paper relies on descriptive data analysis of changes in multilateral trade flows among the five countries with the largest chip-making capacities: the United States, Taiwan, South Korea, Japan, and China.

The findings show that while shifts in chip trade flows are evident, the overall framework of the global chip industry remains largely unchanged. The main rivals—the U.S. and China—have faced minor setbacks. China remains the world's largest chip exporter and importer by value, largely offsetting losses by redirecting trade toward Vietnam and India. Singapore has emerged as a key beneficiary, while Vietnam has become a notable new entrant in the global chip industry.

This data-driven evaluation offers rare empirical insight into the chip race's evolving dynamics. Such evaluation helps test theoretical assumptions and informs future policy and geopolitical decisions.

1. Introduction

The chip race has emerged as one of the central issues in the growing technological rivalry between today's leading powers—the United States and China. Driven by the growing demand for high-performance semiconductors in various industries, the chip race reflects the strategic role of chips in national security, economic strength, and technological progress. Increasingly, control over semiconductor capacity is seen as one of the most essential keys to gaining geopolitical advantage and global influence. In addition to its strategic role, semiconductors generate huge revenues—global demand continues to outpace supply (Casanova 2024)—and are among the most profitable industries (Statista 2024). They generate significant revenue for leading chip-producing countries.

The chip race does not have a generally accepted definition. Rather, it serves as a metaphor for a complex competition over preferential and unobstructed access to the semiconductor market, related technologies, and associated supply chains. In this paper, the chip race is defined as a dynamic and competitive process in which countries with chip-making capabilities leverage their advantages, strategic partnerships, and economic influence—while employing legislative,

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financial, and organizational tools—to achieve technological superiority in the semiconductor industry and related advanced sectors on a global scale.

To grasp the rationale behind the research framework and methodology used in this paper, it is worth pointing out several inherent features of the global semiconductor industry that also shape the dynamics of the chip race and influence international relations among the countries involved.

First, the industry is highly diversified. Semiconductor production is divided into several distinct stages, not to mention R&D—design, wafer fabrication, chip manufacturing, assembly, packaging, and testing. The United States leads in chip design, while large-scale manufacturing and assembly are concentrated in Asia, particularly in South Korea and Taiwan (Zandt 2023). Notably, a single chip may cross international borders up to 70 times before reaching the end user. (Alam et al. 2020).

The industry also relies on critical inputs such as rare earth elements, particularly gallium, where China holds a near-global monopoly. These materials are essential for producing high-frequency chips used in advanced technologies like radar and communications (Cytera 2023). Likewise, semiconductor manufacturing depends on unique, cutting-edge equipment. The Dutch company ASML, for instance, is the world's only supplier of advanced photolithography machines required for fabricating the most advanced chips.

In addition, diversification in the semiconductor industry goes beyond manufacturing stages and critical inputs. Chips themselves are not uniform and can be categorized by function into four main types: logic chips, memory chips, application-specific integrated circuits (ASICs), and system-on-a-chip (SoC) devices (ASML 2024). They also vary by the sophistication of their process nodes, which determine their performance, power efficiency, and applications (Shivakumar, Wessner, and Howell 2023).

Second, the semiconductor industry is heavily concentrated in a few key countries, often referred to as countries with major chip-making capacities. Around 75% of global semiconductor manufacturing is located in East Asia, particularly in South Korea, Japan, China, and Taiwan (Semiconductor Industry Association 2024). Taiwan produces approximately 90% of the world's most advanced chips used in AI and quantum computing, while China controls a significant portion of the global legacy chip market, serving various sectors, including military industries, with such chips often used in US military equipment and ammunition (Whytock 2024), which are used primarily by the military industry, including US military equipment and ammunition. South Korea is a dominant player in memory chip production.

Finally, the semiconductor ecosystem is highly time-consuming and capital-intensive. R&D investments account for over 10% of the industry's revenue, second only to pharmaceuticals. Only highly developed countries can afford such costs. Manufacturing a single chip can take up to 26-30 weeks and 1,400 process steps (Semiconductor Industry Association 2021). The production of a full wafer can cost billions of dollars, factoring in the price of specialized machinery. In addition, building new chip manufacturing facilities requires years of investment and the recruitment of a skilled workforce.

Although some scholars date the first apparent tensions in the semiconductor industry to the 1980s between Japan and the United States (Miller 2022, Reinert 2023), the modern "chip race" is widely believed to have begun in 2018[1]. That year, the U.S. imposed 25% tariffs on $50 billion worth of Chinese imports, including semiconductors, and placed major Chinese tech firms like Huawei and ZTE on the Entity List, restricting their access to key exports. The situation worsened during the COVID-19 pandemic (2020–2021), which exposed vulnerabilities in global semiconductor supply chains (Mohammad, Elomri, and Kerbache 2022). Disruptions led to production delays and economic downturns across multiple industries, highlighting the strategic importance of chip manufacturing (Frieske and Styeler 2022).

Despite some easing under the 2020 "Phase One" trade deal with China during the Trump administration, new export control restrictions were introduced in May and August 2020 under the Foreign-Produced Direct Product (FDP) rule, targeting semiconductor manufacturing equipment (Bown 2020). In addition to political sanctions on China[2], in October 2022, the Biden administration imposed stricter export controls on advanced semiconductor technology in October 2022, increasing geopolitical tensions and impacting China and the global semiconductor industry.

2. Literature Review

In examining the chip race's impact on the global semiconductor ecosystem, scholars and experts consider key features of chip manufacturing that help explain its broader effects on national economies, international trade, and geopolitical alignments. As noted in the introduction, these characteristics include the industry's highly diversified yet capital-intensive and time-consuming nature, along with the heavy concentration of major chip-making capacities in Asian countries. (Yeung 2022; Miller 2022; Frieske and Stieler 2022; Kim and Rho 2024; Malkin and Heb 2023; Lee 2024).

Given the highly diversified and capital-intensive nature of the global chip industry—the first line of the debate—experts and scholars widely agree that no single country, now or in the foreseeable future, can produce all types of semiconductors it needs, nor can it afford to develop the full range of manufacturing capacities required to meet its demand (Flamm 1993; Kim and Pho 2024; Lee 2024; Malkin and Heb 2023; Miller 2022). The semiconductor value chains, including supply networks, are deeply interconnected and mutually dependent. This raises two key questions: Do chip value chains have structural anchors or embedded conditions? And to what extent can the two powerhouses - the chip race participants - influence the global semiconductor ecosystem and reshape it?

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[1] It's also worth considering another view, often shared by Asian experts, which suggests that the 'chip race' actually began in the mid-2010s, when China launched its state-led industrial modernization strategy *Made in China 2025* as part of its push for technological leadership (Allen 2024).

[2] Uyghur Human Rights Policy Act, Hong Kong Autonomy Act, and sanctions related to the Russian invasion of Ukraine for the support Russian military manufacturing.

In this regard, most experts acknowledge that while the United States, where semiconductors were invented, has lost its once-undisputed leadership in specific manufacturing segments, such as memory and logic chips (Yeung 2022; Alam et al. 2020), it continues to exert strong control over the industry. This control is largely maintained through its position of 'value-chain centrality' (Malkin and Heb 2023; Miller 2022) This "value-chains centrality" is secured by the US's ownership of "the software and tools that permit the fabrication of the most complex logic and analog chips" (Malkin and Heb 2023, 682). This includes leading firms such as Synopsys and Cadence [3], as well as Intel, which dominates software for the x86[4] architecture." Additionally, American-based companies like Applied Materials, KLA, and Lam Research provide essential tools and subsystems critical to semiconductor manufacturing (Miller 2022). These firms effectively ensure US technological control over the industry (Miller 2022; Kim and Rho 2024; Malkin and Heb 2023). Although a "cat and mouse game" is possible, global value chains—despite the chip race, which is marked by increasing competition among leading players—remain largely under U.S. control through sanctions and a package of export control restrictions (Miller 2022; Malkin and Heb 2023). On the contrary, China is doomed to be left behind, unable to make up for the lack of technologies, patents, proprietary equipment, and highly skilled engineers. As estimated, this situation is unlikely to change in the short term (Miller 2022; Malkin and Heb 2023; Lee 2024; Bown 2024).

However, experts, particularly those from think tanks, argue that export control restrictions have their limitations and potential loopholes, especially given the reluctance of commercial global chipmakers, also influential players, to give up the huge Chinese market (Allen 2024). In addition, China is stepping up its efforts to develop a self-sufficient industry by increasing state funds and chip manufacturing capacity. The rise of new capabilities, such as the open-source RISC-V architecture[5], has greatly accelerated China's progress (Shah 2023). Therefore, US control over the global semiconductor ecosystem may be more fragile or even illusory (Allen 2024; Shah 2023).

Regarding the heavy concentration of major chip-making capacities in particular Asian countries—the second line of the debate—scholars and experts view this localization not only as the stage on which the chip race between two powerhouses unfolds, but also as a critical factor shaping the future of the global semiconductor ecosystem (Lee 2024; Kim and Rho 2024; Yeung 2022). South Korea, Japan, and Taiwan, the three key players with advanced chip-making capabilities, should be seen as active, independent actors rather than passive U.S. allies. Each has the potential to reshape the global semiconductor landscape in their favor, as well as to undermine U.S. efforts to contain China (Lee 2024; Kim and Rho 2024; Yeung 2022).

[3] Truth to be said, Cadence is a Japanese company based in the UK is also commonly mentioned in this series.
[4] x86 is a widely used computer architecture for central processing units (CPUs). It has become the dominant architecture for personal computers and servers.
[5] RISC-V is an open-source instruction set architecture used to develop custom processors for a variety of applications, from embedded designs to supercomputers.

Notably, while China's official decisions remain opaque due to its characteristic reticence in publicly disclosing industrial strategy, the agendas of Japan, South Korea, and Taiwan are comparatively more transparent. In addition to adopting official strategies to expand domestic chip manufacturing capabilities in the face of cut-throat global competition, these three countries are increasing their public and private investments not only in their own industries but also in those of neighboring countries and counterparts. In discussing the dual approach of East Asian countries "to techno-economic statecraft, combining passive and active strategies," Lee underscores their indispensability in "the restructuring of supply chains in high-tech industries" (2024, 441). These strategies, though at times contradictory, depend on their relationships with both China and the United States, as well as on the depth of market interdependence. For example, Lee (2024) observes greater interconnectedness between South Korea and China, and less between Japan and China. Similarly, the chip value chain's proximity to end consumers influences industrial strategy. As Kim and Rho (2024) note, South Korea relies on the "downstream value chain"; this closeness to consumer markets makes the country more cautious in its dealings with China, while Taiwan, focused on the intermediate market—mainly the United States—may be less prudent.[6]

In this regard, it is worth adding that some papers that look at the changes in the global chip industry and its value/supply chains in connection with the ongoing chip race suggest expanding the scope of the discussion beyond the boundaries of the five countries mentioned. As Alfaro and Chor (2023) argue, the upcoming changes in the entire industry will inevitably impact the restructured chip industry, including the value/supply chains of the European Union (especially the Netherlands), which has already adopted the EU Chip Act, Singapore, Malaysia (Kim and Roh 2024; Yeung 2022) and neighboring chip-making countries, such as Vietnam, Mexico, and India.

For the purposes of this paper, one significant ramification of the main debate should be noted. Scholars and researchers seeking to explain why the chip manufacturing industry is both highly diversified and yet concentrated in a few East Asian countries point to several factors: the logic of multinational corporate deployment (Reinert 2023), rising market demand (Yeung 2022; Miller 2022; Frieske and Stieler 2022), the effects of intense U.S.–Japan competition in the 1980s (Miller 2022; Malkin and Heb 2023), the "fabless revolution in logic chip design" (Yeung 2022, 284), and strong domestic policy support aimed at building a competitive industry (Miller 2022; Alam et al. 2020). In this context, the question of whether established chip value and supply chains have emerged intentionally—driven by U.S. efforts to contain Japan through control of patents, technologies, and tools (Miller 2022; Malkin and Heb 2023)—or organically, as a result of objective factors such as market growth, remains of particular interest. For example, Yeung cites market dynamics as the primary reason why the East Asian region evolved into "much more than a final assembly of ICT products...," becoming instead "a major end market for these products" (2022, 291).

[6] Not to mention that Taiwan has other political and geopolitical reasons for its choice of strategy regarding the chip manufacturing industry and relations with China and the USA.

The first line of the debate—whether the highly diversified global chip industry has a clear leader, namely the United States, and whether that leader can leverage its "value-chains centrality" to manage the semiconductor ecosystem and curb China's technological rise—feeds into a broader, well-established theoretical discourse in international relations. This debate unfolds between two conceptual frameworks. The first is political realism, which emphasizes the necessity of global leadership and frames international dynamics as a predictable contest in which a dominant power seeks to preserve its hegemony and contain rivals. The second is neoliberal institutionalism, which underscores the importance of interdependence and the inevitability of cooperation among states. Notably, the first wave of this theoretical dispute emerged in the early 1980s, as U.S. dominance began to wane due to several factors, including the rise of other influential players such as Japan and Western Europe (Keohane 2005). In this context, the chip race can be seen as a renewed arena through which the United States seeks to reassert and measure its technological supremacy.

The second line of the debate regarding the particular concentration of the largest share of the global semiconductor industry in a few Asian countries raises questions, on the one hand, about the vulnerabilities and interconnectedness of supply chains, and, on the other hand, about whether these Asian countries can be independent actors and pursue their own self-interests. In turn, these questions can be situated within a broader theoretical discourse in international political economy between techno-nationalism and Global Production Networks (GPNs) theory. In this context, the chip race, grounded in the pursuit of national security and technological supremacy, and fueled by supply chain disruptions, can simultaneously evoke the same sentiments aimed at securing self-sufficiency and reshoring production capacities to domestic soil (Reinert 2023). Notably, Robert Reich, who coined the term "techno-nationalism," addressed tightening technological competitiveness, particularly in the context of U.S.–Japan relations that revolved around the semiconductor industry (Reich 1987). On the contrary, Global Production Networks (GPNs) theory emphasizes that cross-regional manufacturing systems and supply chains have created an era of "interconnected worlds" (Yeung 2022). In this sense, the chip race is likely to trigger a restructuring of global supply chains and pave the way to the emergence of new players.

Thus, while scholars and researchers agree that the ongoing chip race inevitably affects the global semiconductor ecosystem, even though in a different ways, they differ in their assessments of the extent of U.S. control over value/supply chains, the scale and geographic scope of changes, the strategies of countries with major chip-making capacities toward the technological tension between the U.S and China, the possibility of emergence of new entrants, the extent of damage to the Chinese chip industry, and other implications for related and dependent industries.

Several observations help distinguish this study from existing research. Most studies in this field primarily focus on government measures aimed at achieving technological supremacy in the semiconductor industry—both restrictive (e.g., sanctions, export controls) and supportive (e.g., subsidies, R&D investments). These studies typically assess the effectiveness of such policies, analyze reciprocal government responses, and explore potential transformations in global chip supply chains.

However, in terms of research focus, relatively few studies examine how the actions of these governments, directly involved in the chip race, influence global chip trade flows. In other words, limited attention has been given to the relationship between official policy decisions—whether aimed at developing domestic manufacturing capacity or curbing competitors' advantages—and the resulting changes in semiconductor trade dynamics.

Likewise, in terms of methodological standpoint, most existing research is either theoretical or analytical. It often relies on historical analysis and case studies (Miller 2022; Reinert 2023), qualitative approaches such as in-depth interviews (Miller 2022; Malkin and Heb 2023), sample-based statistical analysis (e.g., CSIS reports; Shah 2023), or model-based frameworks (Goldberg et al. 2024). Few, if any, studies conduct systematic analyses of semiconductor trade flows using raw import/export data over multiple consecutive years. Meanwhile, a data-driven analysis of semiconductor trade flows—based on raw import/export data over multiple years—can do more than track shifting patterns. It provides concrete evidence of the actions taken by countries and corporations, reveals how the global chip market responds, and highlights emerging vulnerabilities. This approach offers clearer insight into supply chain resilience, potential bottlenecks, and the evolving structure of the global semiconductor ecosystem. Ultimately, it can help anticipate future developments and better understand the strategic intentions of key players.

3. Research Framework, Research Question, and Hypotheses

The two inherent features of the global chip industry mentioned above also shape the choice of research framework. First, the heavy concentration of semiconductor manufacturing in a few Asian countries determines the decision to focus on five key players: the United States (the birthplace of semiconductors), China, South Korea, Japan, and Taiwan (analyzed separately from China). These countries play central roles in global semiconductor production, technological leadership, and chip trade flows, and will hereafter be referred to as the five key countries.

Second, the study examines the semiconductor export–import flows of these countries over seven years, from 2017 to 2023. Given the capital-intensive and time-consuming nature of the global chip industry, this timeframe may appear relatively short—and possibly insufficient—but still allows for the observation of meaningful trends.

One additional point should be noted. Although the chip race can be traced back to earlier periods—such as the US-Japan rivalry of the 1980s, or, from China's perspective, to the mid-2010s—this study considers its current phase to have begun in 2018, when technological competition became intensive due to direct government interventions, including American sanctions and export control restrictions. Thus, in this paper, 2017 is used as the baseline year for analysis.

The overarching research question is how the chip race affects the global semiconductor ecosystem across key chip-making countries. To answer this question, the author focuses on the following sub-questions:

- How is the chip race affecting the chip trade flows among major chip-making countries, particularly between the US and China?
- How has the chip race affected Chinese chip trade flows so far?
- Which chip-making countries have benefited or lost due to the ongoing chip race?
- Has the chip race created conditions for the emergence of new players in the global chip market?

The responses to these questions will help confirm or challenge the two hypotheses presented below.

Hypothesis 1.

The chip race is likely to change multilateral chip trade flows among the top five chip-making countries.

Hypothesis 2.

The chip race is likely to change the semiconductor ecosystem, attracting new players and redistributing benefits among a wider range of countries.

4. Research Methodology

In the paper, the author applies descriptive data analysis to deal with the BACI dataset by CEPII, the leading French center for research and expertise on the world economy. They create databases based on Comtrade, providing data on bilateral trade flows for 200 countries and covering 5,000 products at a detailed product level. The database does not take into account services. These products are classified according to the 6-digit codes of the Harmonized System (HS) nomenclature. The dataset consists of six variables: year, exporter (country code), importer (country code), product code (classified using the HS 6-digit nomenclature), trade value (in thousand USD), and quantity (in metric tons).

Data on 21 semiconductor-related product codes for five key countries – the United States, Taiwan, South Korea, China, and Japan – were extracted from the BACI database for the period 2017–2023, forming the initial dataset for the research. Next, to simplify the calculations and observations, the author combined the 21 semiconductor product groups (product codes) into 7 broad product groups based on the first 4-digit codes (see Appendix 3).

Given the third defining feature of the global chip industry—its highly diversified nature, in which semiconductor-related commodities range from chemical materials and tiny chips to large-scale chipmaking equipment—several methodological caveats should be noted. First, the primary variable used is trade value, measured in thousands of U.S. dollars. Accordingly, all estimates and comparisons throughout the study are based on total trade value. Second, to determine each country's export and import volumes, total trade figures were calculated by aggregating data across all 21 semiconductor-related product codes. To analyze the structure and

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composition of trade flows, the data were further disaggregated by trading partner (country-level analysis) and by the seven broad product groups (product-level analysis). Finally, to assess global positioning, the top 10 semiconductor exporters and importers were identified and ranked based on their aggregated trade values (in thousands of U.S. dollars).

5. Research Findings

5.1. To answer the first sub-question of how the chip race is affecting chip trade flows among the key five countries, particularly between the US and China, the author obtained the following data.

Figure 1 shows that 2022 marked a peak year, with total chip exports (in terms of value) for each of the five key countries reaching their highest levels in the seven years since 2017. Notably, in 2017, having had the same chip export value as Taiwan, China began rapidly increasing its exports. Since 2019, China has remained the world's top chip exporter for five consecutive years. Compared with 2017, by the end of 2023, China, which managed to triple the chip export (in terms of value), was followed by Taiwan, which increased the chip export value by 63%, and South Korea, with a chip export growth of about 50% over the past three years.

Figure 1

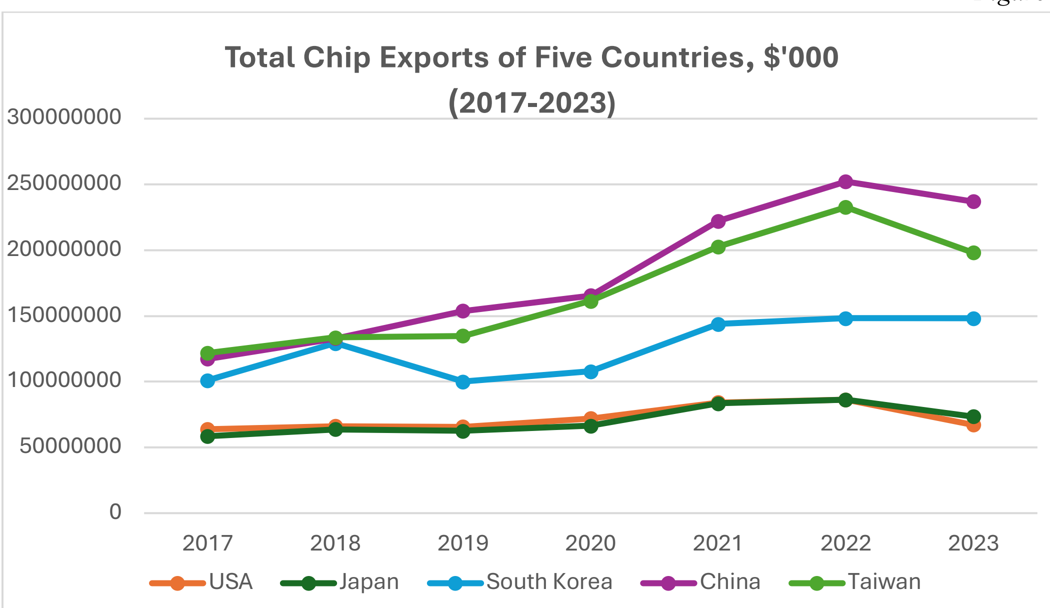

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Figure 2

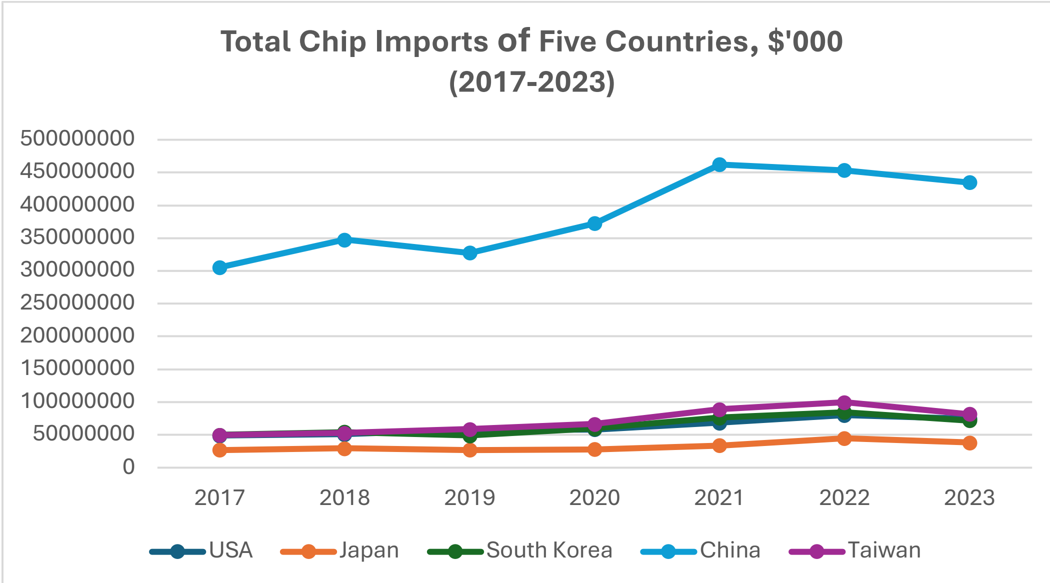

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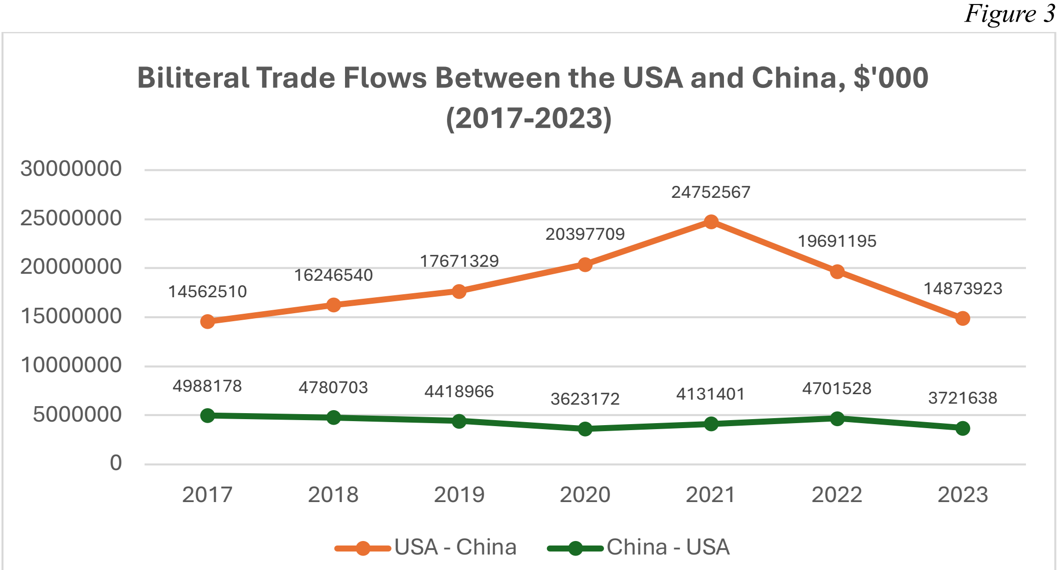
Figure 2 shows that 2022 marked the highest total chip import (in terms of value) for four key countries since 2017, except for China, which peaked in 2021. China has also maintained its position as the unconditional leading chip importer since 2017. From 2017 to 2023, the value of China's total chip imports has consistently been 5 to 11 times higher than the total chip imports of the other four key countries. Compared with 2017, China's total chip import has increased by 42%, despite a slight decline in the past two years. Over the same period, Taiwan and the United States increased their chip import value by 64% and 52%, respectively.

Figure 3



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Chip-related trade flows between the US and China have conspicuously changed (see Figure 3). After a surge in 2021, the value of US chip exports to China fell significantly, by 40%, (by 25% compared to 2022) and almost returned to 2017 levels. Compared with 2017, the value of Chinese chip exports to the US fell by a quarter in 2023, catching up with 2020 levels. Notably, China's total chip export/import ratio has been growing from 38% in 2017 to 54% in 2023. On the contrary, the US total chip export/import ratio declines from 130% in 2017 to 90% in 2023.

To sum up the answer to the first sub-question: overall, the ongoing chip race has not yet brought crucial shifts in chip-related trade flows, which remain a key part of the global supply chain among the five key countries. China remains both the world's largest chip exporter and importer. However, between 2021 and 2023, trade flows between the United States and China did see salient changes—a sharp drop in U.S. chip exports to China, alongside a less severe decline in Chinese chip exports to the U.S.

5.2. Regarding the second sub-question of how the chip race has affected Chinese chip trade flows so far, I compared the mutual chip trade flows among the other three key countries: Taiwan, South Korea, and Japan.

Based on Figure 4, two conclusions can be drawn. First, China's chip exports to the other three key countries conspicuously shrank in 2023. Second, over the past seven years, China's chip exports to South Korea and Taiwan have been times larger than those to Japan: more than 2.5 times in 2017 and more than 4 times in 2023.

Figure 4

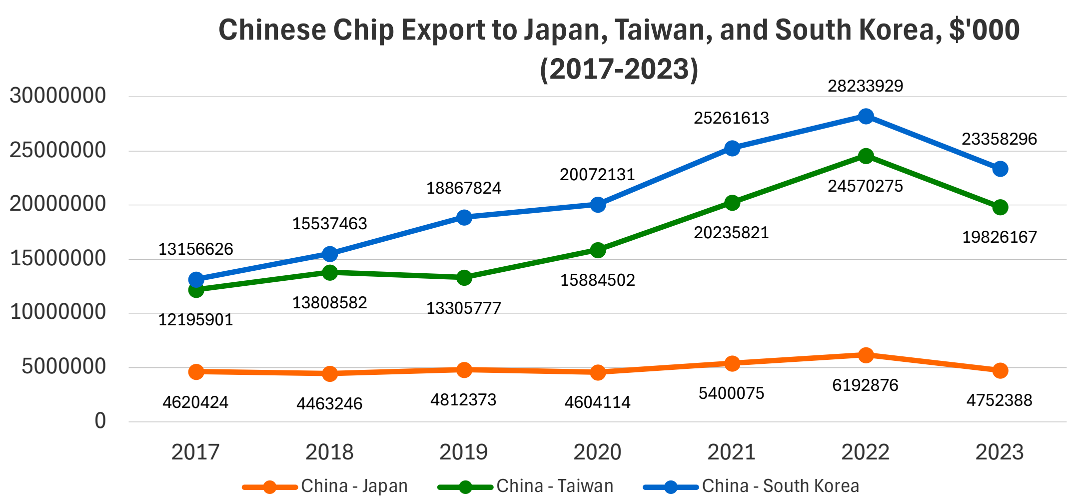

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Figure 5

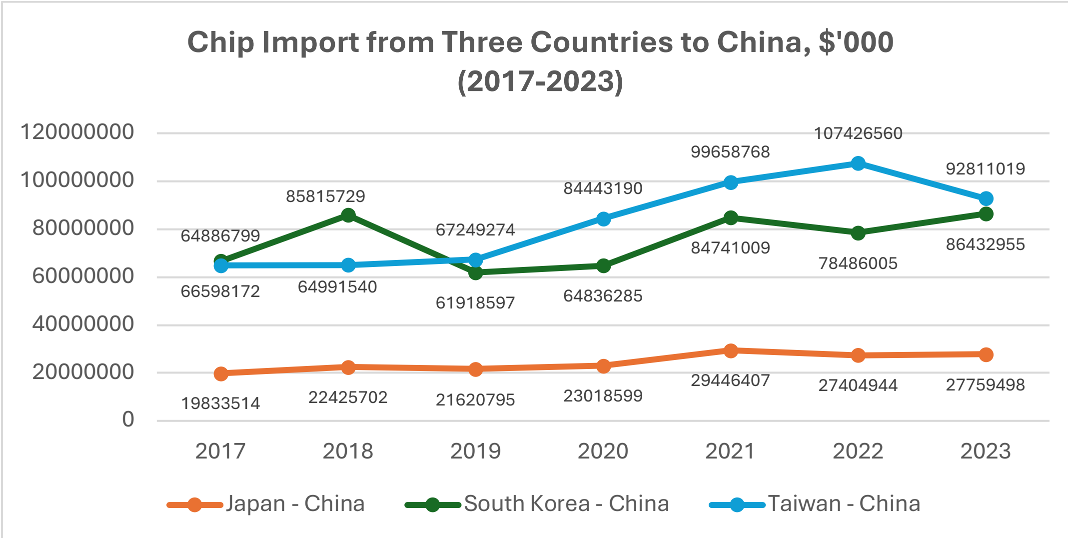

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Figure 5 reveals that chip imports to China (in terms of value) from three key countries have constantly increased since 2019. In 2022, Taiwan diminished its chip import value, whereas Japan and South Korea kept ramping up. Tellingly, Japanese chip imports to China is more than three times less than South Korean and Taiwan chip imports to China.

It is worth noting that China's chip imports have consistently been twice the size of its chip exports. A useful benchmark is 2022, which marked the peak year in terms of the value of both total and mutual chip-related trade flows among the five key countries. Although by the end of 2023, China's chip exports to the four key countries had dropped significantly, ranging from a 30% decline to Japan to a 17% decline to South Korea, its total chip exports fell by only 6% compared to 2022. Notably, China's total chip imports declined even less, decreasing by just 4%, despite sharp reductions in imports from the United States by 25% and Taiwan by 14%.

China appears to be trying to offset losses from declining chip exports in trade with four key countries by changing its chip trading partners, reshaping supply chains, and/or stimulating domestic production. A country-level analysis shows that, amid an overall chip trade decline in 2022, China increased chip exports to India and Vietnam by 3% and 6%, respectively. Notably, China also conspicuously increased chip imports from Vietnam (Appendix 2, Sub-Section 5.2).

To sum up, 2023 marked a turning point for China, as overall chip trade flows among the five key countries began to decline. By the end of 2023, China's chip exports to the four key countries fell by 19% compared to 2022. However, by partially redirecting its chip trade to other markets—primarily India and Vietnam—China limited the overall decline in its total chip exports to just 6%.

5.3. One of the most intriguing questions as of 2023 is which countries have gained or lost ground due to the ongoing chip race. To explore this, rankings of the top 10 semiconductor exporters and importers were created based on the value of a country's total chip exports and imports, respectively. Given the dynamic and rapidly evolving nature of the semiconductor market, it is essential not only to rank countries by static metrics but also to develop comparative indicators such as these rankings. They reveal two key insights: first, how the values of a country's chip exports or imports are growing relative to other market players; and second, which countries are entering—or falling behind—the ranks of the top 10 in terms of trade value.

An analysis of the top 10 semiconductor exporters reveals that Singapore has been one of the key beneficiaries of the chip race. Over the past four years, it climbed from 7th to 4th place, increasing the value of its chip exports by 63% compared to 2017. Notably, Vietnam not only entered the top 10 but also ranked 8th as of 2023. Vietnam will be examined more closely in the next subsection as an emerging player in the global chip trade. Interestingly, the United States dropped two positions in the rankings since 2020, with the total value of its chip exports falling by 22% by the end of 2023 compared to 2022. China also deserves mention for maintaining its top position, having tripled the value of its chip exports since 2017. However, for reasons discussed in the previous subsection, China is unlikely to be considered a clear beneficiary of the chip race.

Figure 6

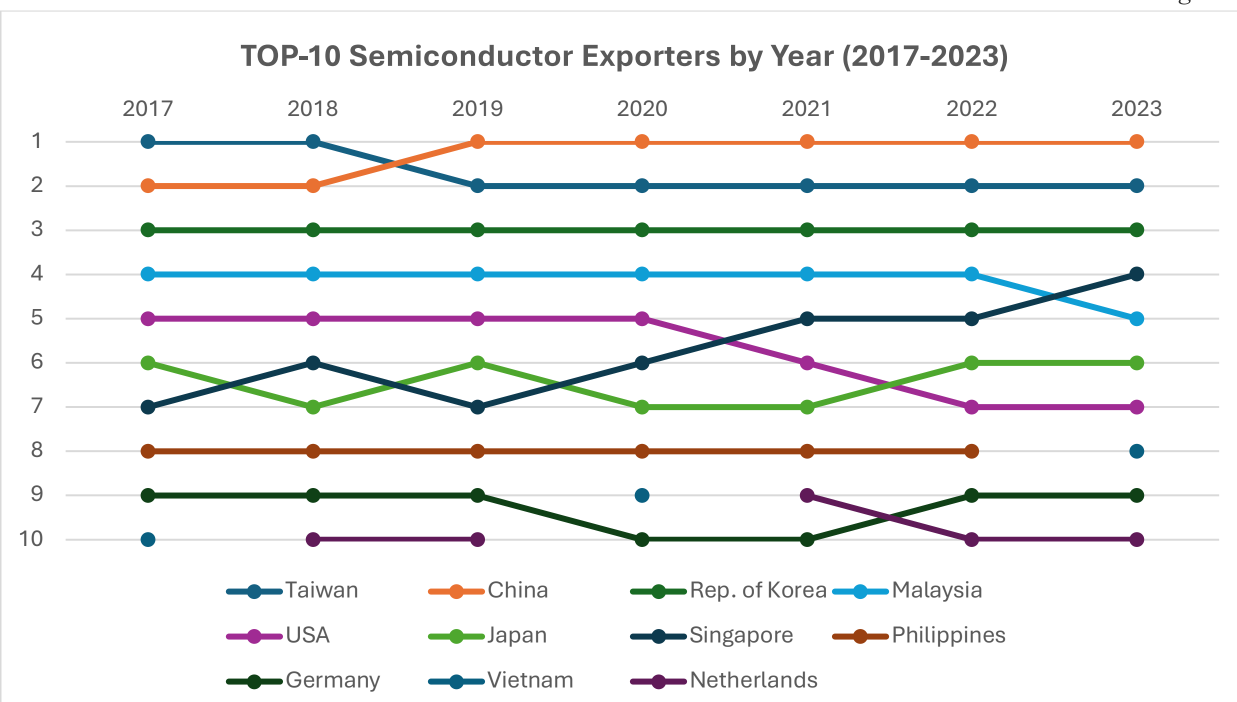

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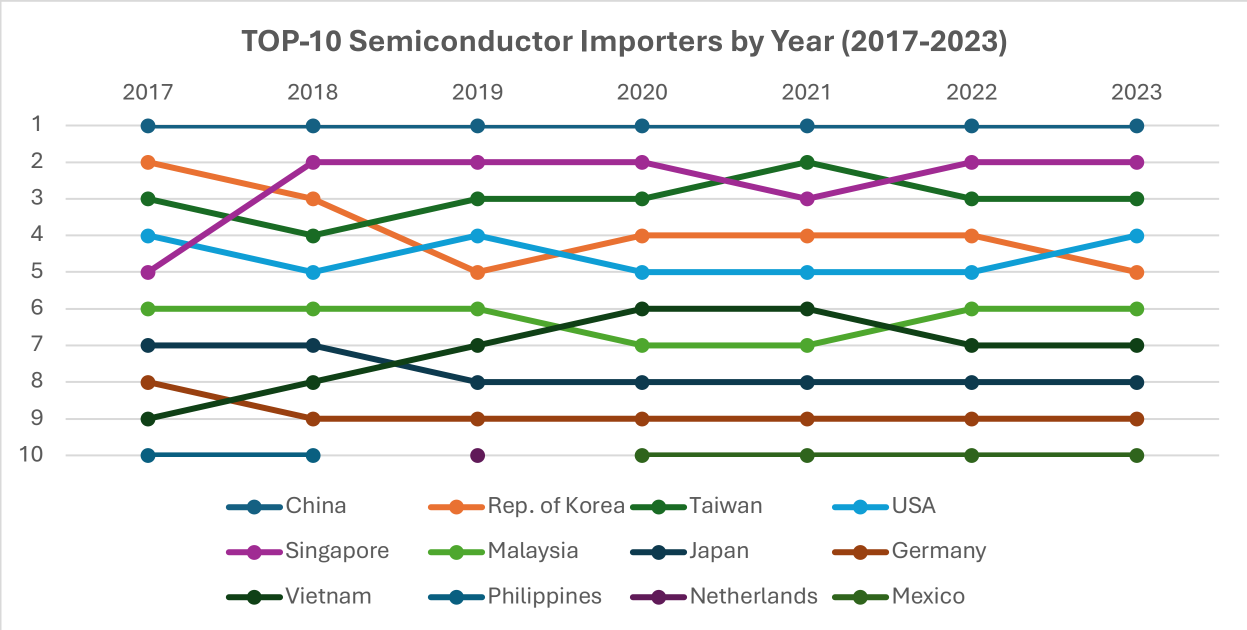
Figure 7



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The ranking of the top 10 semiconductor importers is not as revealing as the ranking of the top 10 exporters due to the high diversification of the global chip manufacturing industry. However, the analysis can reveal new links in the supply chain, as well as countries that are trying to increase their chip manufacturing capacity, for example, by purchasing related manufacturing equipment. Four countries — Singapore, South Korea, Vietnam, and Mexico — experienced significant shifts in their rankings, each moving roughly two to three places or entering and gaining a foothold in the top 10. By the end of 2023, Singapore and South Korea had effectively swapped places, moving from 5th to 2nd and from 2nd to 5th place, respectively. Vietnam moved up from 9th to 7th place. Mexico entered the top 10 semiconductor importers in 2020 and maintained its position.

As of the end of 2023, Singapore stands out as a clear beneficiary of the chip race. The country has significantly improved its position among both the top 10 exporters and top 10 importers, especially over the past two years. Since 2017, Singapore has increased the value of chip exports by 63% and doubled the value of its chip imports (see Figure 8). A country- and product-level analysis shows that all key countries except Taiwan have modestly increased their imports from Singapore[7], with notable shipments of chip manufacturing equipment to South Korea and China in 2022. At the same time, Singapore has increased its imports of integrated circuits and diodes, primarily from South Korea, followed by Taiwan (Appendix 2, Sub-Section 5.3).

[7] To be precise, the country-by-country analysis shows a decline in chip exports from Singapore to Hong Kong, China, over the past two years. It is unclear how to interpret this fact. It may be a result of tightened export control procedures.

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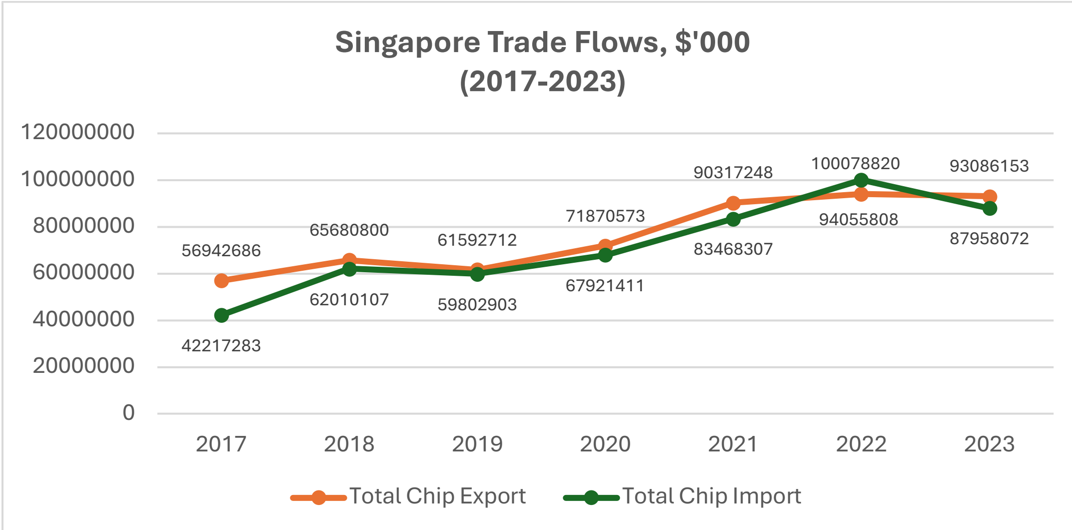
Figure 8



Source: Constructed by the author based on CEPII. "BACI."
Accessed April 15, 2025. https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37

It is unlikely that Singapore will be able to rapidly expand both its total chip exports and imports to enter the number of five key countries. This sharp increase is likely due to the country's growing role as a stable and reliable supply chain hub and intermediary.

To sum up, as previously noted, the chip race has not yet significantly changed the overall balance of power among the five major chip-producing countries. However, it is worth noting that both technological rivals—the US and China—have experienced modest setbacks. At the same time, the chip race has reshaped trade flows in ways that have clearly benefited Singapore.

5.4. Has the chip race not only impacted countries already within the semiconductor ecosystem but also created conditions for the emergence of new players in the market?

An analysis of the top 10 semiconductor exporters and importers reveals the emergence of new players, most notably Vietnam among exporters and Mexico among importers. As previously noted, Vietnam, which ranked 10th in 2017, rose to 9th place in 2020 and reached 8th place by 2023 (see Figure 6), increasing the total value of its chip exports by 121% compared to 2017. Notably, the United States and China (including Hong Kong) are the primary destinations for Vietnamese chip products (See Appendix 2, Sub-Section 5.4). The U.S. accounts for 60–70% of Vietnam's diode and transistor exports (product group 8541), while China (including Hong Kong) imports a similar share of its integrated circuits (product group 8542).

Of particular interest is the rapid growth in U.S. chip imports from Vietnam—from 20% to nearly 80%—within just two years, between 2018 and 2020. This sharp increase likely reflects Vietnam's deeper integration into global semiconductor supply chains and may suggest that both the U.S. and China have established some level of chip manufacturing or end-stage processing, such as testing and packaging, in the country.

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Mexico entered the ranks of the top 10 semiconductor importers in 2020 (see Figure 7), rapidly increasing the value of its total chip imports by 27% in 2021—likely due to pandemic-related disruptions—and has continued to grow, though at a slower pace. Compared to 2020, Mexico's total chip imports rose by 54%. A country-level breakdown shows that the United States remains Mexico's primary supplier, accounting for over 50% of imports, although this share is significantly declining as South Korea's share grows a little. By product-group-level analysis, Mexico's chip imports primarily consist of memory chips, diodes, and integrated circuits (ICs). Mexico's role in global chip trade is likely to be largely shaped by its integration into the supply chains of U.S. and South Korean multinational corporations.

To sum up the sub-section, Vietnam and Mexico appear to be new entrants to the semiconductor ecosystem. However, while Vietnam, which is increasing its overall chip exports, can be considered a new and growing player in the global chip industry, Mexico is more accurately viewed as a link in the supply chain, benefiting from its preferential trade agreements with the United States.

6. Conclusions and Discussion

The research findings support both hypotheses, though with several caveats and clarifications. Regarding the first hypothesis, it can be concluded that the pandemic-related disruptions of 2020–2021 and, more notably, the U.S. export control restrictions against China in 2022 have led to visible changes in chip exports and imports among the five key countries. Bilateral chip trade between the U.S. and China has experienced modest setbacks, particularly in U.S. exports to China. Nevertheless, the overall picture remains unchanged: China has held its position as the world's largest chip exporter and importer (in terms of value) for at least the past five years. Notably, over the past two years, China appears to have offset some of the losses by redirecting its chip trade flows to alternative partners, especially Vietnam and India.

Considering potential spillover effects and a broader range of players in the semiconductor ecosystem—the focus of the second hypothesis—the data as of the end of 2023 points to Singapore as a clear beneficiary of the ongoing chip race. Once considered part of the "second league" in terms of chip-making capacity and value of chip trade flows, Singapore has leveraged its geographic proximity to major chip producers and its reputation as a reliable, low-risk partner to expand both chip exports and imports rapidly. It has now emerged as a significant player in global chip supply chains. Vietnam should also be recognized as an emerging player in the global chip market. Unlike Mexico, which appears to serve primarily as a supply chain link for American and South Korean corporations, Vietnam's emergence and constant presence in the top 10 chip exporters is evidence of its significant chip-making capacity.

From the author's perspective, these observations and conclusions drawn from the numerical analysis of multilateral trade flows in the semiconductor industry are of critical importance for three reasons. First, they provide valuable insight into the ongoing transformations within the semiconductor ecosystem, driven by government policies, market incentives, and the strategic responses of key global players. Second, they offer a reliable empirical foundation that can either support or challenge theoretical assessments and projections. Finally, such numerical analysis of trade flows in the global chip industry can be considered a basis for future forecasts and balanced and informed policy decisions, including geopolitical ones.

In the context of the global economy and trade, almost any industry can be crucial for both international relations and domestic policy. However, the global chip industry stands apart: the stable and smooth functioning of this sector is essential for the prosperity of many strategic and high-tech industries around the world, making it a key factor in shaping both geopolitical developments and the global agenda.

This research has several important limitations, partly objective and partly due to the chosen methodological approach. First, the dataset constructed from UN Comtrade focuses exclusively on commodities, excluding services. This is a notable gap, as a significant share of revenue in the U.S. chip industry comes from services, particularly in chip design and intellectual property, which are not captured in trade flow data. Second, many conclusions are based on aggregated data across all semiconductor-related commodity groups. Consequently, the analysis does not fully account for national specializations within the semiconductor value chain, such as foundry services, assembly, chemical inputs, or equipment manufacturing. Third, as noted in the introduction, the semiconductor industry is highly capital-intensive and time-consuming. A single year of observation (2023)—especially one that immediately follows the introduction of U.S. export control restrictions—is insufficient to fully capture the resulting structural shifts or long-term impacts. Fourth, the quantitative analysis presented here would benefit from being complemented by broader industrial, statistical, and economic assessments to provide a more comprehensive understanding. Finally, as defined by the author, the chip race is a dynamic and competitive process that is being shaped by a constantly evolving scientific, political, and economic landscape. Therefore, ongoing monitoring and long-term analysis of global semiconductor trade flows will be essential for drawing deeper and more robust conclusions.

Acknowledgments

I am grateful to Dr. Byunghwan Son (George Mason University) for his constructive feedback, which greatly contributed to the development of this research and the refinement of the arguments presented in this paper.

Appendix 1

TOP 10 SEMICONDUCTOR EXPORTERS AND IMPORTERS

TOP 10 Semiconductor Exporters

Year	Country	Value (in thousands of USD)
2017	Taiwan	$ 121,813,506
	China	$ 117,284,962
	Rep. of Korea	$ 101,106,295
	Malaysia	$ 64,096,341
	USA	$ 63,827,208
	Japan	$ 58,523,694
	Singapore	$ 56,942,686
	Philippines	$ 24,693,905
	Germany	$ 24,452,472
	Vietnam	$ 18,863,855
2018	Taiwan	$ 133,545,438
	China	$ 132,984,022
	Rep. of Korea	$ 129,254,059
	Malaysia	$ 79,929,811
	USA	$ 66,275,187
	Singapore	$ 65,680,800
	Japan	$ 63,790,082
	Philippines	$ 32,079,483
	Germany	$ 25,725,333
	Netherlands	$ 18,956,785
2019	China	$ 153,862,919
	Taiwan	$ 134,800,008
	Rep. of Korea	$ 100,134,296
	Malaysia	$ 74,528,788
	USA	$ 65,617,168
	Japan	$ 62,487,436
	Singapore	$ 61,592,712
	Philippines	$ 27,140,041
	Germany	$ 24,088,344
	Netherlands	$ 20,224,287
2020	China	$ 165,425,846
	Taiwan	$ 161,243,828
	Rep. of Korea	$ 107,727,401
	Malaysia	$ 78,486,210
	USA	$ 72,133,764
	Singapore	$ 71,870,573
	Japan	$ 66,536,123

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	Philippines	$	26,130,988
	Vietnam	$	25,900,550
	Germany	$	21,666,269
2021	China	$	222,094,974
	Taiwan	$	202,656,844
	Rep. of Korea	$	143,706,795
	Malaysia	$	94,100,822
	Singapore	$	90,317,248
	USA	$	84,175,881
	Japan	$	83,484,308
	Philippines	$	29,937,300
	Netherlands	$	28,764,057
	Germany	$	28,092,843
2022	China	$	252,160,981
	Taiwan	$	232,661,986
	Rep. of Korea	$	148,204,159
	Malaysia	$	102,199,130
	Singapore	$	94,055,808
	Japan	$	86,287,259
	USA	$	83,399,627
	Philippines	$	38,309,716
	Germany	$	32,876,628
	Netherlands	$	27,759,440
2023	China	$	236,951,399
	Taiwan	$	198,092,879
	Rep. of Korea	$	148,227,443
	Singapore	$	93,086,153
	Malaysia	$	93,060,763
	Japan	$	73,574,299
	USA	$	67,212,314
	Vietnam	$	41,778,362
	Germany	$	35,270,202
	Netherlands	$	30,134,034

Table 1. TOP 10 Semiconductor Exporters by Year (2017-2023).

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Taiwan	1	1	2	2	2	2	2
China	2	2	1	1	1	1	1
Rep. of Korea	3	3	3	3	3	3	3
Malaysia	4	4	4	4	4	4	5
USA	5	5	5	5	6	7	7
Japan	6	7	6	7	7	6	6

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Singapore	7	6	7	6	5	5	4
Philippines	8	8	8	8	8	8	-
Germany	9	9	9	10	10	9	9
Vietnam	10	-	-	9	-	-	8
Netherlands	-	10	10	-	9	10	10

Table 2. Ranking of TOP 10 Semiconductor Exporters by Year (2017-2023).

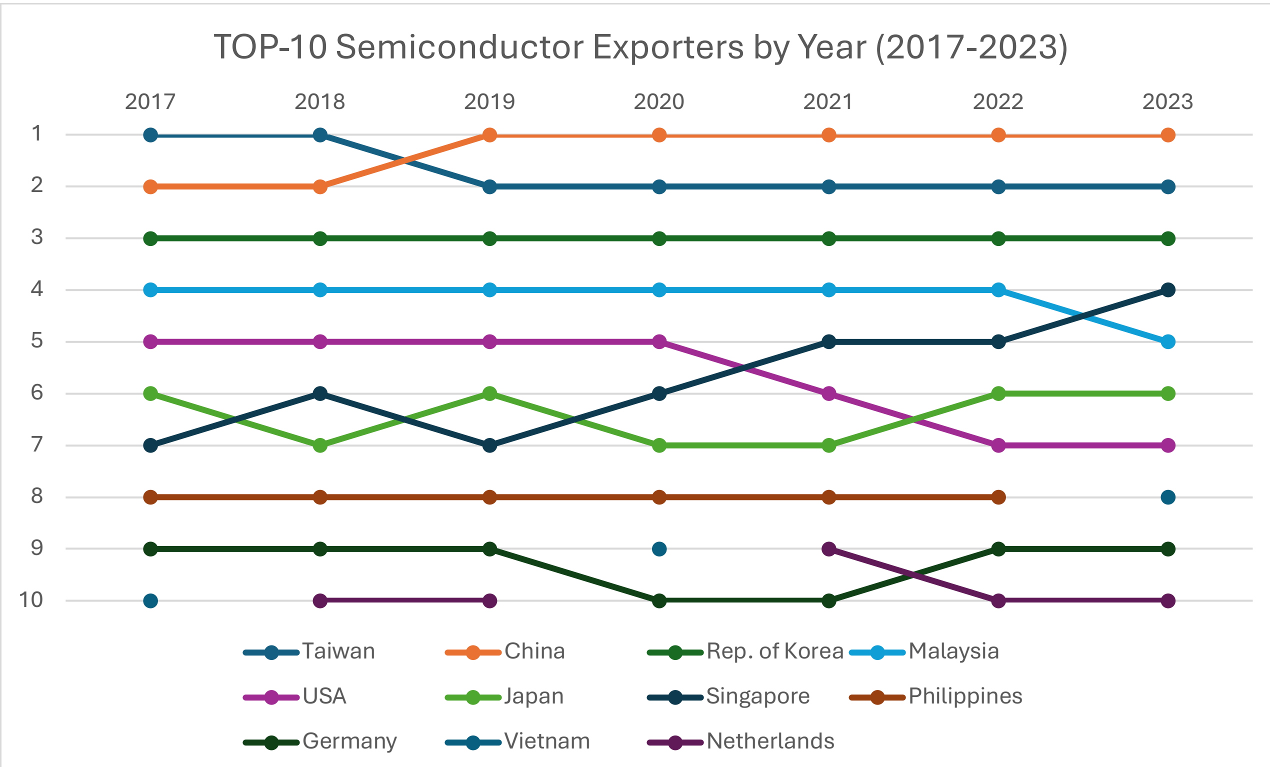

Figure 1. TOP 10 Semiconductor Exporters by Year (2017-2023).

TOP 10 Semiconductor Importers

Year	Country	Value (in thousands of USD)
2017	China	$ 305,559,031
	Rep. of Korea	$ 53,315,854
	Taiwan	$ 49,770,502
	USA	$ 49,089,488
	Singapore	$ 42,217,283
	Malaysia	$ 30,367,623
	Japan	$ 27,204,130
	Germany	$ 25,160,446
	Vietnam	$ 20,022,160

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	Philippines	$	13,571,834
2018	China	$	347,395,784
	Singapore	$	62,010,107
	Rep. of Korea	$	54,456,495
	Taiwan	$	52,930,899
	USA	$	50,780,742
	Malaysia	$	36,307,984
	Japan	$	29,244,084
	Vietnam	$	25,531,245
	Germany	$	25,362,958
	Philippines	$	17,062,201
2019	China	$	327,589,409
	Singapore	$	59,802,903
	Taiwan	$	58,665,206
	USA	$	57,650,115
	Rep. of Korea	$	49,218,262
	Malaysia	$	32,379,078
	Vietnam	$	31,763,842
	Japan	$	26,788,891
	Germany	$	23,888,081
	Netherlands	$	17,047,416
2020	China	$	372,572,815
	Singapore	$	67,921,411
	Taiwan	$	66,504,787
	Rep. of Korea	$	59,499,516
	USA	$	58,209,596
	Vietnam	$	40,141,608
	Malaysia	$	33,000,153
	Japan	$	28,103,950
	Germany	$	20,855,920
	Mexico	$	18,511,947
2021	China	$	462,201,625
	Taiwan	$	88,755,632
	Singapore	$	83,468,307
	Rep. of Korea	$	76,354,881
	USA	$	68,559,255
	Vietnam	$	45,965,185
	Malaysia	$	44,520,466
	Japan	$	33,920,869
	Germany	$	26,614,530
	Mexico	$	23,564,354
2022	China	$	453,630,810
	Singapore	$	100,078,820

	Taiwan	$	99,860,684
	Rep. of Korea	$	84,489,422
	USA	$	80,127,313
	Malaysia	$	53,339,723
	Vietnam	$	51,571,421
	Japan	$	44,849,453
	Germany	$	34,981,345
	Mexico	$	27,281,983
2023	China	$	435,070,838
	Singapore	$	87,958,072
	Taiwan	$	81,478,573
	USA	$	74,639,820
	Rep. of Korea	$	72,149,561
	Malaysia	$	45,890,864
	Vietnam	$	40,691,711
	Japan	$	38,331,315
	Germany	$	36,145,087
	Mexico	$	28,595,450

Table 3. TOP 10 Semiconductor Importers by Year (2017-2023).

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
China	1	1	1	1	1	1	1
Rep. of Korea	2	3	5	4	4	4	5
Taiwan	3	4	3	3	2	3	3
USA	4	5	4	5	5	5	4
Singapore	5	2	2	2	3	2	2
Malaysia	6	6	6	7	7	6	6
Japan	7	7	8	8	8	8	8
Germany	8	9	9	9	9	9	9
Vietnam	9	8	7	6	6	7	7
Philippines	10	10	-	-	-	-	-
Netherlands	-	-	10	-	-	-	-
Mexico	-	-	-	10	10	10	10

Table 4. Ranking of TOP 10 Semiconductor Importers by Year (2017-2023).

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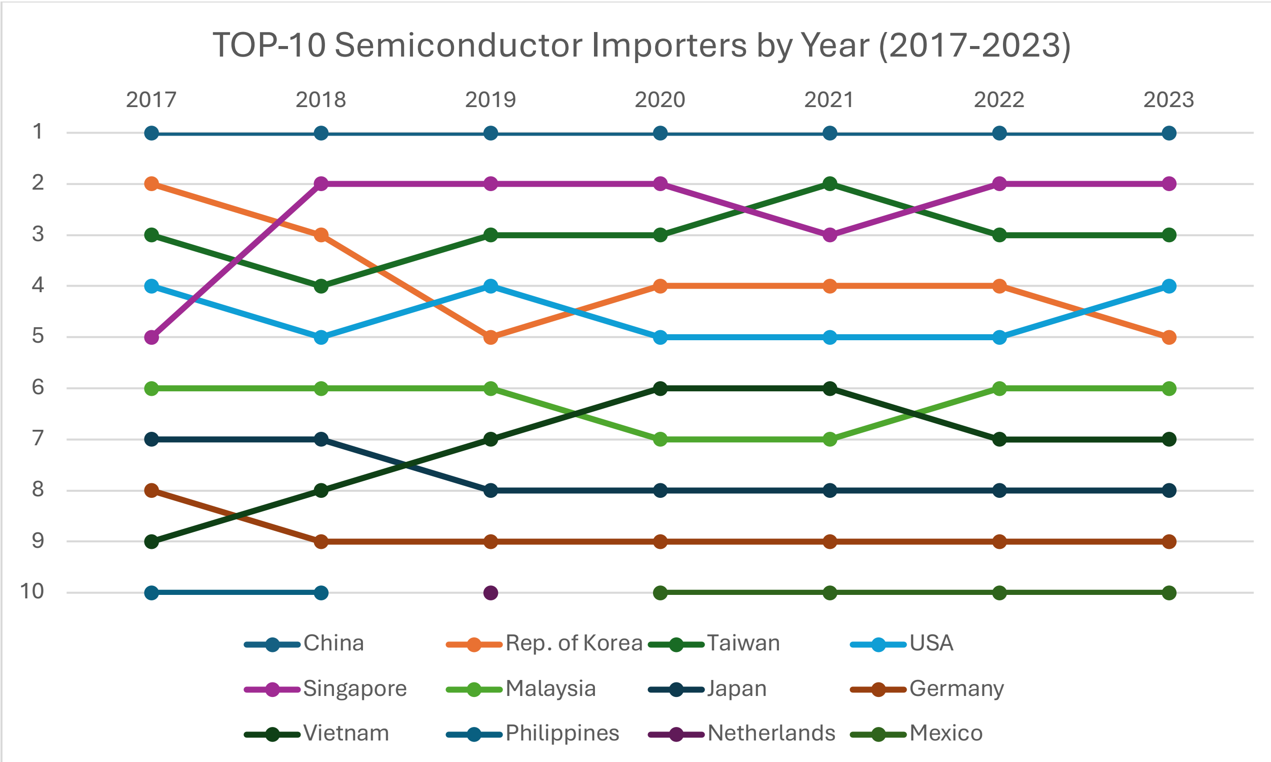


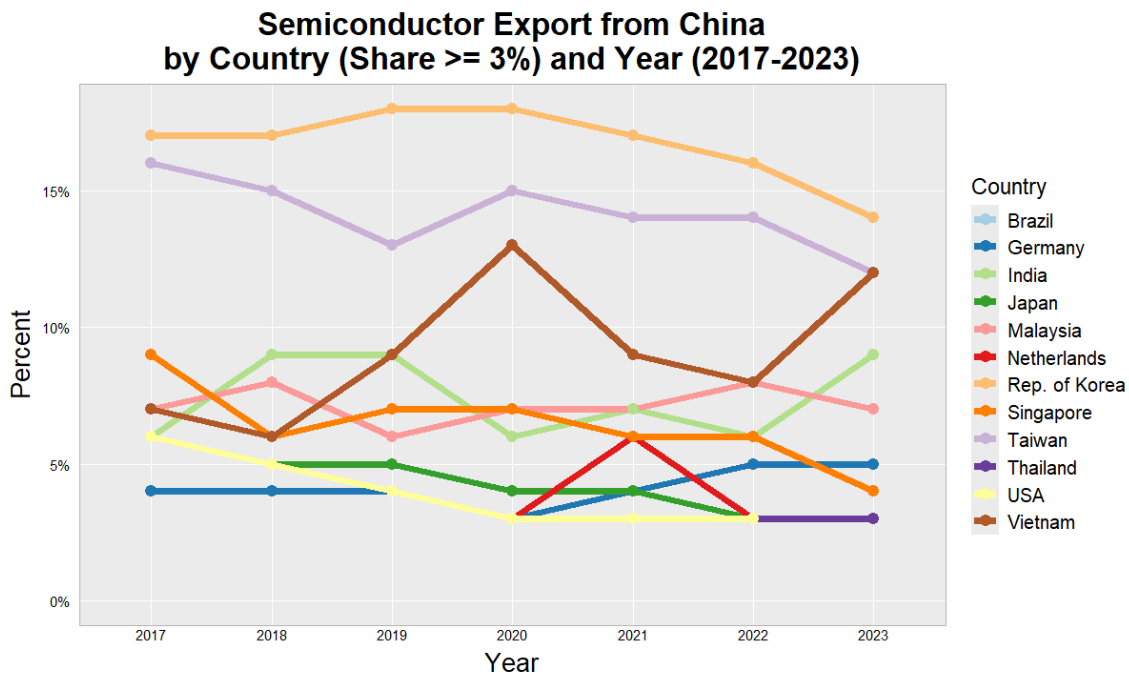
Figure 2. TOP 10 Semiconductor Importers by Year (2017-2023).

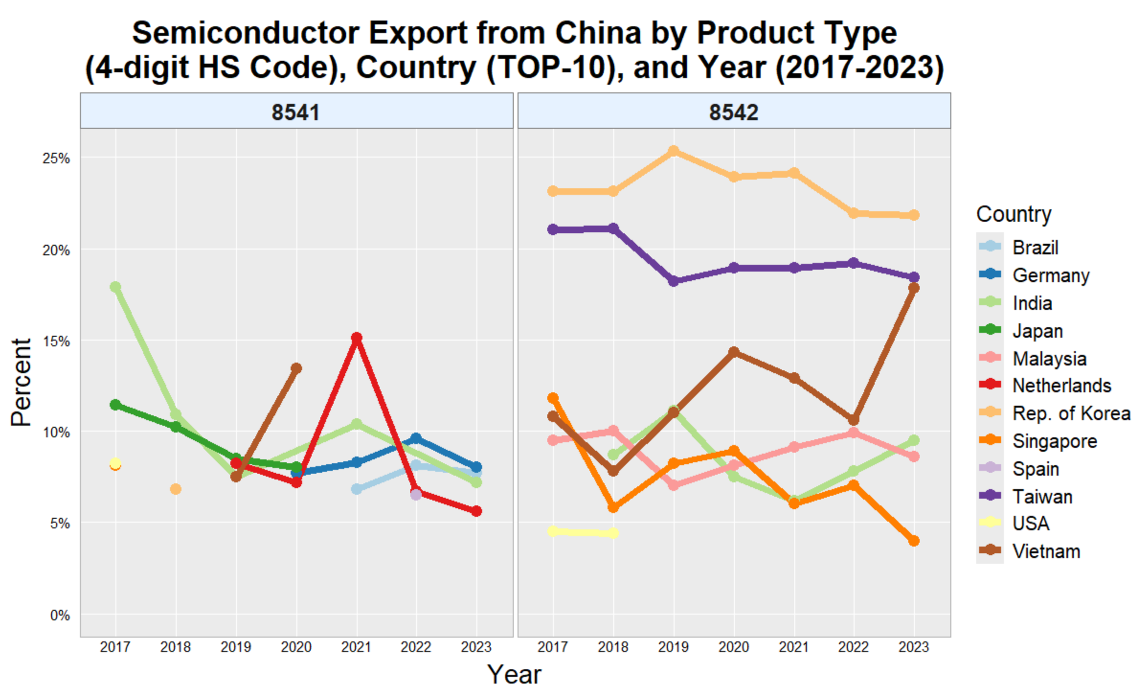
Appendix 2

SEMICONDUCTOR EXPORTS AND IMPORTS FOR SELECTED COUNTRIES

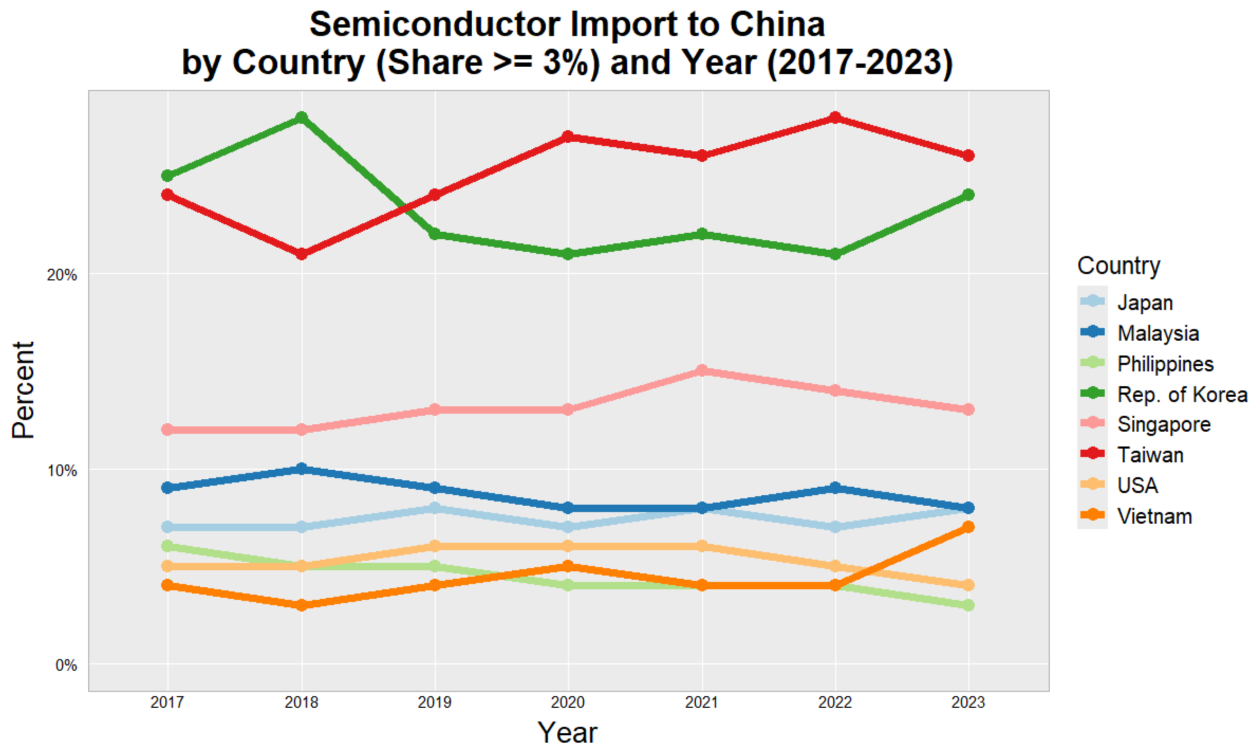
Sub-Section 5.2

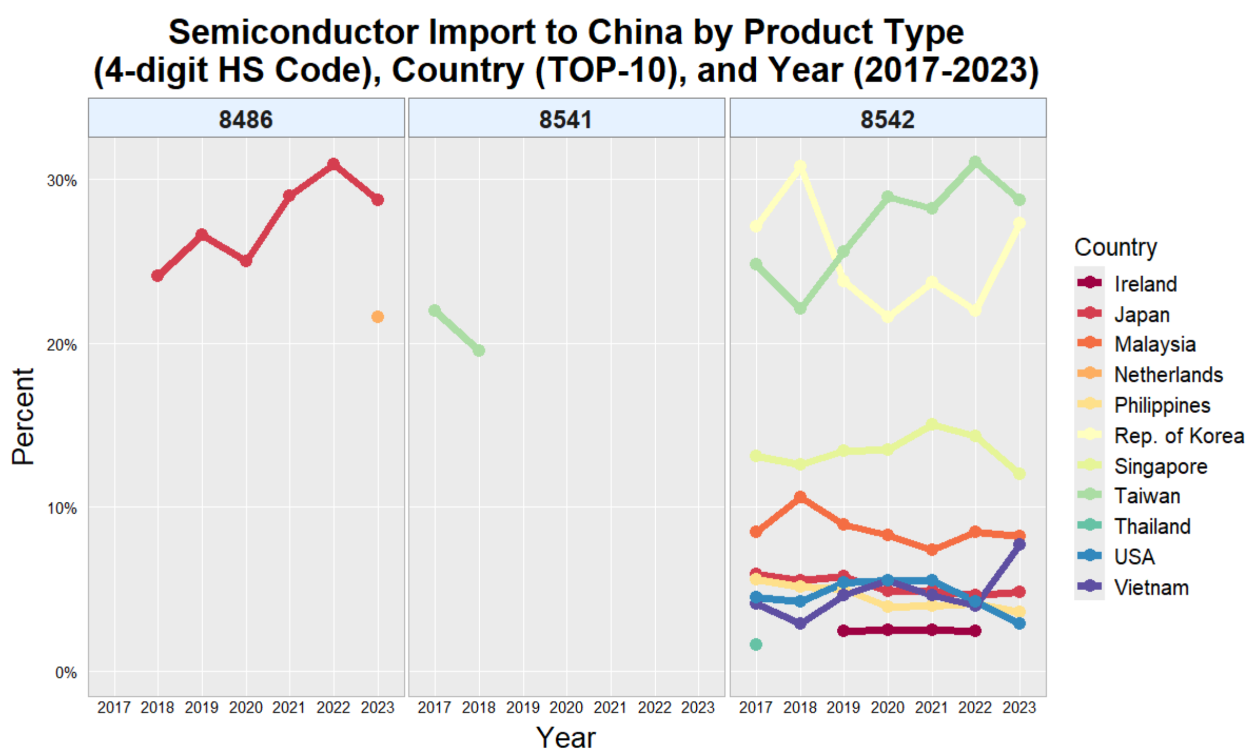
China Export





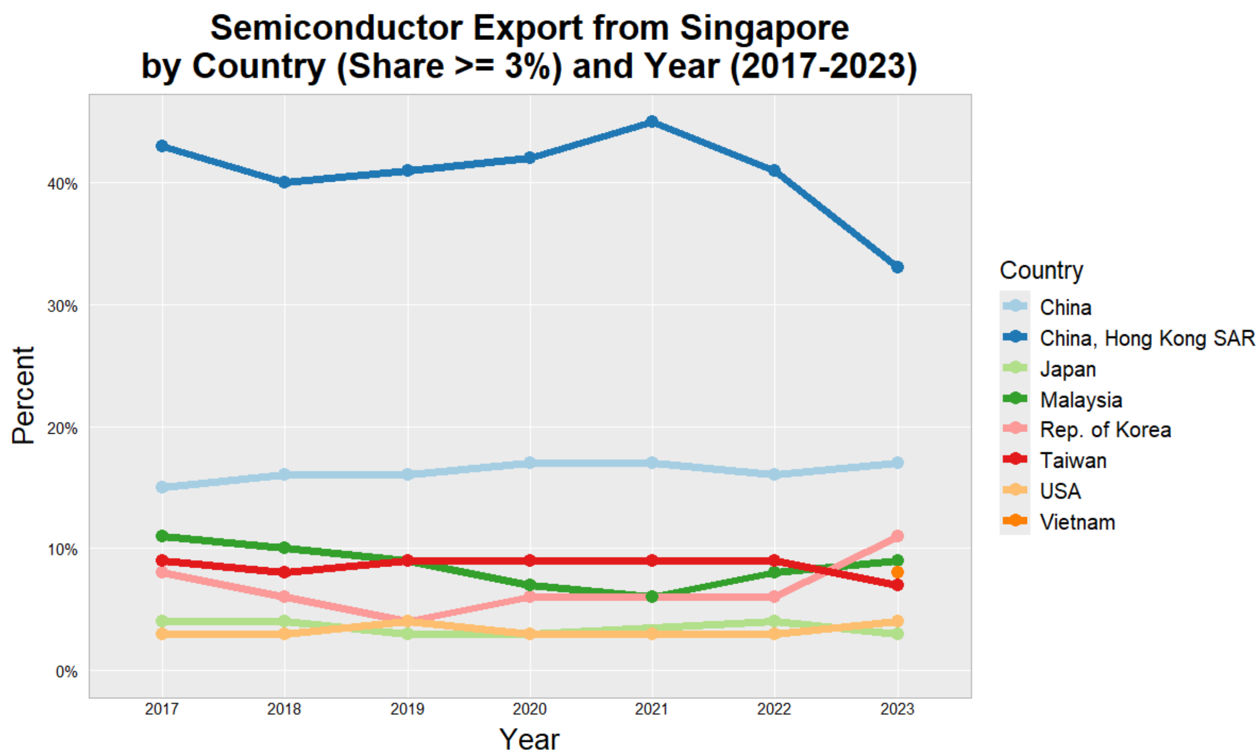
China Import

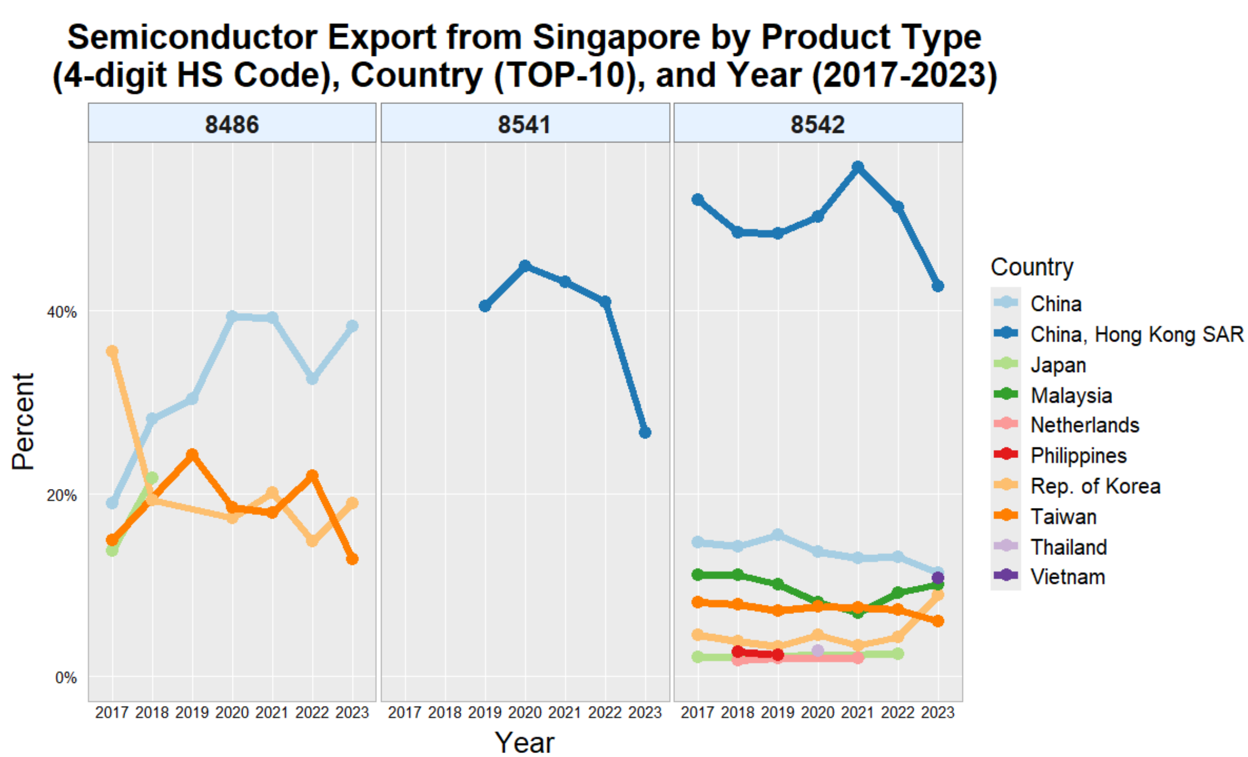




Sub-Section 5.3

<u>Singapore Export</u>





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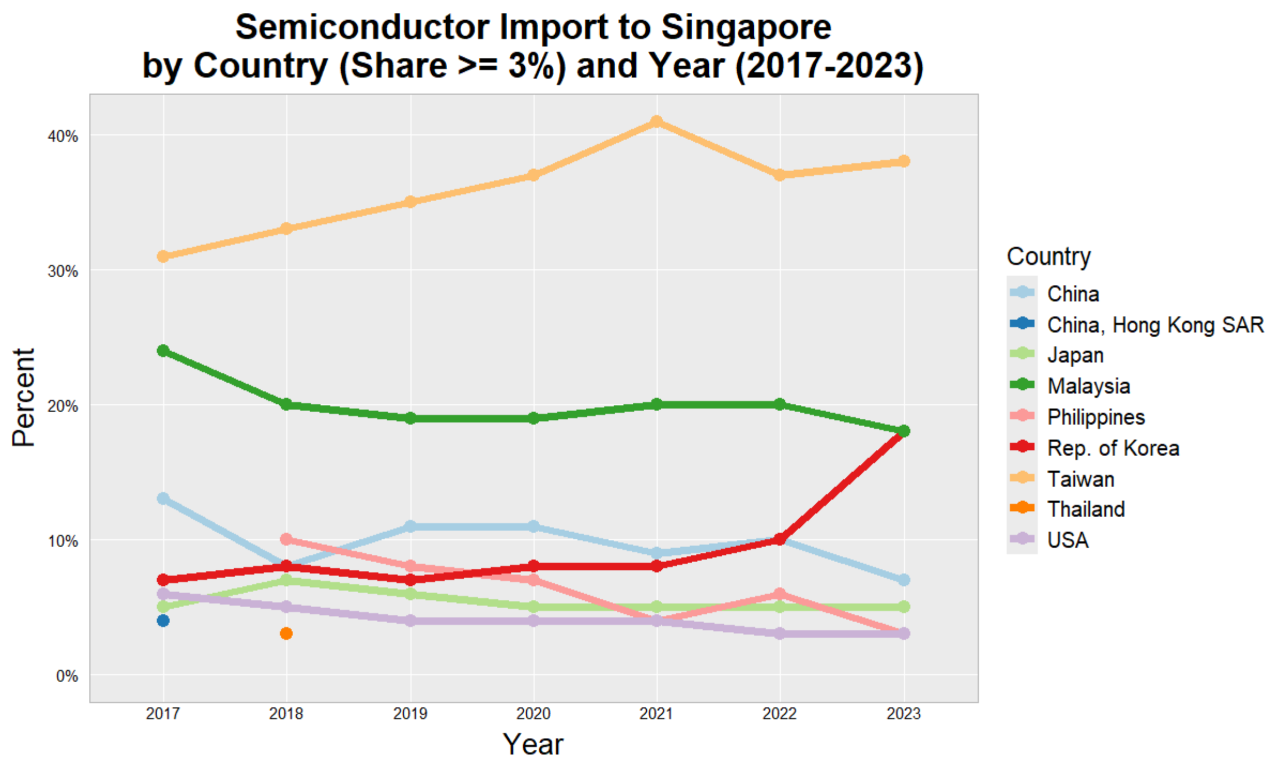
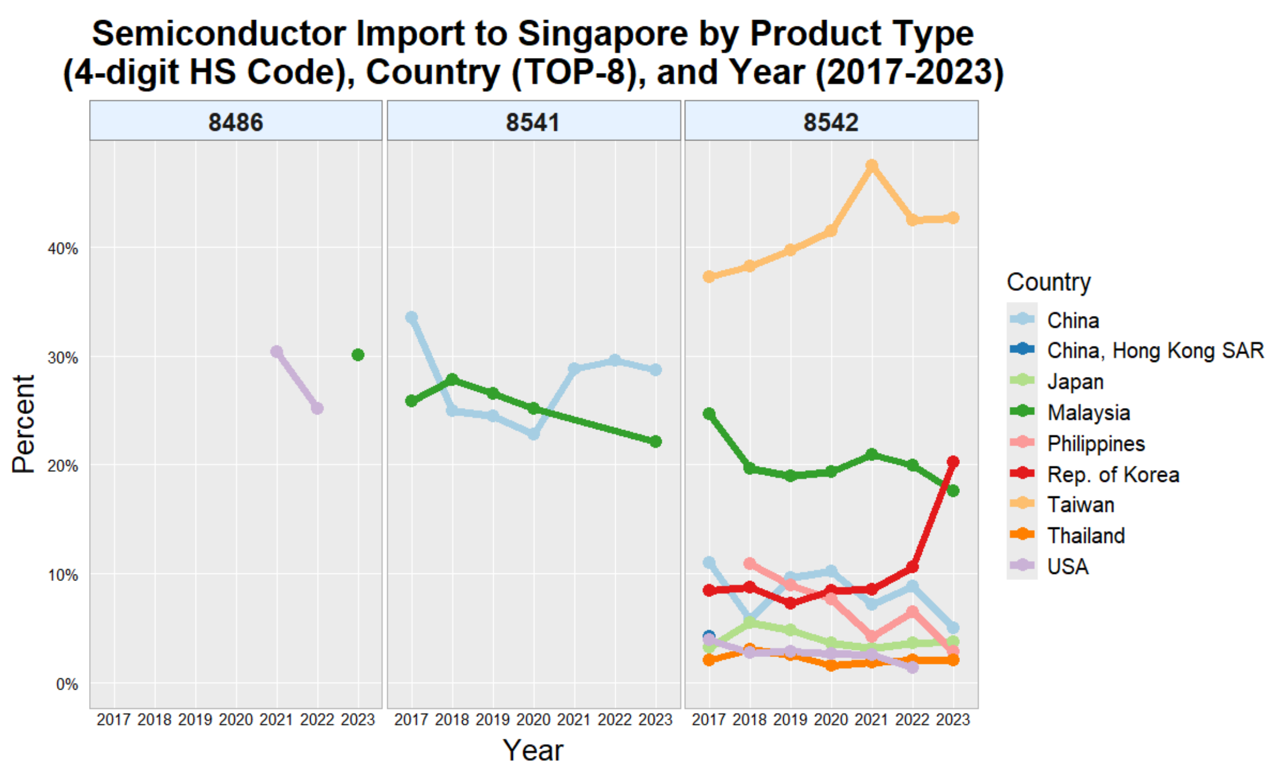
Singapore Import





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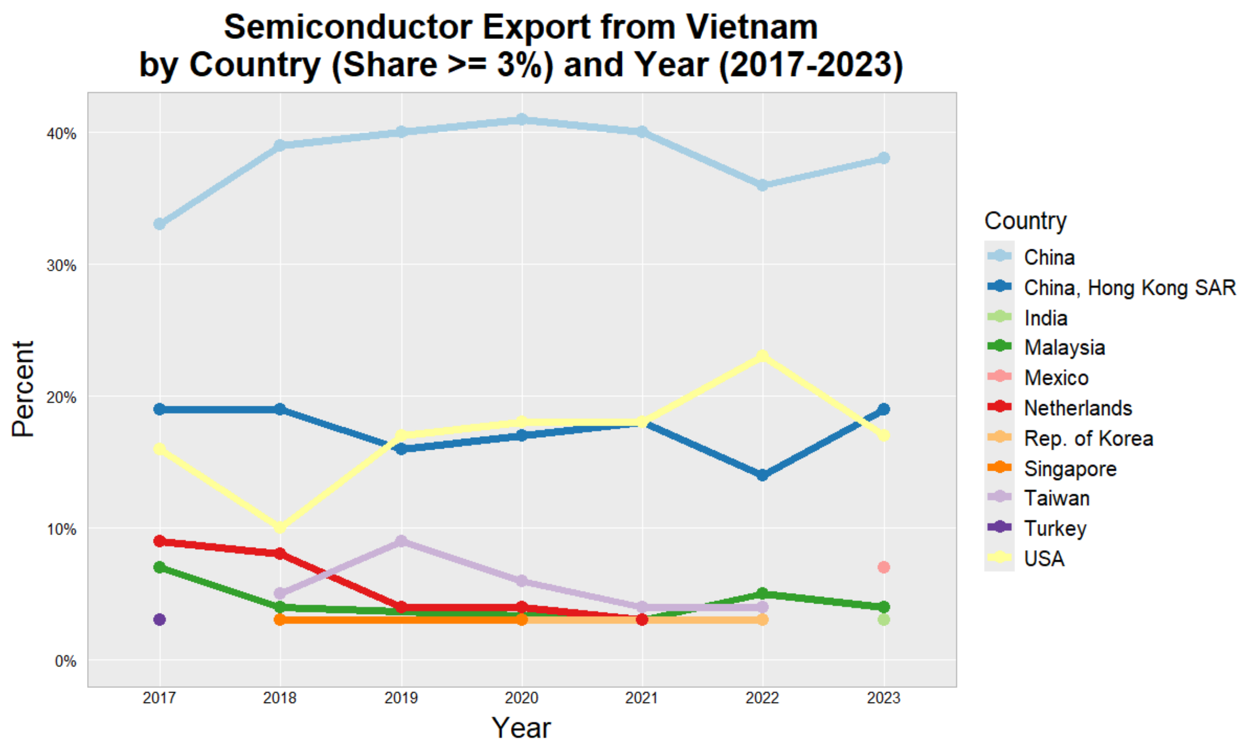
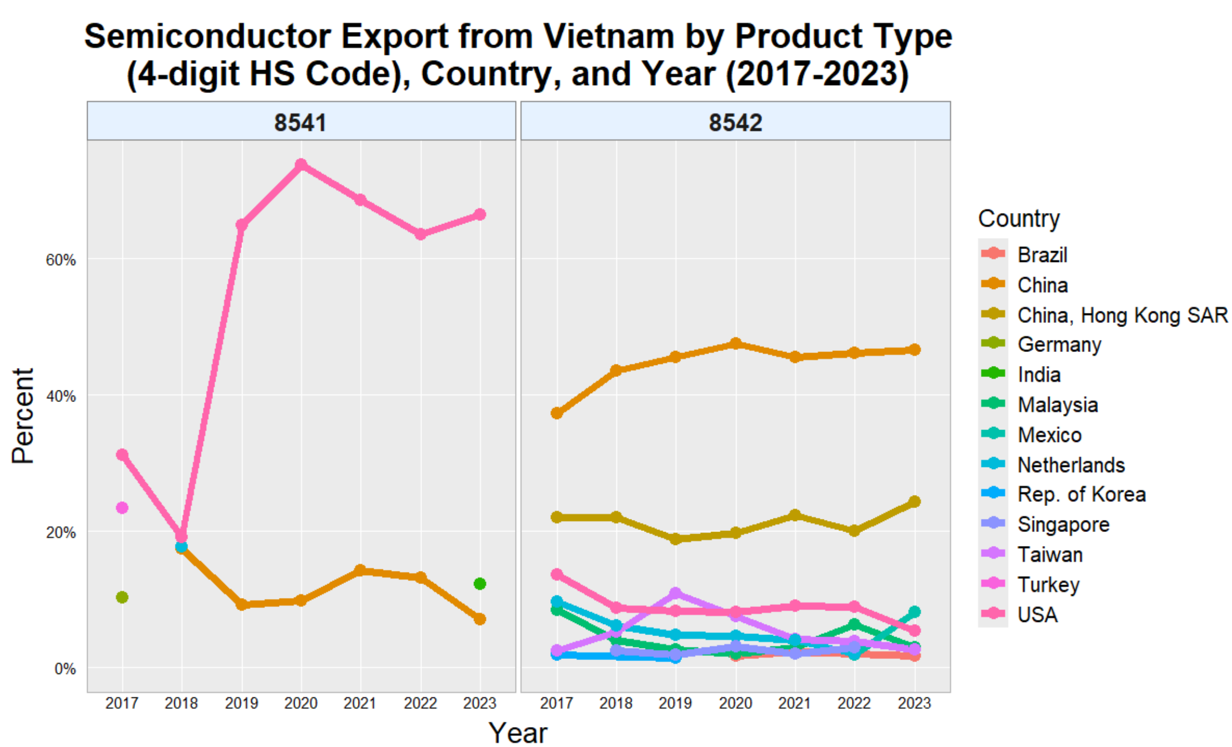
Sub-section 5.4

Vietnam Export





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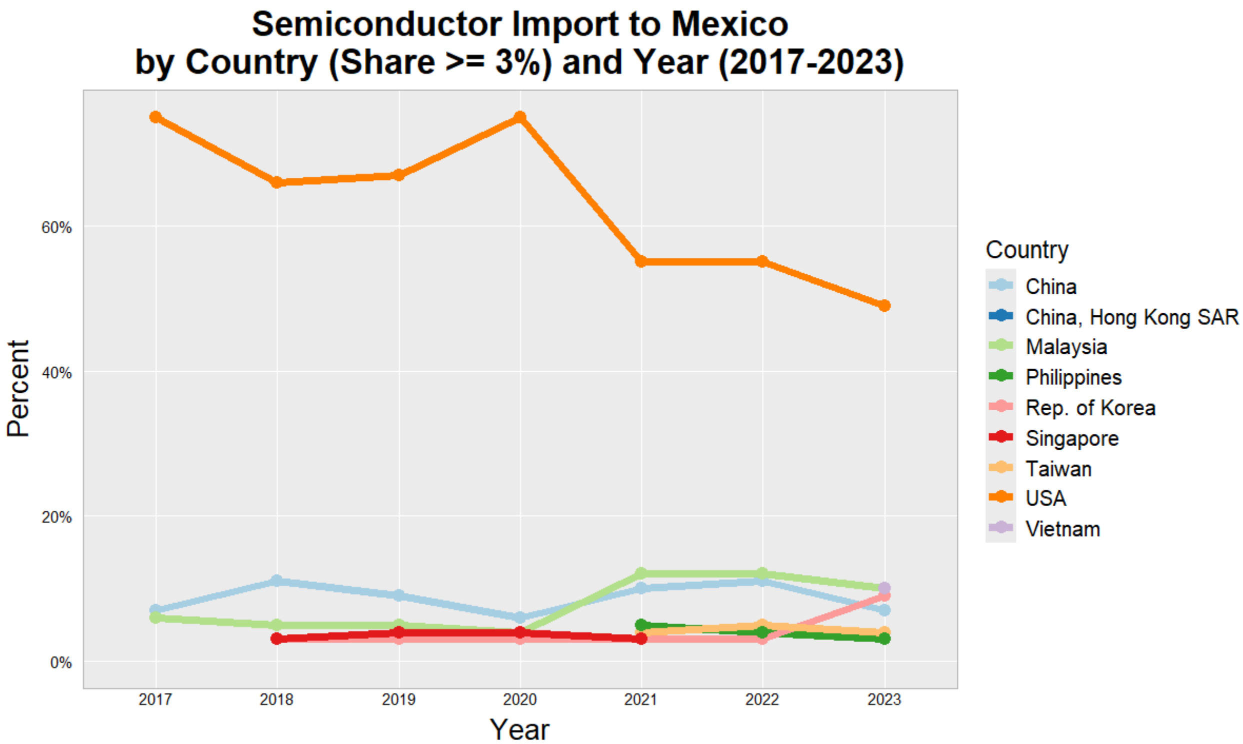
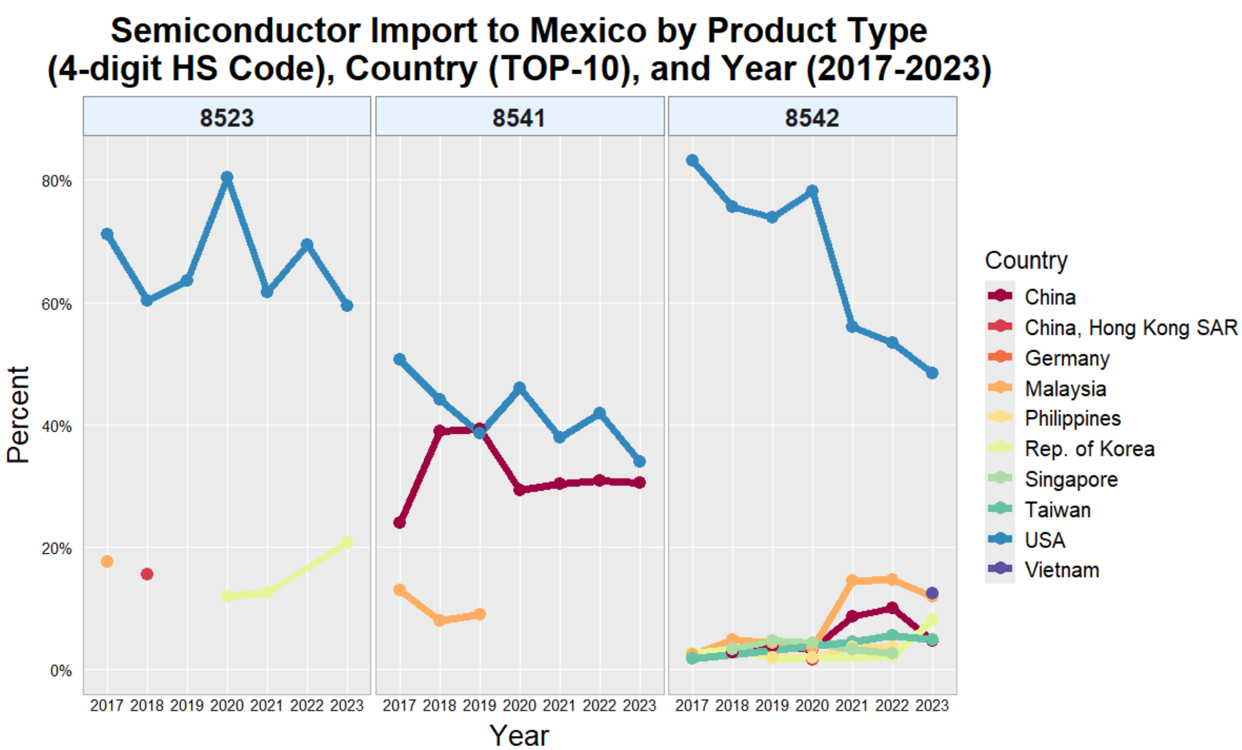
Mexico Import





Appendix 3

HARMONIZED SYSTEM (HS) PRODUCT CODES FOR SEMICONDUCTOR-RELATED COMMODITIES

4-digit Code	6-digit Code	Commodity Description	Examples
3818	**Chemical elements doped for use in electronics, in the form of discs, wafers or similar forms; chemical compounds doped for use in electronics**		
	381800	Chemical elements: doped for use in electronics, in the form of discs, wafers or similar forms: chemical compounds doped for use in electronics	Chemical compounds, chemical elements, discs, doped chemical elements, doped selenium, doped unmounted piezo-electrical crystals, silicon crystal wafer, silicon optical wafer, wafers
8486	**Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers, semi-conductor devices, electronic integrated circuits or flat panel displays; machines and apparatus specified in note 11 (C) to this chapter; parts and accessories**		
	848610	Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers	Boules manufacture apparatus, boules manufacture machines, centrifugal spin dryers, wafer manufacture apparatus, wafer manufacture machines
	848620	Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor devices or of electronic integrated circuits	Deflash machines, dielectric loss electric furnaces, direct write-on-wafer apparatus, electric induction furnaces, electric resistance-heated furnaces, electronic integrated circuit manufacturing equipment, epitaxial deposition machines, ion implanters for doping semiconductor materials, lithography machines for wafers, machines for doping semiconductor chips, machine tools for dry-etching patterns, optical projectors for integrated circuit patterning, repeat aligners, semiconductor device manufacturing equipment, spraying appliances for cleaning semiconductors, spraying appliances for etching semiconductors, spraying appliances for stripping semiconductors, step aligners,

			ultrasonic cutting machines, ultrasonic drills
	848640	Machines and apparatus of a kind used solely or principally for the manufacture or repair of masks and reticles, assembling semiconductor devices or electronic integrated circuits, or for lifting, handling, loading or unloading items of heading 8486	Compression moulds for semiconductor devices, focused ion beam milling machines, injection moulds for semiconductor devices, mask manufacturing equipment, reticle manufacturing equipment
8523	**Discs, tapes, solid-state non-volatile storage devices, "smart cards" and other media for the recording of sound or of other phenomena, whether or not recorded, including matrices and masters for the production of discs, but excluding products of Chapter 37**		
	852351	Semiconductor media: solid-state non-volatile storage devices, whether or not recorded, excluding products of Chapter 37	Semiconductor media, solid state non-volatile storage devices, thumb drive
	852352	Semiconductor media: smart cards, whether or not recorded, excluding products of Chapter 37	Semiconductor media, smart card modules, smart cards
	852359	Semiconductor media: other than smart cards, whether or not recorded, excluding products of Chapter 37	Proximity cards, proximity tags, semiconductor media
8541	**Semiconductor devices (for example, diodes, transistors, semiconductor-based transducers); photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (LED), whether or not assembled with other light-emitting diodes (LED); mounted piezo electric crystals; parts thereof**		
	854110	Electrical apparatus: diodes, other than photosensitive or light-emitting diodes (LED)	Diodes, crystal diodes, liquid crystal diodes (LCDs), Zener diodes
	854121	Electrical apparatus: transistors, (other than photosensitive), with a dissipation rate of less than 1W	Transistors
	854129	Electrical apparatus: transistors, (other than photosensitive), with a dissipation rate of 1W or more	Transistors

	854130	Electrical apparatus: thyristors, diacs and triacs, other than photosensitive devices	DIACs, TRIACs, thyristors, unmounted chips, unmounted dice, unmounted wafers
	854140	Electrical apparatus: photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes (LED)	Diodes, light-emitting diodes (LEDs), LED tubes, laser lights, optical coupled isolators, photosensitive semiconductor devices, photosensitive transistors, solar cells, solar modules, solar panels, unmounted chips, unmounted dice, unmounted wafers
	854150	Electrical apparatus: photosensitive semiconductor devices n.e.c. in heading no. 8541, including photovoltaic cells, whether or not assembled in modules or made up into panels	Ceramic filters for semiconductor use, resonators, semiconductor devices
	854190	Electrical apparatus: parts for diodes, transistors and similar semiconductor devices and photosensitive semiconductor devices	Diode parts, photosensitive semiconductor device parts, semiconductor device parts, transistor parts
8542	**Electronic integrated circuits; parts thereof**		
	854231	Electronic integrated circuits: processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	Controllers, IC processors, processors
	854232	Electronic integrated circuits: memories	IC memories, memories
	854233	Electronic integrated circuits: amplifiers	Amplifiers, IC amplifiers, unmounted chips
	854239	Electronic integrated circuits: n.e.c. in heading no. 8542	Electronic integrated circuits, hybrid integrated circuits, monolithic integrated circuits
	854290	Parts of electronic integrated circuits	Cans for integrated circuits, dice for integrated circuits, electronic integrated circuit parts, electronic integrated microassembly parts, headers for integrated circuits, lead frames for integrated circuits
9030	**Oscilloscopes, spectrum analyzers and other instruments and apparatus for measuring or checking electrical quantities, excluding meters of heading 9028; instruments and apparatus for measuring or detecting alpha, beta, gamma, X-ray, cosmic or other ionizing radiations; parts and accessories thereof**		

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	903082	Instruments and apparatus: for measuring or checking semiconductor wafers or devices	Catalyst test systems, checking instruments for semiconductors, electrical quantity checking instruments, electrical quantity measuring instruments, in-circuit tester, Teradyne Catalyst test systems, waveguides
9031	**Measuring or checking instruments, appliances and machines, n.e.c. or included in this chapter; profile projectors; parts and accessories thereof**		
	903141	Optical instruments and appliances: for inspecting semiconductor wafers or devices or for inspecting photomasks or reticles used in manufacturing semiconductor devices, n.e.c. in chapter 90	Optical checking appliances, optical checking instruments, optical measuring appliances, optical measuring instruments, PCB inspection machines

Sources:

TradeAtlas. "HS Code Categories." Accessed May 4, 2025. https://www.tradeatlas.com/en/hs-code-categories.

United States Census Bureau. "Schedule B 2025 - Browse Chapters." Accessed May 4, 2025. https://www.census.gov/foreign-trade/schedules/b/2025/index.html.

References

Alam, Syed, Timothy Chu, Shrikant Lohokare, Shungo Saito, and McKinley Baker. "Globality and Complexity of the Semiconductor Ecosystem." *GSA*, 2020. https://www.gsaglobal.org/wp-content/uploads/2020/02/GSA-Accenture-Globality-and-Complexity-of-the-Semiconductor-Ecosystem.pdf

Alfaro, Laura, and Davin Chor. "Global Supply Chains: The Looming 'Great Reallocation'." Harvard Business School Working Paper, No. 24-012, August 2023. (in proceedings Jackson Hole Symposium, 2023 (also NBER WP 31661). See feature in NBER Digest, Nov (2023): Economics, Politics, and the Evolution of Global Supply Chains.) Accessed December 4, 2024. https://www.hbs.edu/ris/Publication Files/24-012_b2f8ef5c-dc1b-4897-b66e-0edea5a20942.pdf

Allen, Gregory C. "The True Impact of Allied Export Controls on the U.S. and Chinese Semiconductor Manufacturing Equipment Industries." *CSIS*, November 26, 2024. https://www.csis.org/analysis/true-impact-allied-export-controls-us-and-chinese-semiconductor-manufacturing-equipment

ASML. n.d. "The Basics of Microchips." Accessed April 10, 2024. https://www.asml.com/en/technology/all-about-microchips/microchip-basics

Beckley, Michael, and Hal Brands. 2021. "Into the Danger Zone: The Coming Crisis in US-China Relations." *American Enterprise Institute.* http://www.jstor.org/stable/resrep27632

Blevins, Emily G., Alice B. Grossman, and Karen M. Sutter. "Semiconductors and the CHIPS Act: The Global Context." Congress.gov, September 28, 2023. https://www.congress.gov/crs-product/R47558

Bown, Chad P. "How Trump's Export Curbs on Semiconductors and Equipment Hurt the US Technology Sector." Peterson Institute for International Economics. Accessed December 4, 2024. https://www.piie.com/blogs/trade-and-investment-policy-watch/how-trumps-export-curbs-semiconductors-and-equipment-hurt.

Bureau of Industry and Security. October 7, 2022. "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)." https://www.bis.doc.gov/index.php/documents/about-bis/newsroom/press-releases/3158-2022-10-07-bis-press-release-advanced-computing-and-semiconductor-manufacturing-controls-final/file

Casanova, Robert. March 18, 2024. "Ai, Auto, Industrial Markets Spurred Rebound in Chip Demand during Second Half of 2023." Semiconductor Industry Association. https://www.semiconductors.org/ai-auto-industrial-markets-spurred-rebound-in-chip-demand-during-second-half-of-2023/

CEPII. "BACI." Accessed March 1, 2025. https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37.

CHIPS and Science Act of 2022, Public Law 117-167, U.S. Statutes at Large 136 (2022): 1366-1758.

Chorzempa, Martin. "The US and Korean CHIPS Acts Are Spurring Investment but at a High Cost." Peterson Institute for International Economics, June 10, 2024. https://www.piie.com/blogs/realtime-economics/2024/us-and-korean-chips-acts-are-spurring-investment-high-cost

Cytera, Christopher. August 8, 2023. "Gallium, Germanium, and China — The Minerals Inflaming the Global Chip War." *CEPA*. https://cepa.org/article/china-gallium-and-germanium-the-minerals-inflaming-the-global-chip-war/

Deloitte. n.d. "2024 Semiconductor Industry Outlook." Accessed April 10, 2024. https://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/articles/semiconductor-industry-outlook.html

European Commission. n.d. "European Chips Act." Accessed May 12, 2023. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

Flamm, Kenneth. 1993. "Semiconductor Dependency and Strategic Trade Policy." *Brookings*. https://www.brookings.edu/articles/semiconductor-dependency-and-strategic-trade-policy/

Frieske, Benjamin, and Sylvia Stieler. October 16, 2022. "The 'Semiconductor Crisis' as a Result of the COVID-19 Pandemic and Impacts on the Automotive Industry and Its Supply Chains." *World Electric Vehicle Journal* 13, no. 10:189. https://doi.org/10.3390/wevj13100189

Gaulier, Guillaume, and Soledad Zignago. "BACI: International Trade Database at the Product-Level (the 1994-2007 Version)." *SSRN Electronic Journal*, 2010. https://doi.org/10.2139/ssrn.1994500.

Goldberg, Pinelopi, Réka Juhász, Nathan Lane, Giulia Lo Forte, and Jeff Thurk. *Industrial policy in the Global Semiconductor Sector*, July 2024. https://doi.org/10.3386/w32651

Hufbauer, Gary Clyde, Megan Hogan, and Mingsong Chen. "Industrial Policy through the Chips and Science Act." Peterson Institute for International Economics, January 2025. https://www.piie.com/sites/default/files/2025-01/piieb25-1.pdf

Keohane, Robert O. *After Hegemony: Cooperation and Discord in the World Political Economy*. Princeton University Press, 2005.

Kim, Yongshin, and Sungho Rho. "The US–China Chip War, Economy–Security Nexus, and Asia." *Journal of Chinese Political Science* 29, no. 3 (February 17, 2024): 433–60. https://doi.org/10.1007/s11366-024-09881-7

Lee, Seungjoo. "U.S.-China Technology Competition and the Emergence of Techno-Economic Statecraft in East Asia: High Technology and Economic-Security Nexus." *Journal of Chinese Political Science* 29, no. 3 (January 3, 2024): 397–416. https://doi.org/10.1007/s11366-023-09878-8

Malkin, Anton, and Tian He. "The Geoeconomics of Global Semiconductor Value Chains: Extraterritoriality and the US-China Technology Rivalry." *Review of International Political Economy* 31, no. 2 (August 17, 2023): 674–99. https://doi.org/10.1080/09692290.2023.2245404

Miller, Chris. *Chip War: The Fight for the World's Most Critical Technology*. New York: Scribner, an imprint of Simon & Schuster, Inc, 2022.

Mohammad, Wassen, Adel Elomri, and Laoucine Kerbache. "The Global Semiconductor Chip Shortage: Causes, Implications, and Potential Remedies." *IFAC-PapersOnLine* 55, no. 10 (2022): 476–83. https://doi.org/10.1016/j.ifacol.2022.09.439.

Reich, Robert. (1987). "The Rise of Techno-Nationalism." The Atlantic Monthly 259.5: 63-69.

Reinert, Kenneth A. "*Techno-Nationalism*." In The Lure of Economic Nationalism: Beyond Zero Sum, 137–56. Anthem Press, 2023. http://www.jstor.org/stable/jj.5864765.13

Pryke, Sam. October 23, 2017. "Explaining Resource Nationalism." *Global Policy Journal.* Accessed April 10, 2025. https://www.globalpolicyjournal.com/articles/global-commons-and-environment/explaining-resource-nationalism-0

Semiconductor Industry Association. n.d. "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era." Accessed April 10, 2025. https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

Semiconductor Industry Association. "Chipmakers Are Ramping Up Production to Address Semiconductor Shortage. Here's Why That Takes Time." February 26, 2021. https://www.semiconductors.org/chipmakers-are-ramping-up-production-to-address-semiconductor-shortage-heres-why-that-takes-time/

Sevastopulo, Demetri and Kathrin Hille. October 7, 2022. "US Hits China with Sweeping Tech Export Controls". Financial Times. https://www.ft.com/content/6825bee4-52a7-4c86-b1aa-31c100708c3e/

Shah, Agam. "How China Is Building an Open National Chip Plan around RISC-V." HPCwire, July 19, 2023. https://www.hpcwire.com/2023/07/19/how-china-is-building-an-open-national-chip-plan-around-risc-v

Shivakumar, Sujai, Charles Wessner, and Thomas Howell. March 3, 2023. "The Strategic Importance of Legacy Chips." *CSIS*. https://www.csis.org/analysis/strategic-importance-legacy-chips

Stangarone, Troy. April 13, 2023. "The Role of South Korea in the U.S. Semiconductor Supply Chain Strategy." *The National Bureau of Asian Research*. https://www.nbr.org/publication/the-role-of-south-korea-in-the-u-s-semiconductor-supply-chain-strategy/

Statista. n.d. "Semiconductors - Worldwide." Accessed April 10, 2024. https://www.statista.com/outlook/tmo/semiconductors/worldwide

The Japan News, June 7, 2023. "Growth Strategy Draft Eyes Investment in Semiconductors, Other Strategic Fields". https://japannews.yomiuri.co.jp/politics/politics-government/20230607-114685/

Whytock, Paul. February 27, 2024. "How Close Is China to World Dominance in Legacy Semiconductors?" *Electropages*. https://www.electropages.com/blog/2024/02/will-chinas-legacy-chip-business-achieve-world-dominance

World Population Review. "Semiconductor Manufacturing by Country 2024." Accessed December 4, 2024. https://worldpopulationreview.com/country-rankings/semiconductor-manufacturing-by-country.

Yeung, Henry Wai-Chung. "Explaining Geographic Shifts of Chip Making toward East Asia and Market Dynamics in Semiconductor Global Production Networks." *Economic Geography* 98, no. 3 (March 18, 2022): 272–98. https://doi.org/10.1080/00130095.2021.2019010

Yeung, Henry Wai-Chung. *Interconnected Worlds: Global Electronics and Production Networks in East Asia.* Stanford, CA: Stanford Business Books, an Imprint of Stanford University Press, 2022.

Zandt, Florian. December 5, 2023. "Where Can the Most Chips Be Manufactured?" Statista. https://www.statista.com/chart/31371/distribution-of-global-semiconductor-fabricating-capacity/