

Semiconductor autonomy of the EU in the context of the China - Taiwan conflict: Is the EU going to be self-sufficient?

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Abstract

The significance of semiconductors in today's everyday life is infinite; they are often referred to as the "brains" of today's technology. The thesis explores the pivotal role of the industry, emphasising the fierce competition and significant investments by countries. It starts with an explanation of the terminology, stages in the value chain, and dependencies within the supply chain.

The key findings reveal that the European Union (hereinafter the EU) is currently heavily reliant on Asian producers in the global semiconductor industry. This dependence poses significant risks amidst geopolitical tensions, especially a potential conflict between the People's Republic of China (hereinafter China) and Chinese Taipei, the Republic of China, or Taiwan (hereinafter Taiwan). The thesis briefly examines the implication of a potential conflict in this region.

Chapter 4 focuses on the EU's quest for semiconductor autonomy, analyzing its current position, strengths, vulnerabilities, and reliance on East Asian players. This quest is happening in the middle of the trade war between the United States (hereinafter USA) and China. Consequently, the thesis evaluates the potential effectiveness of the EU Chips Act in achieving self-sufficiency while mostly maintaining status quo in relations with major players in the industry, notably the USA. The EU is still balancing between the national champion and the EU's champion, which is preventing the creation of economies of scale.

To break the deadlock, some recommendations are given, but they suggest that the EU needs stronger policy and more cohesive strategies to overcome the challenges. Otherwise, the history is repeating, and this will be another weak policy, and the technological gap between the EU and the USA and/or East Asia will continue to increase. In the end, due to the complexity of the topic and various related issues, there are numerous options for future research.

1. Introduction

In today's modern world, semiconductors, often referred to, as chips or integrated circuits, are assumed to be a crucial part of modern technology. All the modern devices, from smartphones and computers to cars and medical devices, or in general, the newest technological advancements and innovations such as the Internet of Things (IoT), artificial intelligence, or 5G networks, are based on the semiconductor industry. As a consequence, the global semiconductor industry is witnessing fierce competition, and many countries have made significant investment plans in the semiconductor industry (see Appendix A for detailed information on global investment).

Since the commercial introduction of the semiconductors industry in the 1950s, the industry functions on the basic law – **Moore's law**, named after Gordon E. Moore, the co-founder of Intel, who made an observation that later became known as Moore's Law, stating that the number of components on a single chip doubles every two years at minimal cost, and soon it became a driving force in the industry (Dicken, 2007; Tardi et al., 2024). Moore's Law and economies of scale are intertwined. Some would argue that in the semiconductor industry there is a "*continuous economy of scale*," and if Moore's law slows down, advancement in the chip technology requires increasing capital investment (Groupe La Française, 2020).

Given the fact that semiconductors are essential input across a vast array of industries and many sectors, this industry arguably holds the most important, most critical position of all strategic sectors (García-Herrero & Weil, 2022). The global chip market is a multi-billion-dollar industry, with trade in integrated circuits reaching \$823 billion in 2021, second only to oil trade (Kotarski a., 2024). In 2022, it was world's third most traded product according to the Observatory of Economic Complexity (OEC a., 2024). The Taiwan Strait is crucial to international trade, almost half of the world's container ships regularly go through it (Hmaidi & Chang, 2023). So, any disruptions in this critical sector could have a ripple effect across economies, potentially causing economic damage exceeding USD \$2 trillion (Graham, 2023).

Figure 1 shows the trade network of chips between 15 countries (two in North America, three in Europe and ten in Asia) in 2019, which account for about 98% of the value of world trade in chips (Kotarski a., 2024).¹ Nodes represent countries that have a minimum

¹ Note: Figure 1 (Beaumier & Cartwright, 2024), cited by: Kotarski a., K. (2024, February 21). Čipovi, kruh naš svagdašnji: Tko će biti glavni pekar? (I). <https://arhivanalitika.hr/blog/cipovi-kruh-nas-svagdasnji-tko-ce-biti-glavni-pekar-i/>

share of 0.5% in world trade, including imports and exports (Kotarski a., 2024). Thus, the COVID-19 pandemic exposed that the supply chain has some fragility.

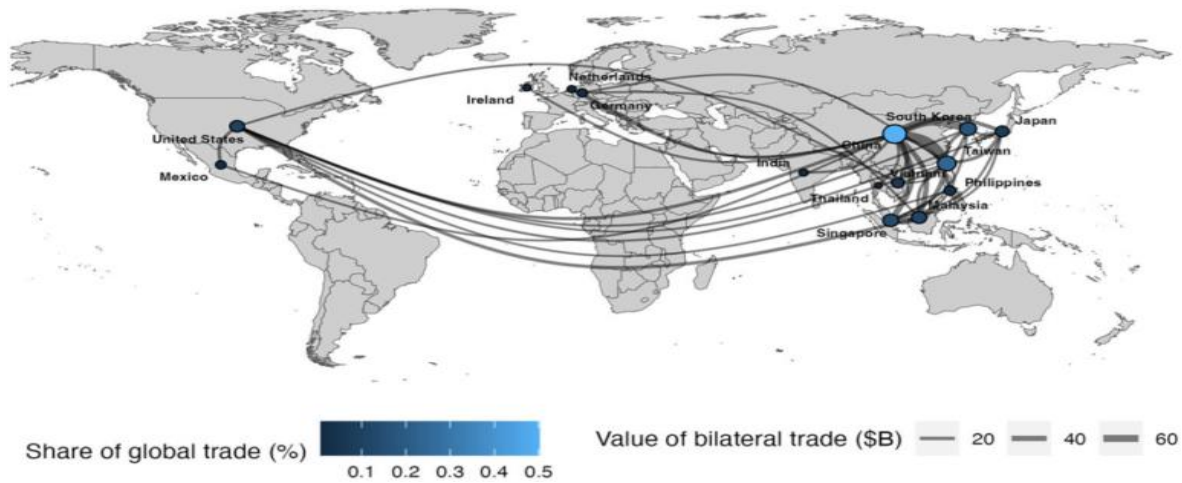


Figure 1 - Global trade of assembled semiconductors in 2019

Fragility was determined during the COVID-19 crisis, but it could also be because of some natural disasters (i.e., a winter storm in Austin, Texas, which closed Samsung's, Infineon's, and NXP Semiconductor's plants) or geopolitical tensions (i.e., tension between Japan and South Korea or between China and Taiwan) (Ji et al., 2023). Shortages in 2020 hit 169 industries (Hamilton, 2022; Howley, 2021; Ji et al., 2023). This has caused economic problems in the EU, and this impact has made people and businesses more aware of the issues, putting pressure on the EU countries to address their reliance on other countries and to secure the security of supply of semiconductors and the resilience of the semiconductor ecosystem through harmonizing law on the basis of Article 114 of the Treaty on the Functioning of the European Union (The EU Chips Act, 2023). But before the Chips Act, based on the joint declaration called "*A European Initiative on Processors and Semiconductor Technologies*", the EU and their Member States have decided to work in order to bolster Europe's electronics and embedded systems value chain, including efforts to reinforce processor and semiconductor ecosystems and to expand industrial presence across the supply chain (European Commission a., 2021).

Currently, the EU has a 10% share of the global chip market, and the goal is to double the share, up to 20% by 2030 (Boston Consulting Group (BCG) et al., 2021; The EU Chips Act, 2023). This implies a need to reduce the dependency on Taiwan; however, Taiwan has a status as a Marshallian district in the ICT industry, and the EU's high dependency could be jeopardised by a potential conflict in the area. The cost of replicating such manufacturing

processes specialised by Taiwan Semiconductor Manufacturing Company (hereinafter TSMC) is unpredictable. The cost of building a new factory is a couple of times more than what the EU will invest in the Chips Act, although it is not just about the money; it is also about the time and human capital.² The EU's plan is ambitious, but probably not enough. To reach the goal, according to some predictions, the EU should roughly invest \$164 billion by 2030 (Timmers, 2022). Thus, the number to completely substitute Taiwan's expertise and capabilities is much greater, considering their share in the industry. Consequently, it comes at a significant economic cost due to the challenges of replicating Marshallian districts and overcoming existing capacity gaps compared to dominant global players like the USA and China. Replicating a successful Marshallian district requires replicating these economies of scale, which are very expensive upfront. The new EU's plan will not yield immediate returns, creating an additional economic burden on already-hampered European budgets. Still, due to all the complexities of the industry, the cost of replicating could be irrelevant because it is hard to achieve complete autonomy. In any case, the question is whether the EU has the capacity to achieve self-sufficiency, because all relevant economic or political parameters indicate that the EU is not at that level yet or will be by 2030.

Before delving into the topic, it is also essential to determine some basic concepts. Krugman, in one of his papers, highlighted as a key feature of the semiconductor industry an extremely rapid pace of technological change, where the real cost of computing capacity is halved every few years, leading to short product cycles (Krugman, 1983, p. 147). This has two major consequences: **strong dynamic-scale economies** and **notable external economies** (Krugman, 1983, p. 147). Short product cycles make dynamic scale economies crucial in two ways: I) research and development (hereinafter R&D) costs cannot be spread over many years of production, making R&D a substantial part of a firm's expenses and heavily influencing per-unit costs based on sales; and II) the short product cycles mean firms are consistently in the early, steep part of the experience curve, causing average costs to decrease sharply with cumulative output (Krugman, 1983, p. 147-148). Even earlier, such trade patterns were established by Ohlin, who determined that producing a large amount of a single product instead of smaller amounts of various products leads to interregional trade (Ohlin, 1933).³

² See more about the monetary consequences of the replications in paragraph 4.3.3. Funding complexity and concerns

³ Cited by Vetenskapsakademien, Kungl. (2009). Trade and Geography: Economies of Scale, Differentiated Products and Transport Costs. The Indian Economic Journal, 56(4), 77–94. <https://doi.org/10.1177/0019466220090406>

Followed by the famous Krugman's very simplistic paper "*Increasing Returns, Monopolistic Competition, and International Trade*" from 1979, many patterns in the semiconductor industry, like why some regions are specialised in large-scale production, can be explained by the birth of economic geography and new trade policy (Vetenskapsakademien, 2009).

Thereupon, this thesis is trying to answer whether the EU is going to be self-sufficient in the context of geopolitical tensions in East Asia. Aside from this question, other sub questions or equally legit questions like why this plan should be successful now, or can the EU build their own Marshallian district? Why should there be EU solidarity if there is no actual financial or economic gain from it? Many problems, like the EU budget proportionality, which complicates the organisation and funding of large-scale projects, historical problems in cooperation in high-tech projects, the technological gap between Europe and the USA and their (un)defined relationship; or, more straightforwardly, the fact that the EU is not a single state like the other competitors, makes the whole process of aiming towards self-sufficiency much harder.

2. Semiconductor industry

2.1. Explanation of the terminology

Also known as semis or chips, semiconductors can be found in thousands of products such as computers, smartphones, appliances, gaming hardware, and medical equipment. They are the brains of modern electronic equipment, storing information and performing the logic operations that enable devices to operate (OECD, 2019, p. 11). Therefore, different definitions will often be found in the sources. For example, the EU is passing the EU Chips Act, but it also wants to develop the EU semiconductor industry.

According to Britannica, a microchip, integrated circuit (hereinafter IC), chip circuit, electronic-grade silicon, microchip, microcircuit, and microelectronic circuit are all synonyms (Lynne Saint & Saint, 2024). Therefore, chips are, by definition an assembly of electronic components, fabricated as a single unit, in which miniaturized active devices (e.g., transistors and diodes) and passive devices (e.g., capacitors and resistors) and their interconnections are built up on a thin substrate of semiconductor material (Lynne Saint & Saint, 2024).

Regulation (EU) 2023/1781 of the European Parliament and of the Council of 13 September 2023 establishing a framework of measures for strengthening Europe's semiconductor ecosystem and amending Regulation (EU) 2021/694 (hereinafter Chips Act) is defining semiconductor in two ways: (a) as a material, including novel materials, either elemental or compound, whose electrical conductivity can be modified; or (b) as a component consisting of a series of layers of semiconducting, insulating, and conducting materials defined according to a predetermined pattern and intended to perform well-defined electronic or photonic functions or both (The EU Chips Act, 2023). On the other hand, a chip is defined as an electronic device comprising various functional elements on a single piece of semiconductor material, typically taking the form of memory, logic, processor, optoelectronics, and analogue devices (The EU Chips Act, 2023).

Semiconductor material is mostly silicon, but in any way, a material product with some of the properties of both insulators and conductors, hence semiconductor (Segal, 2024). The reason why they are usually comprised of silicon is because it conducts electricity more than an insulator, such as glass, but less than a pure conductor, such as copper or aluminium (Segal, 2024). Still, in everyday speech, semiconductors and chips are used in the same way.

Semiconductors can be grouped into three categories: **1) Logic chips**, which process binary information, and include microprocessors (e.g. artificial intelligence applications), microcontrollers (e.g., diodes, transistors) and connectivity chips (e.g., modems, Wi-Fi), primarily used in electronic products and account for 42% of industry revenues (Boston Consulting Group (BCG) et al., 2021, p. 9); **2) Memory chips**, which represents 26% of revenues, are storing data or information (e.g. flash memory) and the two most used semiconductor memories are Dynamic Random - Access Memory (hereinafter DRAM) and NAND memory (Boston Consulting Group (BCG) et al., 2021, p. 9); and **3) DAO Chips**,⁴ accounts for 32 % of the revenues, and used for processing non-binary information, mostly used for machines and transport equipment (e.g. voltage regulators, optical sensors), or in other words semiconductors that transmit, receive, and transform information dealing with continuous parameters such as temperature and voltage (Boston Consulting Group (BCG) et al., 2021; OECD, 2023).

Traditionally, the industry has relied on the size of process nodes in order to differentiate between generations of technology, with smaller nodes corresponding to more advanced technology at two-to-three-year intervals since the 1970s (Ji et al., 2023; OECD, 2019).

2.2. Stages of value chain

According to the OECD, semiconductor value chains consist of three core stages – **1) Design, 2) Fabrication/ Foundry and 3) Assembly, Test and Packaging**. Only a few companies can be named the Integrated device manufacturer (thereinafter IDMs), such as Intel, Samsung, or Texas Instruments, which perform all three steps in-house (Baisakova & Kleinhans, 2020). Still, for the purpose of this thesis, one more is added and put as an initial stage of the chain – **Research and Development** (OECD, 2023).

Thus, the first stage is **Research and Development** with key players in this stage being manufacturers such as Intel, Samsung, and TSMC, and more advanced technologies like AI, IoT, and autonomous vehicles (Business Executives for National Security, 2024; Khera, 2023). The production of semiconductors constitutes one of the most R&D-intensive activities, with almost no assurance that the investments will yield productive assets (OECD,

⁴ DAO stands for “Discrete, Analog and Others.” “Fabless” business models are common in the production of logic chips, whereas IDMs dominate the production of memory and DAO chips (OECD, 2023, p. 11).

2019, p. 12).⁵ Therefore, it forces companies to do the research collaborations, although some are participating simply because of the “*fear of missing out*” (OECD, 2019, p. 15).

The second stage is **design**, where the USA still has highly advanced technical know-how and highly educated workers, so the leading companies are headquartered in the USA, such as Qualcomm, Intel, Broadcom, and AMD (Business Executives for National Security, 2024). There are also companies that do not have their own production capacities, like Nvidia and Apple, and that is why they rely on companies that are focused on the manufacturing process, like TSMC (Kotarski a., 2024). Companies that focus on chip design, are also known as “*fabless*” and/or “*fab*” in the sense of not having fabrication facilities (OECD, 2019). This stage should also include equipment and material suppliers (Khera, 2023).

The third phase would be **manufacturing** or **fabrication**. Semiconductor manufacturing, the process of turning silicon wafers into microchips, is a complex and capital-intensive industry with a major impact on the industry. Initial construction costs range from \$5 to \$20 billion, plus additional inputs like gases, water, dry air, nitrogen, and big electricity consumption (Business Executives for National Security, 2024). In recent decades, due to the geographic distribution of this industry, the focus has shifted from the USA to East Asia. Main American companies are actually manufacturing in Asia, which means that the USA's semiconductor companies make up 47% of global chip sales, but only 12% are actually manufactured or fabricated in the territory of the USA, which is a drop from the 37% in 1990, as Figure 2 shows (Business Executives for National Security, 2024; Graham, 2023; Kotarski a., 2024).⁶ Today, Taiwan stands out as a global leader in semiconductor manufacturing, with the dominant position of their national giant TSMC, which controls around 53% of this market, while Taiwan accounts for approximately 20% of total global chip production, over 90% of the most advanced chips (Business Executives for National Security, 2024; Ting-Fang & Li, 2020). Together with South Korea, Taiwan is dominating in the production of the most advanced chips at 5 nm, while in the USA the most advanced chips are 10 nm, and China has mostly 14 nm chips (Business Executives for National Security, 2024). Predictions are that the USA will continue to lose dominance while China is soaring with its production capabilities in the future. With \$100 billion in government support, China has

⁵ See Figure 1.2. (p. 13) in the OECD. (2019). Measuring distortions in international markets: The semiconductor value chain. OECD. <https://doi.org/10.1787/8fe4491d-en>

⁶ Note: Figure from: Boston Consulting Group, cited by Graham, J. (2023, November 24). U.S.-China Chip War Nears Moment Of Truth. Investor's Business Daily

invested significantly in improving its semiconductor manufacturing capacity in recent years. As a result, China is expected to control 28% of global production by 2030, a significant increase from the current 16%. In a nutshell, fabrication facilities rely on a complex system of equipment, chemicals, and silicon wafers (Baisakova & Kleinhans, 2020). And the whole process thrives on collaboration between other players, like suppliers and chip designers. Eventually, it can lead to the point that none of the countries can be considered “self-reliant” or “strategically autonomous” in the whole process (Baisakova & Kleinhans, 2020).

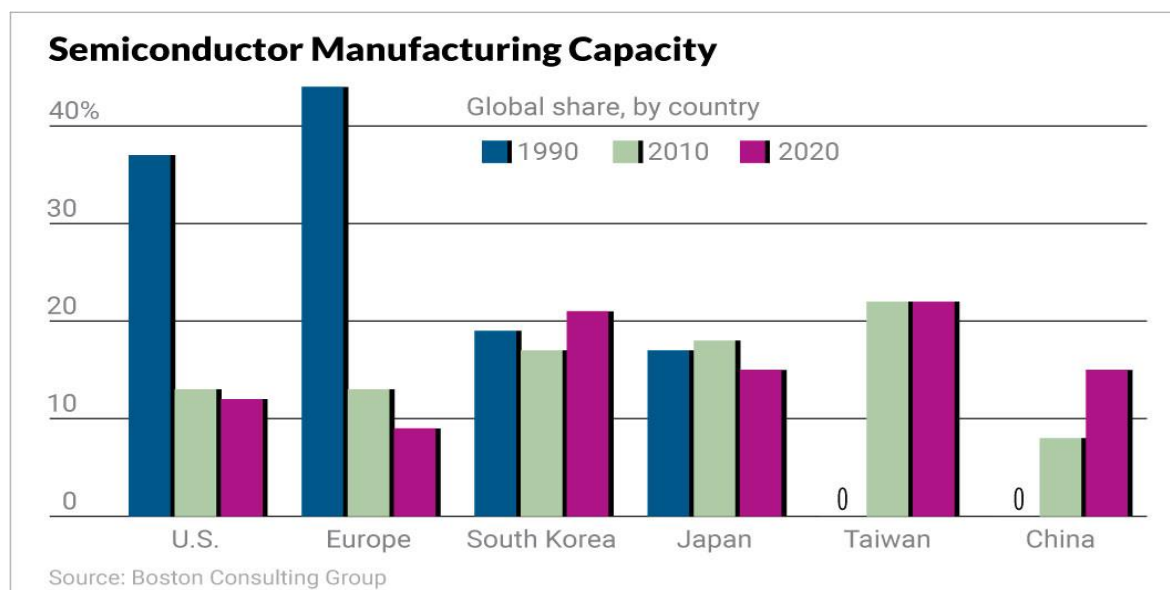


Figure 2 - Semiconductor manufacturing capacity

The last stage is called **assembly, testing, packaging, or abbreviated ATP, and advanced packaging**. In this process, which is cheaper than the previous one, chips are assembled into finished semiconductor components, tested, and packaged into final products (Business Executives for National Security, 2024). Since this process is less capital-intensive, it is possible to have ATP facilities in areas with low labour costs (Business Executives for National Security, 2024). Globally, about 60% of ATP capacity is in China and Taiwan, and the rest is mainly in Southeast Asian countries (Business Executives for National Security, 2024). Although American companies have almost a third of the market for ATP products, almost all production takes place outside the USA (Business Executives for National Security, 2024). In fact, the USA has only 3% of the global chip packaging capacity (excluding testing). Unlike the standard ATP process, there is also advanced packaging where multiple chips or integrated circuits are combined into one package (Business Executives for National Security, 2024). Due to the greater concentration of chips, combining different functions in one package, and more flexible use of standard chips for specific solutions, advanced packaging

requires more capital and a highly skilled workforce (Business Executives for National Security, 2024). It must be noted that both IDMs and fabless firms often outsource part or all of their ATP to another set of specialized companies known as outsourced semiconductor assembly and testing, or abbreviated OSAT firms, mainly situated and dominated by Asian economies (OECD, 2019, p. 21-22).

The Centre for Security and Emerging Technology (hereinafter CSET) published the report in 2021, in which they analysed the supply chain. According to them, most semiconductor firms are headquartered in six countries and regions that control the entire supply chain, which is presented in Table 1.⁷ The table provides an estimation of the contribution to semiconductor value of each supply chain segment in purple (Khan et al., 2021, p. 8). In green, it presents regional market shares of supply chain segments (Khan et al., 2021). Then, in blue, it also provides each region's total value added to the global supply chain (Khan et al., 2021). Each of these values is a weighted average of a region's market shares across all supply chain segments, but the general conclusion can be extracted, and that one is that the USA is the world leader overall, while the others have some world-leading firms in special segments (Khan et al., 2021).

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

Table 1 - Semiconductor value add and market shares by segment and firm headquarters

⁷ Note: Market shares are from 2019, except ATP market shares, which are from 2018. IDMs perform a large percentage of design, fabrication, and ATP and do not separately report revenues for these activities. Therefore, the market shares for these three segments are based on CSET's estimates. ATP market shares and country- and region-level values sum to more than 100 percent due to rounding. Sources: CSET calculations, financial statements, WSTS, SIA, IC Insights, Yale, and VLSI Research. Note: Color intensities are correlated with the magnitude of the values (Khan et al., 2021).

Due to the \$100 billion investment made by the Chinese government to build a staggering 60 new facilities, China's share of global fabrication capacity is expected to grow to 28% by 2030 (Business Executives for National Security, 2024). To compare the numbers, in 2019 alone, of the six new semiconductor production facilities in the world, four were in China and none were in the USA (Business Executives for National Security, 2024). As a result, the Semiconductor Industry Association (hereinafter SIA) predicts that by 2030, the USA's share of global semiconductor manufacturing capacity will fall to 10% while East Asia's will grow to 83% (Business Executives for National Security, 2024).

In conclusion, Figure 3 illustrates the complex division of labour in the global industry and in the different stages of the global value chain (Malkin & He, 2023).⁸

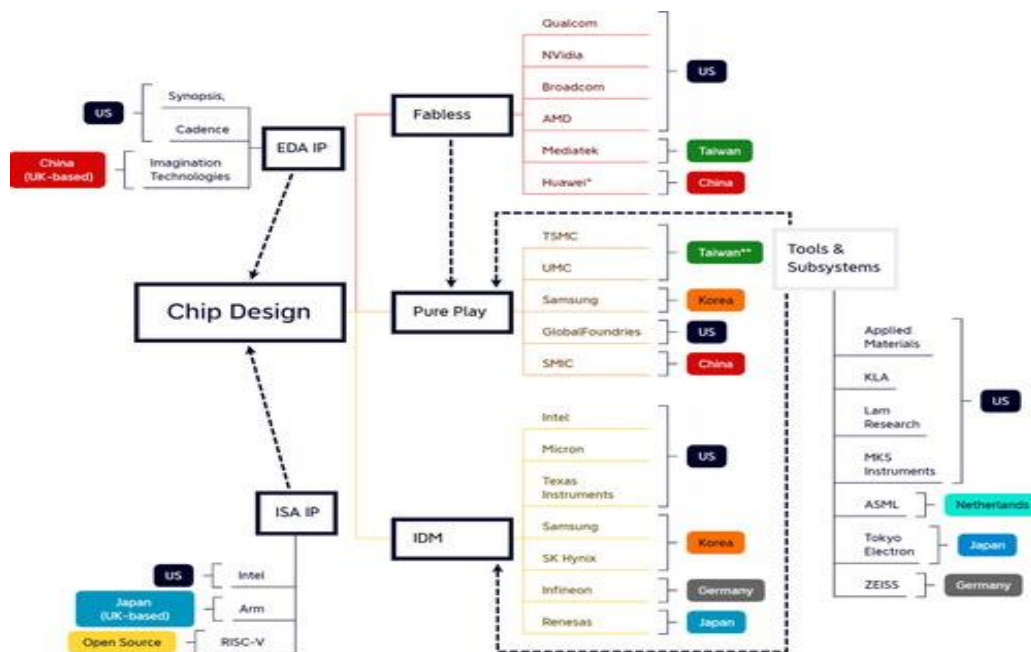


Figure 3 - Leading firms in key nodes of upstream semiconductor production network⁹

2.3. Dependencies of the supply chain

In 1995, the USA and Japan accounted for more than 50%, while China, South Korea, and Taiwan accounted for 20% of the global semiconductor share, and 20 years later, the shares had turned the other way around (OECD, 2023, p. 15). This symmetrical shift makes semiconductor producers and their clients very vulnerable to the disruptions in Asia, whereas

⁸ Cited by Kotarski a., K. (2024, February 21). Čipovi, kruh naš svagdašnji: Tko će biti glavni pekar? (I). <https://arhivanalitika.hr/blog/cipovi-kruh-nas-svagdasnji-tko-ce-bit-glavni-pekar-i/>

⁹ See full Notes in Figure 1 in Kotarski a., K. (2024, February 21). Čipovi, kruh naš svagdašnji: Tko će biti glavni pekar? (I). <https://arhivanalitika.hr/blog/cipovi-kruh-nas-svagdasnji-tko-ce-bit-glavni-pekar-i/>

Asia is dependent on foreign chip designs and equipment (OECD, 2023, p. 15). The migration of semiconductor manufacturing to East Asia has created a precarious situation for producers and consumers, and while such a geographical concentration of production (see Figure 4) offers certain advantages and efficiencies, it also exposes the whole system to disruptions (OECD, 2023, p. 16).¹⁰ Interdependency is sealed by the dependence of many Asian producers on foreign intellectual property and equipment.

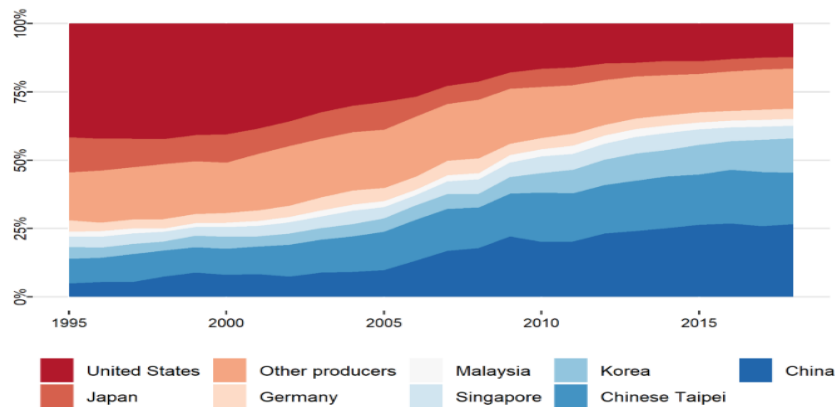


Figure 4 - Semiconductors production concentration in Asia¹¹

In a single economy, supply disruption can have huge downstream effects since semiconductor production is very upstream and geographically concentrated (OECD, 2023, p. 16). This would mean that industry is one of the most distant from final demand when compared with other industries like mining and basic metals (OECD, 2023, p. 16). In recent years, there have only been small changes in the geographic allocation in the industry (OECD, 2023, p. 17). This is backed up with data for the total value of traded semiconductors, which had surged by nearly 30% between 2018 and 2021, but the share of trade accruing to the leading economies has remained anchored (OECD, 2023, p. 17).¹²

¹⁰ Note: The main producers are defined as the economies with the highest average value added between 1995 and 2018. Source: OECD semiconductor augmented ICIO tables.

¹¹ Cited by OECD. (2023, June 19). Vulnerabilities in the semiconductor supply chain | en | OECD. <https://www.oecd.org/publications/vulnerabilities-in-the-semiconductor-supply-chain-6bed616f-en.htm>

¹² See Figure A B.3 and Figure A B.4 on p. 35 in the OECD. (2023, June 19). Vulnerabilities in the semiconductor supply chain | en | OECD. <https://www.oecd.org/publications/vulnerabilities-in-the-semiconductor-supply-chain-6bed616f-en.htm>

3. The impact of China-Taiwan conflict for the industry and the EU

This thesis will not go into the historical and political reasons for the war but rather delve into the consequences for the semiconductor industry. China is trying to unite with Taiwan, but the island is protected and provided with political and military support by the USA. In addition, China and the USA are in a trade war, fighting to be global economic leaders in every possible way, especially escalated during the Trump administration. Trade war is currently in the phase where China raised the request for consultation, which initiated a dispute in the WTO against the USA's China, claiming that the USA's export measures are inconsistent with multiple provisions of the WTO's General Agreement on Tariffs and Trade 1994, the Agreement on Trade-Related Investment Measures, the Agreement on Trade-Related Intellectual Property Rights, and the General Agreement on Trade in Services (WTO, 2022).

Despite military tensions, China and Taiwan are still cooperating and maintaining their economic relations. Moreover, Taiwan's main import (19%, or \$79,9 billion) and export (22,4%, or \$121 billion) destination is China (OECD, 2024). Taiwan's dominance in the industry is actually astonishing, despite its limited political status in international relations (Tsang, 2023, p. 6-7). As President Tsai Ing-wen described it, Taiwan's chip industry is described as a "*silicon shield*" (Graham, 2023; Tsang, 2023, p. 6-7). While China is striving for the autonomy in the semiconductors and relies on Taiwan to fill the gap in the meantime, this creates a delicate interdependence that actually fosters cross - strait peace for now (Klingler-Vidra & Kuo, 2021; Shattuck, 2021).¹³

Taiwan, accounting for over half of the world's production, holds a pivotal position in the global semiconductor landscape as the world's leading manufacturer of advanced chips, or up to 92% of the production of logic semiconductors whose components are smaller than 10 nm comes from Taiwan (Boston Consulting Group (BCG) et al., 2021; Buchholz, 2023; Ezell, 2021). Any kind of disruption, especially the potential war conflict, would have a devastating impact not just for participants but for the whole world because most analysts would mark it as the Third World War. During the COVID-19 crisis, the world had a glimpse of what it could look like if the conflict started.

¹³ Cited by Tsang, I. (2023, January 20). Silicon shielding: How the Taiwanese semiconductor industry co-evolved with Taiwan [Info:eu-repo/semantics/masterThesis]. University of Twente. <https://essay.utwente.nl/94187/>, p. 55-56

Experts estimate that replacing Taiwanese foundries with alternatives would require a monumental effort, taking years and €350 billion investment (Ezell, 2021; Fried, 2021). The situation is further complicated by China's being the world's largest producer of silicon, a vital raw material for chip production (Statista c., 2024; Wafer World, 2021). According to the Rhodium Group, a Chinese blockade of Taiwan, even without war, could cause massive economic damage of over \$2 trillion, by cutting off the world's main source of advanced chips (Graham, 2023). Behind China's attempt to return the rogue island, the USA-China chip war is actually being held, and thus it likely increases China's sense of urgency to seize Taiwan (Graham, 2023).

TSMC is also crucial because they make 70% of smartphone chips, 30% of car microcontrollers, and a huge portion of high-end computer chips (Graham, 2023). This feeds into \$1.6 trillion in revenue for their global customers each year (Graham, 2023). China's plan to make most of their own chips by 2025 is far behind schedule (Graham, 2023). In 2021, Chinese companies only made 7% of the chips they needed. Even counting foreign-owned factories in China, they still rely on outside sources for 83% of their chips (Graham, 2023). This dependence on Taiwan acts as a "shield" against China using force (Graham, 2023). The technological giant TSMC has important relations with Huawei, China's biggest tech company, which are realized in the fact that Huawei is the TSMC's fastest-growing and second-largest customer, behind Apple, accounting for more than 15% of revenue and eager to test cutting-edge technology (Ting-Fang & Li, 2020).

The impact of a potential war will accelerate the reorganization of the supply chains, probably implying protectionist measures, and consequently, it will reshape the geopolitical landscape. Therefore, the EU is compelled to achieve self-reliance in critical technologies, so it must increase investments in R&D and production capabilities. The EU should consider several mitigation strategies to ease the impact of a China-Taiwan war in the semiconductor sector. Those strategies already include the ongoing process of investing in domestic production, prioritizing the increase of production capabilities through attractive financial incentives, R&D support, and attracting leading companies to establish factories within the region. The goal is also to diversify supply chains and lean on other producers like South Korea and Japan to reduce its reliance on Taiwan, if not China.

The EU might have been forced to speed up efforts to diversify its semiconductor supply chain. By doing so, the goal is to double market share, and consequently reduce dependence on East Asia (European Council & Council of the EU, 2023). By doing this, the

EU is not actually derisking the possible China-Taiwan conflict, leaving Taiwan without its survival strategy of being a key indispensable player in the semiconductor industry (Hmadi & Chang, 2023). The EU is officially pursuing “One China” policy, but at the same time, it seeks closer ties with Taiwan. The EU faces some hurdles, and Taiwan is open to cooperation, but the EU’s lack of a semiconductor market, potential low profits, and uncertain investor base have stalled the progress (Tsang, 2023, p. 58). Both sides have mismatched aims, the EU wants a full value-chain solution, while Taiwan prioritizes diplomatic gains, and due to these reasons and the EU’s fear of changing “One China” policy, Taiwan rather sees East Asia as a more profitable and established location (Tsang, 2023, p. 58-59). On the contrary, the USA is actively working on restraining Taiwan from selling chips to China, even constructing TSMC’s new plant in Arizona, securing its own supply chain while hindering China’s access to most advanced chips, especially for the USA military (Shattuck, 2021; Tsang, 2023).¹⁴ This investment could be seen as the act of preparation in the case of conflict.

The conflict between China and Taiwan could be interpreted between the USA and China due to the USA's support for Taiwan’s “independence” and security reasons, accordingly national interest (Shattuck, 2021). Here, the EU would probably be both a collateral and a bystander. A good example of why Europe is a bystander in the conflict between two global powers, China and the USA, is the case of Semiconductor Manufacturing International Corporation (SMIC), the company that Trump’s administration put on the blacklist and forced the Netherlands to block the sale of advanced technology and machinery to SMIC to prevent China from advancing its semiconductor capabilities (Business Executives for National Security, 2024).

In any case, military conflict could directly damage or halt chip production facilities in Taiwan, leading to immediate supply shortages and price elevations. A war would not only have economic and technological consequences but also raise significant ethical and social concerns like the humanitarian cost, disruption to technological progress in many heavily reliant on semiconductor’s sectors, and impact on global security that can escalate to more regional tensions and pose a threat, potentially triggering wider military conformations.

¹⁴ Notably, Taiwan made sure that the new Arizona factory will not have the same production capabilities as their own factories in Taiwan (Tsang, 2023)

4. Autonomy of the EU's industry

The EU endeavours for long-term autonomy in the semiconductor industry, and at first, the conclusion is that it will take some time to pay off the initial investments. Of course, the significantly invested funds will also depend on other factors, such as the geopolitical landscape and international tensions in different parts of the world, with an emphasis on China and Taiwan. Likewise, it needs to determine how this path will affect other EU plans, such as the Green Deal, sustainability issues, or whether it will conflict with some ethical issues, such as human rights.

Krugman highlighted the importance of firm-level dynamic scale economies and additional external economies that benefit many firms (Krugman, 1983, p. 147). The spillovers effect should occur in high-tech clusters like those in the EU to create the “*European Silicon Valley*” in the semiconductor industry, affecting both national and global levels (Krugman, 1983, p. 148). In ICT industries, Krugman believes that comparative advantage is primarily driven by access to suitable human capital, with successful regions and countries having an abundance of highly educated workers (Krugman, 1983, p. 148). These are essential conditions that need to be satisfied in order to have economies of scale and a decrease in innovation capacities. The current EU's plan is valued at around €43 billion, comparable to TSMC's \$40 billion investment in a single factory in Arizona. The problem could be rendered ineffective if the investment is not concentrated in one place or in a single Member State. For instance, Germany solely plans to invest half of the EU's plan, and it is attracting foreign giants like Intel or TSMC, and it seems like it also has its own strategy (Alkousaa et al., 2023; DW, 2023; Noyan, 2023). Still, while economies of scale provide substantial benefits, there are some limitations (Miller b., 2024). At some point, where additional cost savings from economies of scale are no longer possible, cost reductions may not occur (Miller b., 2024).

Regardless, with the mentioned essential conditions, the EU possibly could reduce its dependency, compete with others, and be less affected in the case of conflict or any future disruptions in the global value chain. Because of that, first it needs to be determined what is the actual position of the EU in the semiconductor value chain, but also what is the situation with the EU's industry. Then, the focus will be on the EU's response – the Chips Act. The EU is experiencing slow growth, and it already had ambitious action programs such as the “Lisbon Agenda,” whose goal was to make Europe by 2010 “*the most competitive and*

dynamic knowledge-based economy in the world”, or Europe's Digital Decade (Markevičiūtė, 2023; van Ark et al., 2008). Hamilton believes that the EU should avoid illusions of autonomy (Hamilton, 2022). Although there are many challenges, the special part is dedicated to the EU-USA relationship, and the fact that the EU is not a single country, or totally integrated, so there will be wavering if there should be EU or national champions in the semiconductor industry.

4.1. The position of the EU in the semiconductor value chain

4.1.1. The EU in the global value chain

To determine how well the EU has been integrated into the global value chain (hereinafter GVC), one of the best indications is the World Integrated Trade Solution (WITS) of the World Bank (Joint Research Centre et al., 2022) and its index. Figure 5 shows the total GVC index and how well integrated the EU's industrial sector, in the global value chains by computing the amount of output that can be assigned to GVC linkages, and the conclusion is that the EU's integration has significantly increased over the past decade (Joint Research Centre et al., 2022).¹⁵

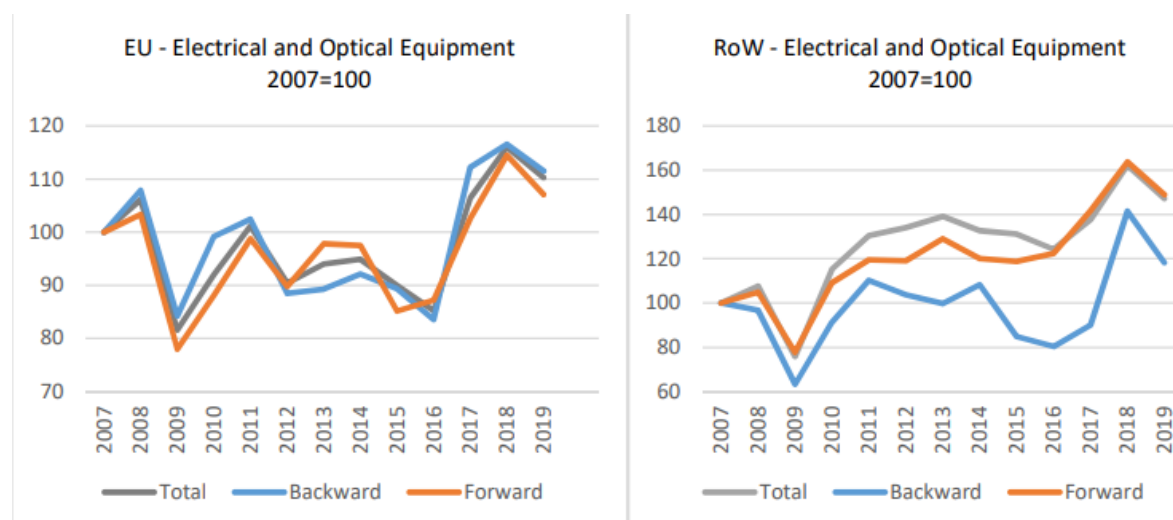


Figure 5 - Total backward and forward GVC integration in the EU.

This growth indicates a stronger reliance on foreign suppliers, or backward integration, and increased exports, or forward integration (Joint Research Centre et al., 2022). While the EU's overall GVC integration growth surpassed 10%, it lags behind the rest of the

¹⁵ Note: Semiconductors are falling under „Electrical and Optical Equipment“ (Joint Research Centre et al., 2022). See Figure 2 (p. 10) in the Joint Research Centre et al., 2022.

world's 47% increase, driven primarily by their focus on forward integration. Regarding which single Member State is the most integrated, Germany leads the EU, accounting for nearly a third of the total, followed by the Netherlands and Italy (see Figure 6) (Joint Research Centre et al., 2022).¹⁶

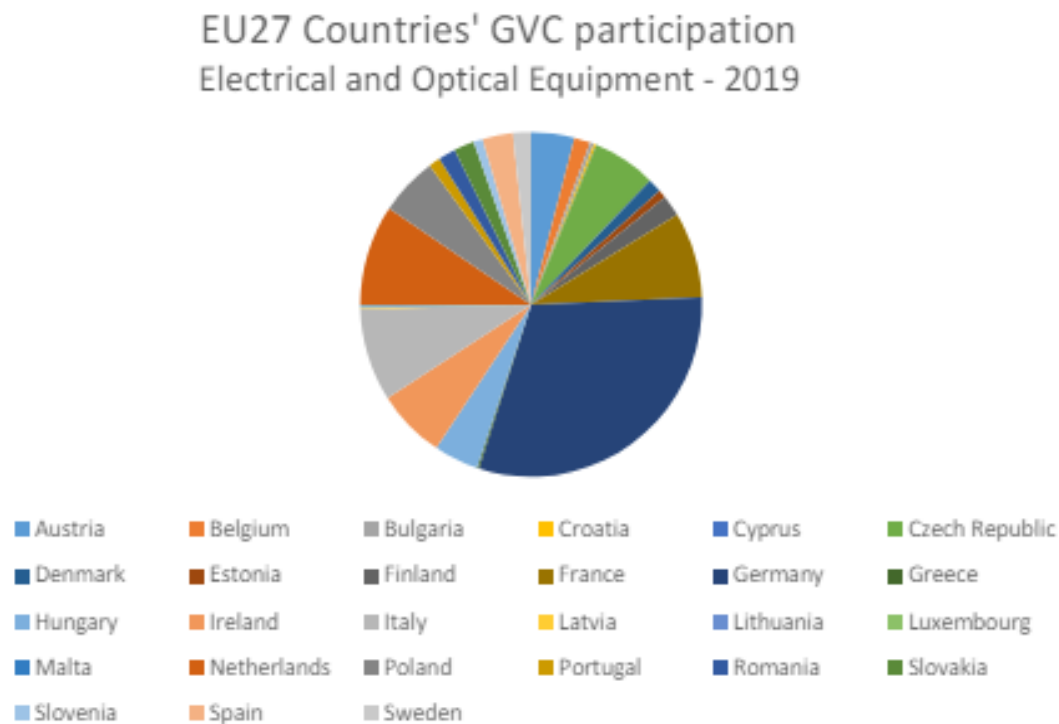


Figure 6 - EU involvement in the Global Value Chain, Total integration 2019.¹⁷

According to the JRC investigation of the EU's trade balance in the industry, less developed semiconductors are: 1) diodes, transistors, and similar semiconductor devices (HS 8541); and 2) electronic integrated circuits such as processors, memories, and amplifiers (HS 8542) (Joint Research Centre et al., 2022, p. 11).

Specifically, for some product categories within the semiconductor value chain (hereinafter SVC), the EU is a net importer of less advanced semiconductor devices, with a trade deficit exceeding €4 billion since 2018 (see Figure 7), and the conclusion is that the EU is mostly importing for China, Taiwan, and Japan (Joint Research Centre et al., 2022, p. 12).¹⁸

¹⁶ See Figure 3 (p. 10), in the Joint Research Centre, Ciani, A., & Nardo, M. (2022, April 5).

¹⁷ Cited by Joint Research Centre, Ciani, A., & Nardo, M. (2022, April 5). The position of the EU in the semiconductor value chain: Evidence on trade, foreign acquisitions, and ownership - European Commission. https://joint-research-centre.ec.europa.eu/reports-and-technical-documentation/position-eu-semiconductor-value-chain-evidence-trade-foreign-acquisitions-and-ownership_en

¹⁸ See Table 1 (p. 12), Figure 4 (p. 12) and Figure 5 (p. 13) in Joint Research Centre et al. (2022) for details on EU's imports of HS 8541.

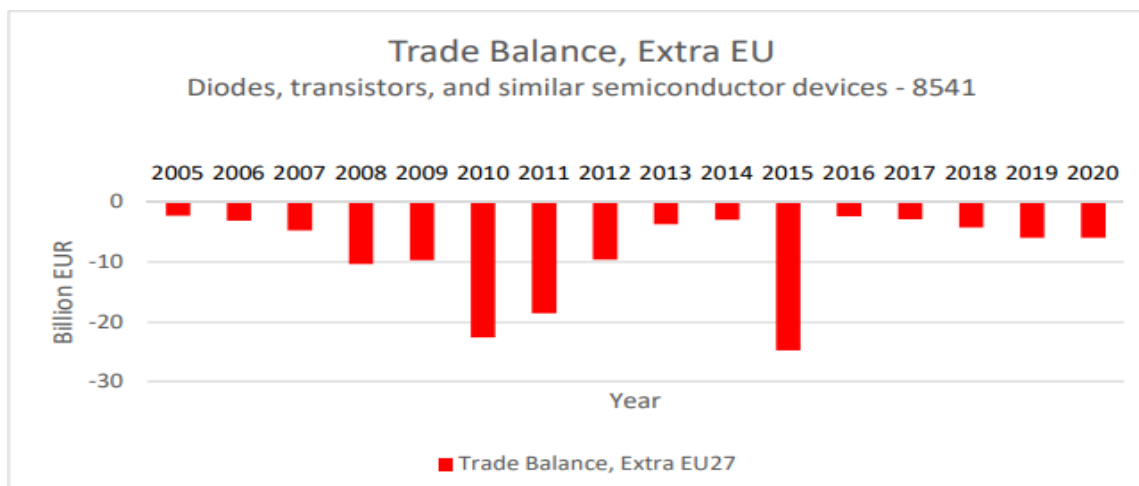


Figure 7 - Diodes, transistors, and similar semiconductor devices – 8541.

In the product category HS 8542, which includes electronic integrated circuits such as processors, memories, and amplifiers (advanced chips and memory crucial for consumer electronics, automotive, and aerospace industries), the EU is even more dependent on external sources, and the deficit is bigger (Joint Research Centre et al., 2022, p. 13). This reveals a continuous trade deficit exceeding \$6 billion since 2016 (see Figure 8), with Taiwan dominating EU imports (e.g., processors, electronic integrated circuits, DRAMs, and multi-combinational memories), accounting for roughly 20% on average (Joint Research Centre et al., 2022, p. 13-14).¹⁹

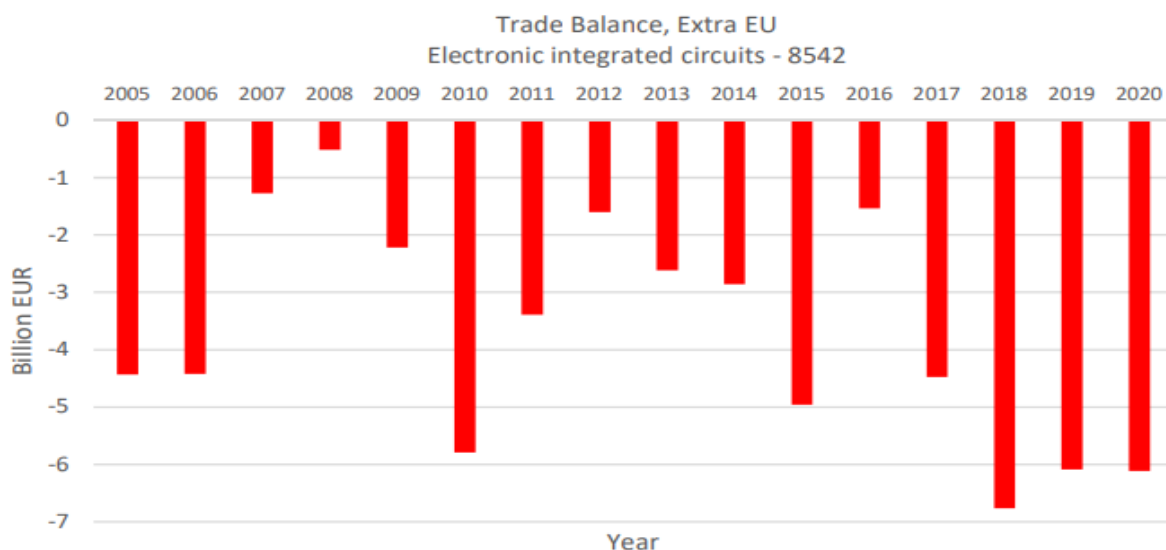


Figure 8 - Trade balance, Extra EU, Electronica integrated circuits - 8542.

¹⁹ See Table 2 (p. 14), Figure 6 (p. 14) and Figure 7 (p. 15) in Joint Research Centre et al. (2022) for details on EU's imports of HS 8542.

Notably, Taiwan’s rise and dominance coincide with the shift of USA and EU companies like Phillips towards fabless models, allowing Asian giants like TSMC and Samsung to capitalize on investments in manufacturing (Joint Research Centre et al., 2022). While the EU, through companies like ASML, remains a leader in specific segments of the supply chain (e.g., lithography equipment), its reliance on foreign suppliers for the final, most advanced chips has significantly increased (Joint Research Centre et al., 2022).

The EU also has another negative balance with metals for wafer creation (HS 811).²⁰ Here, the leading exports of metals to the EU are China, Russia, and the USA, which accounted for over 68% combined in the period 2017–2020 (Joint Research Centre et al., 2022). According to the Bruegel calculation from Eurostat, the EU totally relies heavily on out-EU sources (see Figure 9) (Le Mouel & Poitiers, 2023).²¹

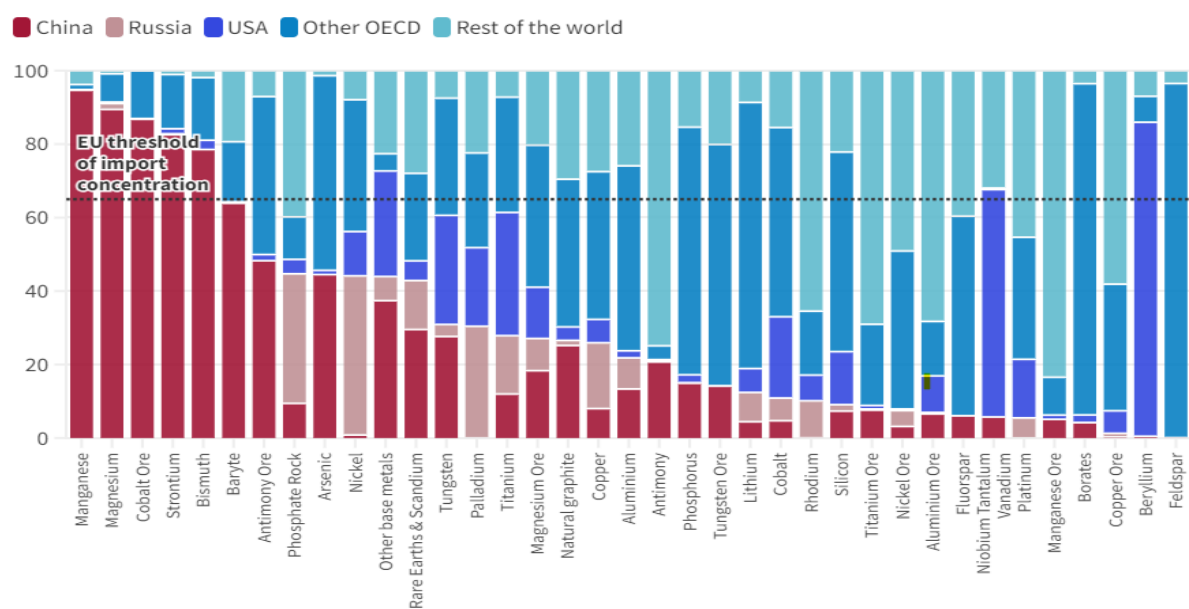


Figure 9 - Origin of EU imports of critical raw materials in 2021.²²

In a nutshell, the EU’s dependence on a limited number of suppliers creates a risky situation because of this high import reliance (i.e., 100% of imports for rare earth elements used for magnet manufacturing), coupled with rising global demand and geopolitical tensions, which exposes the EU to potential supply chain disruptions for crucial components (Righetti & Rizos, 2024).

²⁰ Metals included are beryllium, chromium, germanium, vanadium, gallium, hafnium, celtium, indium, niobium, columbium, rhenium and thallium (Joint Research Centre et al., 2022)

²¹ More about the EU's reliance on imports in Table 1. Main EU suppliers, import reliance and strategic applications of strategic raw materials (Righetti & Rizos, 2024)

²² Source: Bruegel calculations from Eurostat DS-045409 (Le Mouel & Poitiers, 2023)

Despite the EU sanctions on Russia and decreasing dependency on Russia's sources, the EU obtained between March 2022 and July 2023 €13.7 billion worth of critical and strategic raw materials from Russia, which are used in the semiconductor industry, but the question remains: what would be the case with possible sanctions on China if the war starts with Taiwan (Hansens et al., 2023). In relation to the Russia - Ukraine war, it throws a spotlight on Ukraine's potential wealth of rare earth materials, maybe the biggest recoverable sources in Europe, including beryllium, niobium, lithium, niobium, and others, but the problem is that they are mostly located in the occupied areas (Muggah & Dryganov, 2022).

Regarding the equipment used in chip production (HS 8486), the EU loomed as a net exporter, capitalizing on the expertise of companies like ASML, ASM, Rhode, and Schwarz (Joint Research Centre et al., 2022). This strength stems from a limited number of the EU foundries, like STM and NXP, which are focusing on East Asian customers. It is a well-known fact that Europe has a problem with foundries that offer advanced manufacturing of components with feature sizes below 22 nm, necessary for memory and processor chips, and therefore it simply has to rely on Samsung or TSMC to that end (European Commission a., 2021, p. 87).

4.1.2. The EU's companies in the industry

In essence, there is an innovation and technological gap within the EU, notably among the South and the East, which correlates with the situation in the semiconductor industry, and which also correlates with the general economic prosperity gap among these regions in the EU (Maucorps et al., 2023). The technological and innovation gap between the USA and Europe is also well-known. This raises some questions about the current and future state of the semiconductor industry in these regions, although there is a solid foundation in Europe.

The EU has some European semiconductor champions, notably ASML in the Netherlands, the only company that builds the equipment used by TSMC and Samsung to produce the smallest chips, and it makes it with extreme ultraviolet lithography (hereinafter EUV) machines, the most sophisticated type of lithography equipment that is required to make advanced processor chips (van Wieringen, 2022; Williams, 2022). There are innovative

research facilities, including Imec in Belgium, Leti in France, Fraunhofer in Germany, and others (see Figure 10) (van Wieringen, 2022).²³

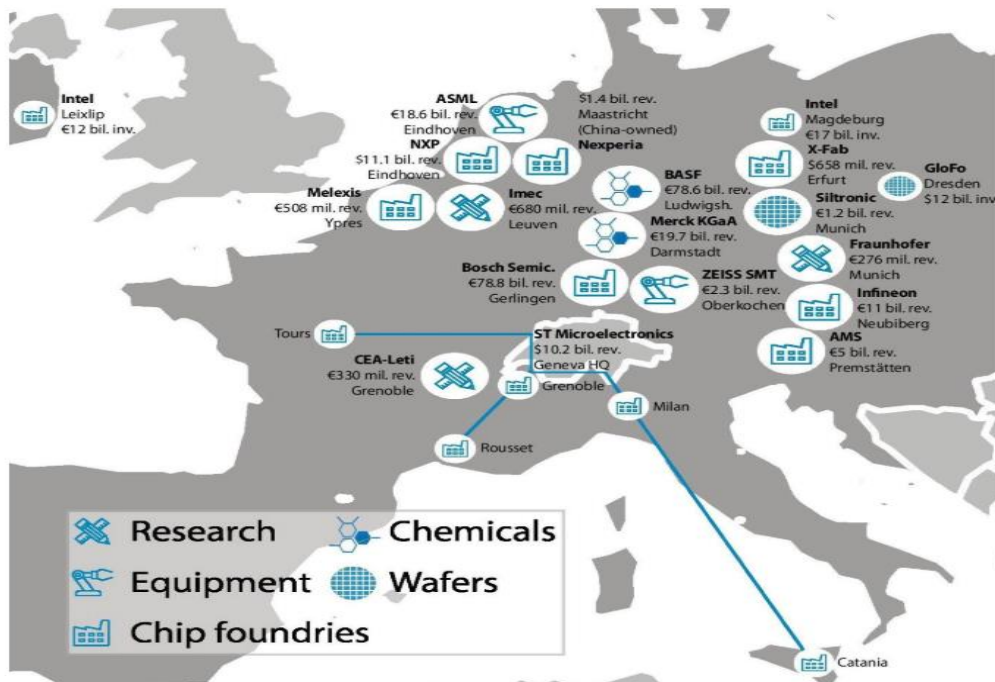


Figure 10 - Major European semiconductor companies, revenues, and FDI

Nearly half of the EU's exports for wafer fabrication are from the Netherlands, and one-third of all the EU exports of equipment in production are done by AMSL, which itself relies on a broad network of 5,000 suppliers across the USA, Europe, and Asia (Ji et al., 2023). Then the merger champion, Franco-Italian chip maker STMicroelectronics, is globally impactful in a way that it will help Foxconn's focus in India and will participate in Taiwan's decoupling from China, but at the same time it will build a chip factory in China (Capri, 2023; Feng, 2023).

For the analysis of the EU's companies within the industry, the Joint Research Centre is using the NACE Rec. classification system of industrial sectors from Eurostat (Joint Research Centre et al., 2022). There are several relevant NACE codes. The first two codes are the following: 1) 26.11 is encompassing "manufacturers of electronic components"; 2) 26.12 is "manufacturers of printed circuit boards" (Joint Research Centre et al., 2022). Under first, there are foundries, fabless companies, and IDMs, with the special case of OSATs, who can also operate as sub-sectors of category 3 - 46.5 "wholesale of information and communication

²³ Figure 10 (Figure 3, p. 4 in the publication *Global Semiconductor Trends and the Future of EU Chip Capabilities*) is the source compiled by author Kjeld van Wieringen with annual revenues (budgets for research centres) reported online in 2022 (van Wieringen, 2022)

equipment” (Joint Research Centre et al., 2022).²⁴ Based on that, from 2019 and 2020, the Joint Research Centre identified and examined financial data for 4.406 companies in the European semiconductor industry and determined that 41% of them are foreign-owned, while the remaining 59% are controlled by EU investors (Joint Research Centre et al., 2022, p. 20). It is also established that the market is quite concentrated, with the top 10 European companies capturing 53% of the total revenue (Joint Research Centre et al., 2022, p. 20). Notably, ASML, a Dutch manufacturer of cutting-edge EUV lithography machines, contributed a significant share of over 12% to the EU’s total turnover in the sector (NACE sector 26.11 for 2020) (Joint Research Centre et al., 2022, p. 20). Additionally, foreign companies hold more, exceeding 18% of the total revenue generated by EU-based semiconductor companies (Joint Research Centre et al., 2022, p. 20). In addition, nearly 80% of the suppliers to the European semiconductor firms are based outside the EU, using the data for 2021 for NACE sectors 26.11 and 26.12 (Joint Research Centre et al., 2022, p. 25-26).

The significance of the industry is also reflected in the generation of employment opportunities, attracting and retaining talent, and raising skill levels (European Commission f., 2022). In 2018, the EU 27 accounted for 219 000 employees in the manufacturing of electronic components and 455 000 high-skilled jobs in the microelectronics sector in the EU, including the design and production of components, materials, and equipment (European Commission f., 2022). Furthermore, as a crucial sector for the entire electronics value chain, it accounts for 2.6 million jobs overall, so the Chips Act could create additional jobs in the industry but also in related sectors due to the high employment multiplier (European Commission f., 2022).²⁵

4.2. Government’s role in the semiconductor industry and lessons for the EU

When speaking about this type of technology, the government's intervention is something that is quite understandable. At least it started as such, since NASA’s mass purchase of integrated circuits continued with mostly research activities (OECD, 2019). In general, today’s leaders in East Asia were just a few decades ago described as “*developing countries*,” who tried to close the technology gap through government-directed industrial

²⁴ See other relevant NACE codes in Appendix C.

²⁵ See Table 2 (p. 84) in the European Commission f. (2022, May 12). European Chips Act: Staff Working document | Shaping Europe’s digital future. <https://digital-strategy.ec.europa.eu/en/library/european-chips-act-staff-working-document>.

policy, creating their own technologies in high-tech fields through strong domestic companies but borrowing technologies in import substation production or by joint ventures with transnational corporations, and consequently, the rise in the global value chain through transnational corporations encompassing vast populations occupied in low-wage countries (Majerowicz & Medeiros, 2018).

During the 1960s and 1970s, the Japanese government built a competitive semiconductor industry by limiting foreign competition in the domestic market and acquiring foreign technology and know-how (Krugman et al., 1986, p. 99). Also, Japan rejected all applications for wholly owned subsidiaries and for joint ventures in which foreign firms would hold majority ownership, and it rejected foreign purchases of equity in Japanese semiconductor firms (Krugman et al., 1986). Today, the EU's giant ASML's biggest shareholders are two American companies: Capital Research and Management Company and Blackrock Inc. (ASML, 2024). Another popular way to boost the industry are tax breaks for companies doing R&D, and the majority of the OECD countries are offering such incentives (see Figure 11).²⁶

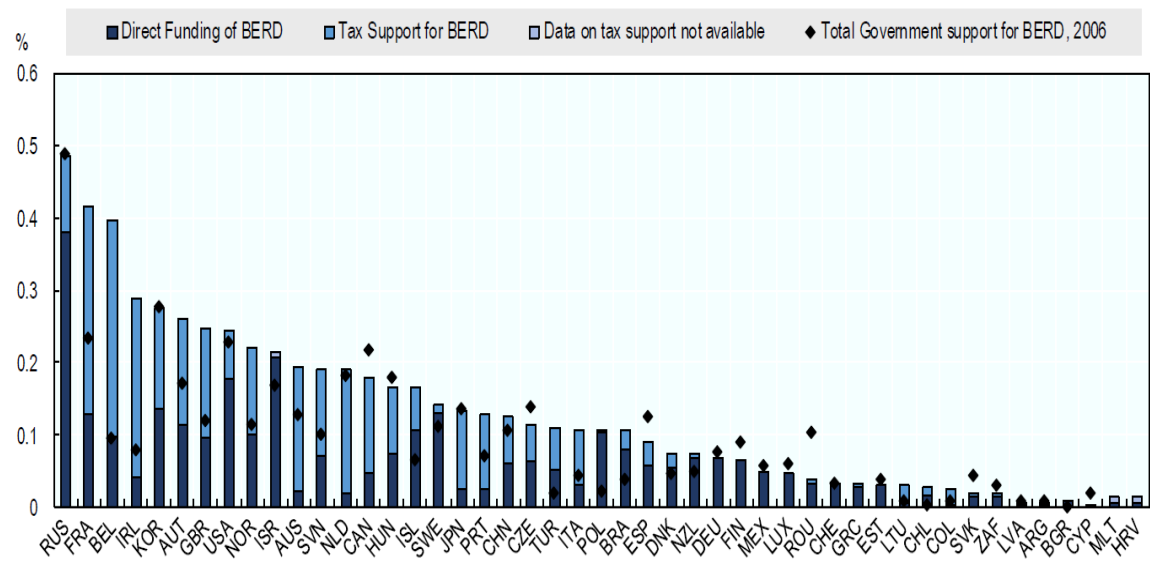


Figure 11 - Direct government funding and tax support for business R&D, % of GDP (2016).²⁷

To bridge the gap between advanced and less advanced technology, countries rely on international transfers of technology (hereinafter ITT), involving activities like importing

²⁶ See Appendix B and Figure 2.1. (p. 33) in the OECD. (2019). Measuring distortions in international markets: The semiconductor value chain. OECD. <https://doi.org/10.1787/8fe4491d-en>.

²⁷ BERD stands for business enterprise research and development (OECD, 2019).

equipment, attracting inward FDI, licensing technology, etc. (OECD, 2019, p. 40). The ITT had a huge impact on the developing countries in the 1960s because they had a spillover of knowledge, especially in the case of Taiwan and South Korea, which benefited from USA firms having located their assembly plants in their countries (Andrenelli et al., 2019; Dicken, 2007; OECD, 2019, p. 40).

In 2014, China started its industrial policy strategy, which will eventually reduce its reliance on the rest of the world. In 2015, a strategy called “*Made in China 2025*” or “*Manufacturing 2025*” was published, along with semiconductors as one of the main areas where China wants to focus its industrial policy (García-Herrero & Weil, 2022; Majerowicz & Medeiros, 2018). The result is massive government support for semiconductor firms, as shown in Figure 12 (García-Herrero & Weil, 2022).²⁸

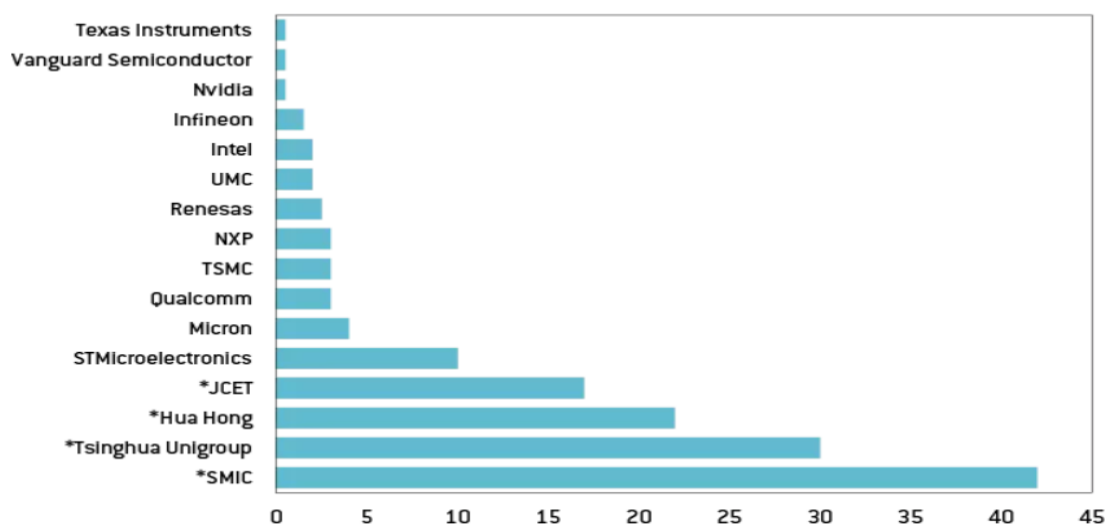


Figure 12 - Estimated total government support provided to semiconductor firms, 2014-2018.

The Chinese are assumed to get inspiration from the German policymakers of the German industrial strategy “*Industrie 4.0*,” which aimed to promote digitalization and the integration of new technologies (Horst & Santiago, 2018; Huda, 2023). Since 2014, China’s state-backed national semiconductor fund and related sister funds have been at the local level, suggesting non-market forces are the strongest in the industry (OECD, 2019, p. 7). In the same OECD analysis, it was highlighted how government financial support, especially equity investments, fuels China’s semiconductor industry because Chinese firms received 86% of

²⁸ See Figure 3: Estimated total government support provided to semiconductor firms, 2014-2018, cited by García-Herrero & Weil, 2022, Source: OECD, 2019; Note: *indicates Chinese firms

such support (OECD, 2019, p. 9). This includes direct connections between government equity injections and the building of new factories, and on the other hand, government support elsewhere was lower and focused on financially struggling companies through debt, not new facilities, in the period 2014–2018 (OECD, 2019, p. 9). Despite significant financial investments, China's push for self-sufficiency has fallen short because, after all, upgrading production is very difficult, as even giants like Intel or Samsung are struggling to keep pace with the TSMC (García-Herrero & Weil, 2022). This could be explained by the low starting point in the highest-value parts of the supply chain, which proves that simply subsidizing will not bring you success for sure (García-Herrero & Weil, 2022).

The most common arguments in favour of government support are the spillover effect, especially in knowledge, and learning-by-doing in the industry (OECD, 2019, p. 30). Still, sometimes public R&D support does not enhance additional firm-financed R&D spending beyond the amount of the subsidy (Dimos & Pugh, 2016).²⁹

From Taiwan's experience, the solution could be based on the idea that small companies, clustered together and guided by the government, are a good starting point, the opposite of South Korea's strategy, where the government gave lots of money to special companies called *chaebol* (Asianometry, 2022). The government was inspired by Silicon Valley and founded a bunch of small companies and gave them a starting boost, which led to the creation of Hsinchu Science Park (Asianometry, 2022). Key person in the creation of TSMC and Taiwanese industry is Morris Chang, who came back to the island after the education and working experience in the USA and who knew that it would be beneficial to become an American primary ally by solving their problem with the investments in manufacturing by solely focussing on chip manufacturing and creating strategic economic advantage (Durán Morenilla, 2024; Miller a., 2022).³⁰ Specifically, what distinguished TSMC was the innovative introduction of the foundry model. Unlike designing their own chips, TSMC focused solely on manufacturing chips designed by other companies, essentially acting as a production workshop, but that strategy provided very good business benefits, including economies of scale and the ability to refine its manufacturing processes (Miller b., 2024). Unlike many other governments that resort to protectionism, Taiwan fostered its

²⁹ Cited by OECD. (2019). Measuring distortions in international markets: The semiconductor value chain. OECD. <https://doi.org/10.1787/8fe4491d-en>

³⁰ All the information from the book *Chip War: The Fight for the World's Most Critical Technology* Hardcover – October 4, 2022, by Chris Miller is taken from the short Summary on Shortform website.

semiconductor industry with low early-stage tax incentives (only 1.5% in the early 1990s), but then avoided subsidies and shielded markets, allowing domestic companies to compete freely. Another trap was avoided in the sense that, unlike many governments that bail out failing companies, Taiwan avoided such interventions, understanding that such politicized failures can discourage any future investments (Asianometry, 2022).

In the case of Japan, Miller in his *Chips War* wrote how significant increase in funding for R&D in semiconductor manufacturing equipment, from 2% at the beginning of 1970s, grew up to 26% of Japan's total R&D spending by 1977, enabling Japan to challenge the USA (Miller b., 2024). Conversely, the fall, according to Miller, was an excess of cheap capital and overinvestment. (Miller b., 2024). This complex interplay of government support, strategic planning, and market dynamics highlights the multifaceted approach needed in the industry, a lesson the EU tries to incorporate in its own ambitious initiative, called the EU Chips Act.

4.3. The EU Chips Act

4.3.1. The aim of the new regulation

The Chips Act is the EU's foundation for semiconductor autonomy, and it requires a multi-faced strategy, or multi-facet approach: short-term (toolbox coordination between Member States), medium-term (strengthening manufacturing activities and supporting innovation), and long-term (maintaining technological in the industry measures or positioning the EU as a technological leader) (Emilio, 2023). Among other things, the strategy includes understanding the landscape of the industry, fostering involvement, diversifying supply chains, analyzing the policy framework, decoupling with China and Taiwan, etc.

Before the EU Chips Act, the EU's main plan for investments in semiconductors and chip technology was through the Recovery and Resilience Facility, with 20% of its budget (up to €145 billion) dedicated to digital transformation over the next few years (European Commission a., 2021). Through this program, the biggest investment for the semiconductor industry was the stated aid of a €292.5 million direct grant to support STMicroelectronics' €730 million investment for the construction of a silicon carbide wafer plant in Catania (European Commission d., 2022). In the Mid-Term Evaluation of the Recovery and Resilience

Facility, nothing was established as part of the semiconductor and/or chip plan, besides the notification that there will be a Chip Act, so it was clearly that there should be a special act.³¹

On September 21, 2023, the European Chips Act entered into force and became effective. This enthusiastic plan was launched to strengthen the EU's semiconductor industry by fostering research, development, and manufacturing of next-generation chips within Europe. Until 2030, the investment plan amounts to €43 billion, with €11 billion coming from public funds and the remaining amount expected to come from private sources. The primary objective is to double the EU's share of the global chip market to 20% by 2030, a significant increase from the current 10% (Boston Consulting Group (BCG) et al., 2021; Dachs, 2023; The EU Chips Act, 2023). Although a step forward, such big investments may be insufficient to achieve the goals set up in the Chips Act. For instance, in Table 2, there is a presentation of some other investments in Asia or in the USA that match or exceed, the entire EU budget (Dachs, 2023, p. 2).³²

Company	Location	Amount	Announced
Intel	Europe	33 bn EUR	March 2022
Texas Instruments	Texas, USA	30 bn USD	May 2022
Samsung	11 facilities, Texas, USA	200 bn USD	July 2022
GlobalFoundries	Dresden, Germany	1 bn EUR	August 2022
Intel	Ohio, USA	20 bn USD	Sep. 2022
Infineon	Dresden, Germany	5 bn EUR	Nov. 2022
TSMC	Arizona, USA	40 bn USD	Dec. 2022

Table 2 - Investment plans for chips fabs in the EU and the USA.

Under the Horizon Europe work program, the EU has launched the Chips Joint Undertaking (hereinafter JU), a collaborative tool between public and private entities, to achieve its goals in the semiconductor industry (Emilio, 2023; European Commission c., 2024). After the COVID-19 crisis and problems with supply chains, the EU leaders announced they were aware of the EU's strengths in the industry but also asserted a few

³¹ In the Mid-Term evaluation, only connection to the semiconductor or chip industry is on p. 111 about the cross-border project amounted to €250 million and investment in Austria to “promote Europe’s autonomy in semiconductor production and promotion of integrated projects along the hydrogen value chain” (European Commission e., 2024)

³² Cited by Dachs, B. (2023). The European Chips Act (Research Report 58). FIW-Kurzbericht. <https://www.econstor.eu/handle/10419/274201>; Original Source: (Financial Times, 2022).

challenges. The first one is how to cope with the low share of global production; the second one is how to manage the dependence on third-country suppliers, which makes the EU vulnerable to disruption; and the third one is the risk of shortages in critical sectors like the automotive industry (Emilio, 2023; European Commission c., 2024).

4.3.2. Overview of the Chips Act

The Chips Act consists of the following three pillars: **1) Chips for Europe; 2) Security for supply; and 3) Monitoring and crisis response** (Dachs, 2023; European Commission c., 2024). The goal of the first pillar is to support R&D and innovations in the field of chip technology, with additional focus on chip design tools and pilot lines for prototyping and testing new technologies (Dachs, 2023, p. 2; European Commission f., 2022, p. 62). Support means supportive training and skill development for the workforce (Dachs, 2023, p. 2). The second pillar is about the new legal framework, which should attract immersive investments in chip production based on the state aid rules of Article 107 of the Treaty on the Functioning of the European Union (TFEU). This pillar provides legal provisions for state aid to support investments in new chip fabs in the EU, making new production facilities eligible for such aid (Dachs, 2023, p. 2). More importantly, the Chips Act is not providing options for direct investment projects but rather trying to give an impetus for the Member States to work on such investments (Dachs, 2023, p. 2). The third pillar is a mechanism to monitor the market and anticipate potential crises and possible supply shortages in the industry (Dachs, 2023; European Commission c., 2024). The governance of the EU Chips Act will be divided between the European Semiconductor Board (hereinafter ESB), which will succeed the existing Semiconductor Expert Group, and the Chips JU, which will be formed out of the current Key Digital Technologies JU (Dachs, 2023). The participating states of the Chips Joint Undertaking are all EU members plus Norway, Iceland, and Israel.³³ Here, a very interesting fact is the inclusion of Israel in the Chips JU due to its significant role in the industry, especially after Intel decided to invest a significant amount of \$25 billion in a chip plant supported by the support of the Israeli government in the amount of \$3.2 billion (Reuters, 2023). Funding for the second pillar is estimated to be as much as €30 billion (Dachs, 2023).

All participating Member States will provide their representatives on the ESB, chaired by the European Commission (hereinafter the Commission). The Governing Board of the

³³ See more on the following page: <https://www.chips-ju.europa.eu/members/>

Chips JU will include representatives from participating Member States, corporate members of the JU, and the Commission (Chips JU, 2024; Dachs, 2023). Within the Commission, the Chips Act is administered by the Directorate-General for Communications Networks, Content, and Technology (DG CNET) (Dachs, 2023).

Dachs's first criticism is about the governance and funding structure.³⁴ The second critic is related to the focus on “*first-of-a-kind*” facilities, as proposed by the Industry, Research, and Energy Committee (hereinafter ITRE), primarily suited for cutting-edge chips in communication and data processing equipment, which only form a small part of Europe's overall demand (Dachs, 2023; European Commission a., 2021, p. 87). What the industry in Europe needs are chips produced at larger sizes above 10 nm (Dachs, 2023). Also, it is noted that chips made in Europe could be more expensive than the products of Asian competitors and may find it difficult to find a market (Dachs, 2023). The ITRE's suggestion to broaden the definition to include advancements in efficiency, sustainability, or security has expanded funding opportunities, but the core tension between industry needs and cutting-edge goals still persists (Dachs, 2023). Consequently, the Chips Act is unlikely to be a short-term or medium-term solution to Europe's chip shortages. In fact, the Act, along with similar initiatives worldwide, could even lead to future risks of overcapacity (Dachs, 2023).³⁵ The third critique is that the EU faces a potential policy contradiction because the Chips Act might make it difficult for the EU to criticize foreign subsidies while simultaneously engaging in its own chip subsidy race (Dachs, 2023).

4.3.3. Funding complexity and concerns

The proposed funding target of 43 billion includes both public and private funds, so it is difficult to assess the exact amount of each source of money. For example, it is not very clear how much money will come from the European Regional Development Fund or the European Development Bank (Dachs, 2023). The EU leaders are hoping that private funding will not be as bad as it was, for example, in the period between 2006 and 2010. It was the time of the economic crisis, but compared to other developed economies, private companies in the EU invested significantly less in information and communication technologies (ICT) and R&D, including the semiconductor industry, creating a gap (Directorate-General for Research and Innovation (European Commission), 2016). This lack of focus on R&D hindered Europe's

³⁴ See Chapter 4.3.3. Funding complexity and concerns.

³⁵ See Chapter 4.3.4. Risk of overcapacity.

ability to become a major player in the ICT sector and limit the positive impacts of ICT advancements on other parts of the economy (Directorate-General for Research and Innovation (European Commission), 2016).

The EU budget comes only with €3.3 billion (Emilio, 2023; European Council & Council of the EU, 2023). This amount is based on the sum from Article 3, paragraph 2 of the Chips Act, which stipulates the following: “*The Initiative shall be supported by funding from Horizon Europe and the Digital Europe Programme, and in particular Specific Objective 6 of the Digital Europe Programme, for a maximum indicative amount of EUR 1,725 billion and EUR 1,575 billion, respectively.*” (The EU Chips Act, 2023). 10 years ago, a quite similar amount was spent over 4 years, as stated in the well-known Report to Commissioner Gabriel from 2018 (European Commission & Fraunhofer, 2018). The same report indicates that the European ecosystem for research and innovation in semiconductor devices has been extended to the research, development, and manufacturing of electronic components and systems (ECS), comprising the whole supply chain from research and technology organizations (hereinafter RTOs) to system houses, with the ECSEL Joint Undertaking playing a key role by investing €2.6 billion in 51 collaborative projects involving more than 1,600 research, development, and end-user organizations (European Commission & A report to Commissioner Gabriel, 2018, p. 7).

The European Chips Act allocates €11.15 billion in public funding to this initiative by 2030 (Dachs, 2023). This sum combines €5.85 billion from the Commission’s budget and an expected additional €5.3 billion from the EU Member States, again by 2030 (Dachs, 2023, p. 3). Notably, the EU will utilize part of its existing programs like the Horizon Europe budget for the Chips Act, with implementation handled through both Horizon Europe and Chips JU (Dachs, 2023, p. 3). The Commission also anticipates that Member States will redirect funds from the Recovery and Resilience Facility (RRF) to further support the Chips Act (Dachs, 2023). Additionally, national and regional funds from the Member States will contribute to the overall investment. (Dachs, 2023).

The criticism of this plan is the governance and funding structure, since it is delicate to understand who is funding what and how much money is available for the Chips Act (Dachs, 2023; Poitiers & Weil, 2024). The amount of money that shall be driven is expected to be in total around €43 billion, but it remains unclear how much will come from the EU level, Member States, and the companies, although only €3.3. billion directly from the EU budget (Dachs, 2023; Emilio, 2023; Poitiers & Weil, 2024). The EU Member States are likely to

contribute the most public funding through the Important Project of Common European Interest (hereinafter IPCEI) for microelectronics, which allows the Member States to directly support industrial R&D (European Commission & Fraunhofer, 2018; Poitiers & Weil, 2024). While IPCEI has some drawbacks related to transparency and governance, it is a significant EU tool for channelling both public and private funds towards achieving industrial objectives like boosting production (Poitiers & Weil, 2024). The Bruegel analysts believe that state subsidies offer some support; developing a more robust venture capital project is a more long-term solution, and that is an issue that the EU is comparing with, for example, the USA's high-tech sector, which the EU Joint Research Centre determined in their 2022 report accounts for 60% of venture capital investments originated outside Europe (Joint Research Centre et al., 2022, p. 23; Poitiers & Weil, 2024).

The following concern is about the funding that might be simply redirected from already existing programs like Horizon Europe (Dachs, 2023). For example, the budget of Horizon Europe will be decreased by €400 million to make the equivalent increase available for the Digital Europe Programme, and to compensate for this, the Commission proposes to make a further amount of €400 million available again for Horizon Europe in the period 2023–2027 (Nove, 2022). Additionally, the Chips Act mentions the “*first-of-a-kind*” designation for the investments, but it could spark a sort of subsidy war between Member States (Dachs, 2023).

Furthermore, the Chips Act's focus on “*first-of-a-kind*” industrial facilities might be misguided because it seems clear from the notion of “*first-of-a-kind*” facilities that only investments in the production of cutting-edge chips are conceivable; however, such cutting-edge chips represent only a small portion of Europe's total chip demand (Dachs, 2023, p. 3). In addition, building such domestic capacity could present significant risks for public funds (Poitiers & Weil, 2024). Building a new facility to produce advanced chips costs around \$20 billion (Bassot & EPRS, 2022). Some sources are saying it can be done for less; for example, Intel claims it can be done for \$12 billion, but it took years and 6,000 construction workers to build it (Hmaidi & Chang, 2023). Simply put, mastering these enormously complex technologies is far from guaranteed, and factories need a constant high level of operation to turn a profit (Poitiers & Weil, 2024). The global players are pouring more money into the

industry, including Europe, but it is still declining in decades, as presented in Figure 13 (European Commission f., 2022; Timmers, 2022).³⁶

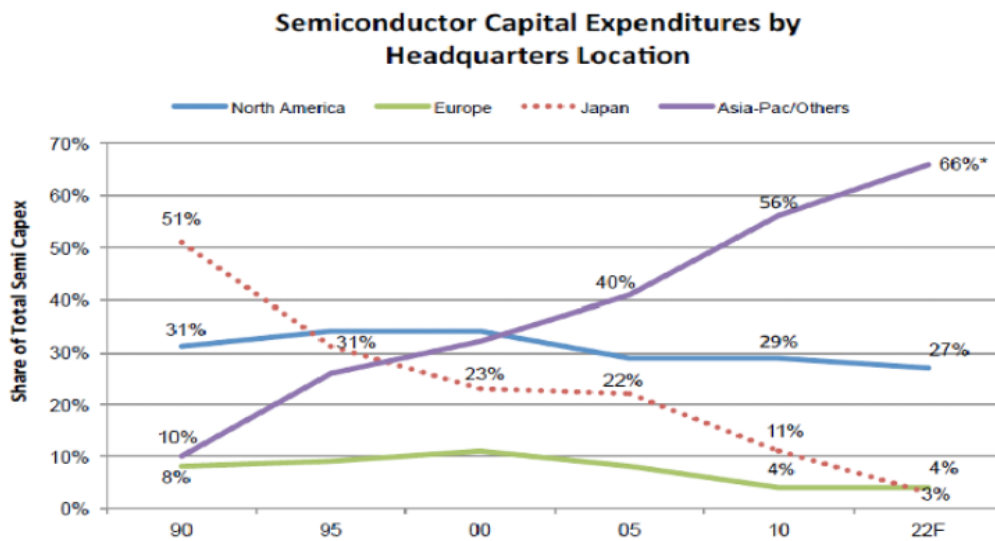


Figure 13 - Evolution of capital expenditure in semiconductor sector by region, based on headquarters location.

Currently, only a few companies (TSMC, Samsung, and Intel) produce cutting-edge logic chips, and these companies have huge negotiating power when countries are competing to attract them (Poitiers & Weil, 2024). The first such major investment based on the Chips Act is Intel's €80 billion investment in Europe in the next decade, but Intel has to negotiate with each Member State where its locating facilities for state aid are (Euronews & Reuters, 2022).

The Commission determined that two application areas that are built on cutting-edge chips (3% in communication and 5% in data processing equipment) are only 8% of the EU's total demand (Dachs, 2023, p. 3; European Commission, 2021). Thus, the Chips Act prioritizes cutting-edge technology below 10 nm, but the European industry primarily relies on larger chips above 10 nm (Dachs, 2023, p. 3).

4.3.4. Risk of overcapacity

Chip demand is expected to surge in the following years, and current shortages are pushing governments and companies to ramp up production, but there is also a fear of a future glut (Poitiers & Weil, 2024). The proof of this could be the prices of chips, which were

³⁶ Note for Figure 13: China share is forecast to be (% in 2022, up from 6% in 2016 (European Commission f., 2022; Timmers, 2022), see Figure 43 (p. 74); source: IC Insights 2022 as referred to in EC staff working document (European Commission f., 2022; Timmers, 2022).

forecast to plunge 16% in 2022 as supply races ahead of demand, which is historically normal boom-and-bust cycles in the industry (Poitiers & Weil, 2024). However, the Commission has not clarified what market failure the Chips Act aims to fix or how achieving, at best, a minor market share in cutting-edge technology will bolster the EU's geopolitical standing (Poitiers & Weil, 2024).

Emergency measures to manage the supply of chips in the EU do not correspond to the real dynamics of supply and demand in the high-end chip sector (Poitiers & Weil, 2024). High-end logic chips are produced according to customer specifications, take a long time, and cannot be quickly redirected. A request to divert production would be inconsistent with the industry, as shown by the shortage of chips in 2021 (Poitiers & Weil, 2024).

Another dilemma for the Commission is that if they are going to act as buyers, they must choose which companies will allocate the funds. Bruegel believes the better solution is if the companies review the trade-offs between lean inventories and supply sustainability or adapt to the risks of the GVC since the pandemic shortage crisis (Poitiers & Weil, 2024). Protective measures in an import sector like semiconductors could set a dangerous precedent for the EU, potentially triggering similar actions by other players (Poitiers & Weil, 2024). Chip shortages stemmed from many economic factors, not just export bans (Poitiers & Weil, 2024). Stronger trade policy is better achieved through general trade defence tools than export controls on chips (Poitiers & Weil, 2024). The EU should resist protectionism triggered by recent global crises and instead force sustainable trade, balancing between creating global cooperation with likeminded partners for strategic good and retaining policy independence from the USA (Poitiers & Weil, 2024).

Some trade experts believe that overcapacity is driven by China, similar to what has transpired in steel and solar markets, as summarized in the quote: “*China is always enticing industries to grow. The system breed overcapacity.*” (Benson et al., 2024). Besides China's efforts to less rely on foreign imports, another reason that drives potential overcapacity are the pandemic-related supply chain disruptions, pushing governments to build more resilient supply chains to avoid future disruptions (Benson et al., 2024). Yet, it could be that the industry has just been cyclical since the 1950s and the birth of the industry (Benson et al., 2024; Dicken, 2007).

4.4. National champions vs. EU champions

The EU's semiconductor components are developed and produced mainly in the following countries: Germany, France, Italy, the Netherlands, Austria, Belgium, and Ireland (European Commission a., 2021, p. 85). Several major European suppliers have a global reach, including Infineon and Bosch Semiconductors (Germany), NXP (Netherlands), and STMicroelectronics (France and Italy) (European Commission a., 2021, p. 85). These companies are leaders in supplying Original Equipment Manufacturers (OEMs) across various sectors, including the automotive industry, industrial automation, security, and healthcare (European Commission a., 2021, p. 85). The car industry was especially hit during the 2021 and 2022 semiconductor crunch, with estimated damage of €100 billion (Subran, 2022).

The question that arises is: should the EU foster its national champions within Member States, or should it pursue a more unified, EU-wide approach? Arguments in favour of national champions are surely faster decision-making and implementation on a national level, but on the contrary, there is a risk of fragmentation and duplication of efforts across the EU, potential competition between the Member States, and perhaps the most problematic - how to achieve the economies of scale needed for global competitiveness. The EU approach undoubtedly enables pooling of resources and expertise across the EU and fosters collaboration and knowledge sharing, creating a unified and competitive EU semiconductor industry. The problem with that is a slower decision-making process due to bureaucracy and the risk of an unequal regional distribution of benefits across the EU. The EU's approach likely lies somewhere between these two extremes. It can encourage collaboration and knowledge sharing through EU-funded research and development initiatives while allowing member states to support the development of domestic chip manufacturing capabilities. This hybrid approach would leverage national strengths while fostering a unified European industry. The semiconductor industry is not an exception to the usual problems the EU is facing when it comes to strategies. They mostly lack significant geopolitical analysis, leading to political and strategic emptiness, and consequently, it is very hard for them to see themselves as fully-fledged actors in any field of the international arena due to the different national visions of the 27 Member States (Vimont, 2016).

The question is also what benefits the rest of “New Europe,” particularly South, Central, and Eastern Europe, might gain. Investments like those above could be a chance for

Central and Eastern Europe because of their geographical proximity to the EU's leader, Germany (Nikolova, 2021). For example, according to the Polish policymakers, Poland offers a central location, resources, good communication, low production costs, ready infrastructure, and an educated workforce, which new Intel investments in Wroclaw prove, but the state still needs an appropriate state policy, a long-term strategy, and consistent support from the EU, which is to be served by the EU Chips Act (Intel a., 2023; Nikolova, 2021). Another potential area to benefit one day could be Ukraine, with an estimated value of rare earth materials ranging from \$3 trillion to \$11.5 trillion, making it the world's fourth economy and Europe's first in terms of the value of its deposits (Hazla, 2023). Therefore, there is some potential to include the entire Europe towards self-sufficiency.

Yet, Europe is experiencing a sort of boom in semiconductor manufacturing, with several multi-billion-dollar investments announced. TSMC and Intel are partnering with the EU governments and companies to build new fabrication plants, aiming to strengthen the EU's chip production capabilities and lessen dependence on Asian suppliers (Giovanni, 2023). The leader is Germany, where both TSMC and Intel are setting up factories there. TSMC agreed to a joint venture with Infineon, Bosch, and NXP, creating the ESMC (European Semiconductor Manufacturing Company) in Dresden, and Intel is launching new fabrication worth \$30 billion in Magdeburg (DW, 2023; Giovanni, 2023). Similar projects are underway in France and Italy, where GlobalFoundries is partnering with STMicroelectronics on a €7.5 billion fab in Grenoble. STMicroelectronics is also building a new factory in Italy focused on automotive, industrial, and consumer electronics and a unique plant in Catania to manufacture silicon carbide wafers (Giovanni, 2023).

Although it is a step towards self-sufficiency, challenges such as high labour costs and long-term competitiveness remain. A solution could be found in increased automation and attracting skilled workers from abroad (Giovanni, 2023). Therefore, further investments should be made in education systems to create a skilled workforce (Giovanni, 2023). However, this wave of investments presents a similar problem to the subsidy race – competing to attract investments, especially to attract American companies. This competition could hinder the creation of a cohesive Marshallian district in the EU, a needed condition to compete against other major players. In other words, Member States might end up competing against each other, potentially leading to counterproductive outcomes and presenting obstacles to the unified approach of the EU.

4.5. The USA – the EU’s partner or competitor?

The EU and the USA are sharing a concern regarding China's dominance, but at the same time they are also competing for market share and technological leadership. During the 1980s, the USA moved chip production to Asian countries with cheaper labour but still held a power derived from network centrality that enables American multinational corporations to create and extract value (Kotarski a., 2024). In fact, the USA still appropriates the largest percentage of added value in the total production of chips, and its influence is particularly evident in designing software and equipment for chip production, as shown in Figure 14 (Kotarski a., 2024).³⁷

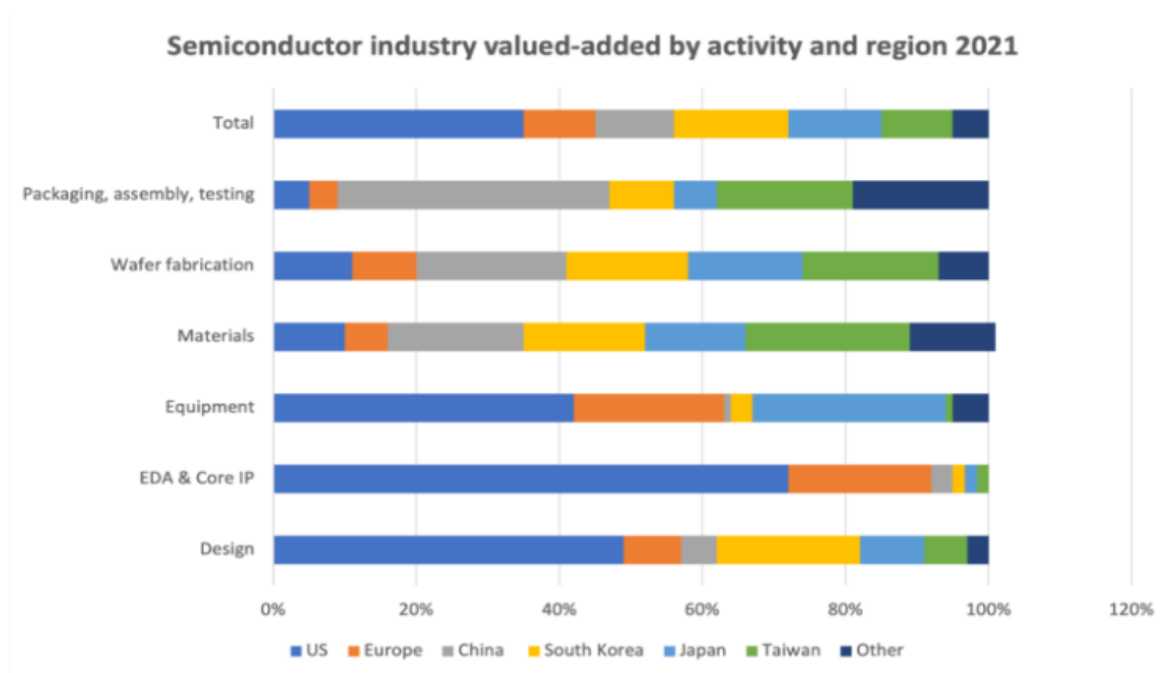


Figure 14 - Semiconductor industry valued-added by activity and region 2021.

Such a level of control is echoed in the fact that the USA’s multinationals had as much as 48% of the global chip industry's revenue share, while South Korea had 19%, Japan had 9%, Europe had 9%, Taiwanese had 8%, and China had 7% (Kotarski a., 2024). Moreover, the USA’s multinationals appropriated 275 of the totals of \$574 billion in sales of the sector (Kotarski a., 2024; Semiconductor Industry Association, 2023).³⁸ Thus, despite decentralization, the USA holds the focal point in the global chain.

³⁷ Original source is Semiconductor Industry Association, 2022 as stated in Kotarski a., 2024.

³⁸ Cited by Kotarski a., K. (2024, February 21). Čipovi, kruh naš svagdašnji: Tko će biti glavni pekar? (I). <https://arhivanalitika.hr/blog/cipovi-kruh-nas-svagdasnji-tko-ce-bit-glavni-pekar-i/>

According to Malkin's and He's article from 2023, the USA has several instruments divided into three main groups to maintain the existing distribution of economic and, indirectly, military and political power (Malkin & He, 2023).³⁹ These groups are: 1) occupying a central position in the global value chain; 2) legal-jurisdictional power; and 3) power based on the control of military-diplomatic alliances (Malkin & He, 2023).⁴⁰ The first instrument refers to the retention of innovation capacity in the design of increasingly complex chips and the control of key parts required for the production of chips (Kotarski a., 2024). The second implies using the concept of extraterritoriality, or, in other words, the application of national regulations outside the borders of the home state, and this is the case of the Foreign Direct Product Rule (FDPR), which allows the USA to enforce a ban on the export of capital equipment or semiconductors to a seller based in another country and a potential buyer in a third country if the equipment or final product in question relies on a certain percentage of American parts (Kotarski a., 2024). The third line entails diplomatic pressure on allied governments, which we recently witnessed when the USA pressured the governments of the Netherlands and Japan, which can ensure control over manufacturers in their own countries to comply with the ban on the export of computer lithography equipment to China (Kotarski a., 2024).

The recent announcement of Intel's new investments in Germany, France, Italy, Spain, Poland, and Ireland signifies even better cooperation between the EU and USA (Intel b., 2022). However, concerns remain regarding potential USA dominance and restrictions on technology transfer. The fact that the EU's giant ASML's biggest shareholders are two American companies: Capital Research and Management Company and Blackrock Inc., which China would never approve, with its continued aggressive trade policies against China in trade wars, indicates that the USA is still dominating over the EU. In addition, it is heavily reliant on its San Diego-based affiliate Cymer (Hamilton, 2022). Especially, in the case of the EU's giant AMSL, whose EUV lithography tools, maybe the most expensive mass-produced machine in history, are not really Dutch, as most of the components are American (Miller a., 2022, p. 230).⁴¹ Europe could take a different approach, and instead of pouring vast amounts of money into the fabrication process, it could focus on becoming a champion of advanced

³⁹ Cited by Kotarski a., K. (2024, February 21). Čipovi, kruh naš svagdašnji: Tko će biti glavni pekar? (I). <https://arhivanalitika.hr/blog/cipovi-kruh-nas-svagdasnji-tko-ce-bit-glavni-pekar-i>

⁴⁰ *Ibid.*

⁴¹ Crucial components came from Cymer and Zeiss, which is a German firm, but also relies on American equipment (Miller a., 2022, p. 230).

chip design, focus on R&D, or choose intellectual property over manufacturing like Israel did (Friedmann, 2023; García-Herrero & Weil, 2022). Europe can strategically steer the future of semiconductors by directing resources and expertise towards designing new chip types like AI-focused domain-specific architecture (DSA) (Friedmann, 2023). In any case, there is a technological gap between the USA and the EU. While the EU excels in the medium-high technology sector, the USA is a leader in high R&D intensity sectors, so this presents an opportunity for the EU to enhance their innovation potential by focussing on higher-technology-intensive sectors (Marin et al., 2017).⁴² In 2024, American company Nvidia has become the most valuable company in the world, mostly because of the fact that it is estimated to control between 70% and 95% of the AI chip market, further reassuring the dominance between the USA and the EU (Pequeño, 2024).

Partnership between the USA and the EU is still unquestionable, but in reality, the EU's position is subordinate. Political bodies like the EU-US Trade and Technology Council (TTC) are proposing the USA-EU cooperation, which could form the core of a broader semiconductor consortium of like-minded nations, including Japan, Taiwan, and South Korea, that could also consider forging a common innovation base with R&D of next-generation semiconductor designs and materials (Hamilton, 2022).

4.6. Comparison between the EU and other major players

First of all, it must be noted that making comparisons between the EU's and other major players policy plans in semiconductors is at this moment very hard and unthankful. The reliability of the data is questionable, and for academic research, it would be much better to do the research after the measures are effectively done, probably after 2030.

For the purpose of comparison, only the major global players are taken into consideration, the EU's competitors. The figures are very estimated and conservative, based on the available data, and sometimes ambiguous. It is hard to determine how much money comes from the state budget and how much from private sources, but for the purpose of this comparison, the total amount will be taken. For example, although it is stated in this thesis that the EU Chip Act will drive in a total of around €43 billion in investments, from the EU

⁴² The EU is focusing mainly on medium-high technology like motor vehicles, chemicals, and industrial technology, whereas the USA focusing on high R&D intensity sectors like software, biotechnology, and computer electronics (Marin et al., 2017)

budget comes only €3.3 billion, but the total amount will be taken as the relevant one, which includes EU budget sources, private and public spendings.

Among competitors, the first to be noted is China, which in 2022 announced that it would spend more than 1 trillion yuan, or \$143 billion, to support its semiconductor industry (GPA, 2022; The Economic Times, 2022; Zhu, 2022).⁴³ For Taiwan, some reports claim that Taiwanese suppliers will invest around \$210 billion in the next five years globally (Tzu-yu & Huang, 2023; Wu, 2022). TSMC's plan is to invest \$40 billion to build two advanced wafer fabs in Arizona, then to spend \$1.60 billion to build a fab in Japan's Kumamoto through a joint venture (Kinery, 2022; OCAC, 2023). Also, there is a plan to form a joint venture to set up wafer fab in Dresden. Taiwan's equivalent of the similar act or bill is called the Statute for Industrial Innovation, the law that mostly introduces massive tax incentives aimed at encouraging manufacturers to invest in cutting-edge production and research (Ebrahimi & Lu, 2023). The World Bank does not have GDP data about Taiwan, but still data about Taiwan's GDP for 2023 is very differentiated, from \$755,3 billion, according to the Taiwan Representative Office in the EU and Belgium, to 731,44 billion, according to the World Economics, and all up to the Statista, which is estimating Taiwan's GDP to be \$1.572 trillion (Statista a., 2024; Taipei Representative Office in the EU, 2024; World Economics, 2024).⁴⁴ South Korea has a huge plan to bring in investments in the staggering amount of \$470 billion by 2030, but the deadline could be to some reports by 2047 (European Commission d., 2022; Fritz, 2024; TrendForce, 2024).⁴⁵ Japan revealed a \$67 billion investment plan to become a global chip superpower again, as they once were, with a homegrown venture called Rapidus Corp. to manufacture 2 nm logic chips (Nohara, 2024). Part of the strategy is also establishing the LSTC, a government-supported R&D centre for advanced chip research (Shivakumar et al., 2023). President Biden signed the Chips Act in 2022, launching a new \$52.7 billion plan to bolster the USA's leadership in semiconductor research, development, manufacturing, and workforce development (House, 2022). Out of this, \$39 billion is dedicated to manufacturing incentives, \$13.2 billion to R&D and workforce development, and \$500 million to international information and communications technology security and semiconductor supply chain activities (House, 2022; Sargent Jr. et al., 2023).

⁴³ The amount is different in the Introduction Chapter.

⁴⁴ Statista figure is converted from New Taiwan Dollars to US Dollars on 17 May 2024.

⁴⁵ Different amount is stated in the Introduction Chapter

All the data for R&D expenditure as a percentage of GDP is taken from the World Bank for 2021 for five states; additionally, data for Taiwan is taken from Statista (Statista b., 2024; World Bank a., 2023). Therefore, as shown in Figure 15, which is a very rough estimation and not timely aligned, Taiwan and South Korea have the highest investment in semiconductors relative to their GDP, which indicates that these countries are prioritizing the development of their semiconductor industries.⁴⁶ South Korea has the highest R&D expenditure relative to the GDP and the highest amount pledged for investments, followed by Japan and China.

Country	Investment (\$ billion, estimated)	GDP in 2023 (in billion)	Investment/GDP Ratio	R&D expenditure in 2021 (% of GDP), World Bank
China	143	17960	0,80%	2,43
Taiwan	210	803	26,15%	3,77
EU	46,76	16750	0,28%	2,28
Japan	67	4260	1,57%	3,3
South Korea	459	1670	27,49%	4,9
USA	52,7	25440	0,21%	3,46

Figure 15 - Comparison of semiconductos investments among main players.

In general, this indicates that the EU is still lagging, but these are general numbers and not specified within semiconductor industry, but if the goal is to generally reduce dependency, the EU should incentivize more investments. The low ration for China indicates that they are also still importing for their needs or that there is inefficiency in translating their investments into production capabilities. Returns on investments should translate into a bigger market share, but it depends on the precise niche of products within the semiconductor industry. Therefore, it is crucial for the EZ to significantly boost its investments to close the gap.

⁴⁶ Note for Figure 15: all amounts are converted to USD.

5. Recommendations

In the Report to the Commissioner Gabriel in 2018, it was stated that despite, at that time, huge investments, many macro-economic and technological factors have negatively impacted the European position in the global value chain in the ICT industry (European Commission & Fraunhofer, 2018). Several actions were proposed based on some established flaws, like the fact that European semiconductor manufacturers are not active in central processing units for computers or in mass storage memory, but on the other hand, they have the necessary know-how and technology for developing such solutions (European Commission & Fraunhofer, 2018). One of the goals is to create a pan-European research infrastructure for advanced computing technologies with companies like Imac, Fruanhofer, and CEA, who are key European RTOs (European Commission & Fraunhofer, 2018).⁴⁷ The next one should be to strengthen microelectronics manufacturing by extending and enhancing the IPCEO framework beyond 2020 (European Commission & Fraunhofer, 2018).⁴⁸ Additionally, securing component sovereignty through a strategic "sovereignty" program to develop essential assets for critical electronic components, particularly in aerospace, defence, security, and other sectors, is vital (European Commission & Fraunhofer, 2018).⁴⁹

Veugelers and Cincera challenge the EU's innovation policy, noting the lack of young, leading innovators, or "yollies," in the EU compared to the USA, especially in the semiconductor sector, therefore creating a gap between the EU and the USA in this case (Veugelers & Cincera, 2024).⁵⁰ In relation to innovation, the thing that the EU should work on is productivity. Since 1995, it has been declining compared to the USA, according to some analyses, which indicate that the productivity slowdown is attributable to the slower emergence of the knowledge economy in Europe compared to the USA (van Ark et al., 2008). Therefore, investing in talents, education, and their development, should be considered. When the total number of jobs fell in the ICT manufacturing industry by about 20,000 between 2002 and 2004, which led to the rise of East Asian hubs in the semiconductor industry, production and assembly shifted to Mexico, Eastern Europe, and other lower-cost nearshore locations (Remes et al., 2018). Thus, Europe should unify its efforts, leveraging current economic

⁴⁷ Proposed action 8 in the Boosting Electronics Value Chains in Europe: A report to Commissioner Gabriel (European Commission & Fraunhofer, 2018).

⁴⁸ Proposed action 2 in the European Commission & A report to Commissioner Gabriel, 2018, p. 12

⁴⁹ Proposed action 3 in the European Commission & A report to Commissioner Gabriel, 2018, p. 13

⁵⁰ See more details in Table 1: Comparing EU to US yollies in key sectors. Note: explanation of the gap between USA and EU

challenges like inflation and supply chain crises to adopt a united approach that benefits the whole Europe. Could Eastern Europe at least play a role in ATP and advanced packaging as a stage in the value chain? There is innovation gap and a problem with skilled labour force, but one of the goals of the Chips Act is investment in skilled workforce (European Commission f., 2022).

Given the diverse economic capabilities of the Member States, achieving further integration in the industry is easier for wealthier countries with more established technological infrastructure, such as Germany and France, who are likely to be the winners of the EU's plan in the semiconductor industry. Therefore, the Marshallian districts are likely to be created in those regions. However, to include other Member States, particularly less developed ones, the EU should offer those countries more attractive financial compensation. If not, those countries will simply lean on the non-EU technology.

In general, the EU should foster international cooperation, diversify their supply chains, pursue alternative partners in any stage of the value chain, and reduce dependence on Asia. This strategy aligns with objectives set in the Chips Act. Definitely, intra-cooperation should also be incentivized, offering substantial incentives for participation in the integrated supply chains. Moreover, achieving economies of scale should be essential to fulfilling these objectives, but only on the EU level. Otherwise, there will be competition among Member States, and that should be avoided because such fragmentation and multiple production facilities do not maintain the responsible industrial policy.

6. Conclusion

The world is currently witnessing a global race for chip dominance, which is reflecting the strategic importance of semiconductors. Hence, the potential consequences if there is a China-Taiwan war will be devastating to the EU's semiconductor sector. Surely, the EU needs to be prepared for numerous scenarios and actively pursue mitigation strategies by, for example, diversifying its supply chains, investing in domestic production capabilities, and fostering international cooperation. Simply due to the nature of the industry and the complexity of the supply chain, achieving self-sufficiency by 2030 is not a realistic plan because the EU is not ready at all in the period of six years to achieve something that was built in decades. Obviously, mutual interdependence will persist because not a single country can be self-sufficient due to its complexity, geographic specialisation, and deep interconnection (van Wieringen, 2022). Even China recognizes that the replication and establishing an all-domestic supply chain are simply impossible (Miller a., 2022).

Nevertheless, the EU can still work on its strategic level of autonomy by building an industry and, therefore, gaining greater control over its technological future. Building the industry necessitates the construction of the new facilities. Qualcomm, a company that might not have survived if they had invested billions in building fabs, exemplifies the fabless model (Miller a., 2022, p. 213). The fabless model and outsourcing are still valid, but today's geopolitical reality might be different, so the EU's approach is sort of logical and understandable.

For sure, investment in R&D must be constant since it is essential for maintaining leadership and the development of cutting-edge technology. As stated before, Europe must diversify its supply chain so it can be more resilient and less reliant on any geopolitical risk. For some Member States, the EU's Chips Act does not affect their plan to boost their position in the industry, like Germany, which initiated the creation of the European Semiconductor Manufacturing Company, a planned joint venture with TSMC, Infineon, Bosch, and NXP, but the company will be 70% owned by TSMC, with Bosch, Infineon, and NXP each holding a 10% equity stake (NXP Semiconductors, 2023). Clearly, the EU decided to release state aid rules to incentivize the industry, and it is a good sign, but for now, it is not enough compared to others.

The Chips Act is likely to become a pioneer of the EU's strategic autonomy, and despite all the imperfections, it lays a foundation for more comprehensive and practical

strategies that address critical dependencies (Timmers, 2022). In Commission Staff Working Document SWD (2022) 147 final, the Commission appointed several, general objectives that would be assumed to be a success: Strengthen EU research and technology leadership; Address the skills shortage, attract new talent, and support the emergence of a skilled workforce; Reinforce the capacity of Europe for innovation in design, wafer manufacturing, and packaging; Establish a framework to increase substantially production capacity by 2030; Develop an in-depth understanding of global semiconductor supply chains and enable the EU to take appropriate measures when necessary (European Commission f., 2022). There is a base, there are upcoming investments, and the objectives are set broadly, meaning that probably it will bring some improvements and increase, but how much and who will benefit from it is matter that can be analysed after some time. In the short run, the complete replication of supply chains is impossible, especially with these scales of investments.

It was previously discussed that the economic burden of replicating established systems is so significant that no country can achieve complete self-sufficiency in all production stages (Kotarski b., 2024). Despite that, the EU should focus on their strengths, like the automotive industry, and not, for example, consumer electronics (Subran, 2022). In general, the EU lacks unity in these ambitious plans. One of the reasons why, for example, the Lisbon Agenda failed is because, at the common EU level, national interests prevented the creation of a unified research space, as famously summarised in the Kok report, which identified a lack of political will as the main culprit (Wyplosz, 2010). The EU's "Digital Decade" faces almost the same challenges, notably the problem of the European innovation ecosystem, designed to support the entire innovation lifecycle, which is characterised by fragmentation (Markevičiūtė, 2023). In the Commission's Report about the Implementation of the Strategic Action Plan on Batteries, crucial for the ambitious Green Deal, similar problems could be found, like imports of critical raw materials, dependency on East Asia, the reorganisation of financing, and others (European Commission g., 2019). All these problems from previous plans could also appear with the Chips Act, which is for sure a step forward, but simply because it is not big enough to catch the other dominant players, the plans and announcements should be more realistic in that sense.

Another crucial factor in reducing dependency is achieving economies of scale. Miller explained that by mass-producing chips, TSMC achieved cost efficiency (Miller a., 2022).⁵¹ Is this feasible with the current EU plan? It is very hard to believe and to expect. Of course, this is maybe too harsh and depends on the precise type of chip, but the EU should be close to this TSMC's extreme in order to achieve a 20% global share by 2030. In that case, there should be more subsidies, which could provoke race among Member States, according to Dachs, but it is a condition to make the production cheaper for TSMC and Samsung (Dachs, 2023; Miller a., 2022). Obstacle is also the competition among Member States, which could slow down the process of creating Marshallian districts in Europe. Centralized governments have an advantage in organising such districts, as they can more effectively coordinate economies of scale. In contrast, the EU will face the issues of duplication and multiple production facilities because no Member State wants the other Member State to benefit, so this fragmentation hinders cohesive industrial policy regarding semiconductors and chips.

In conclusion, the EU faces a critical decision: whether it will move with deeper integration and a more united approach or continue with the balancing between national and EU interests. So far, the balancing act is not showing the indication of catching up with the USA or China. The year 2024 is marked by numerous and important elections worldwide. The rise of political movements that favour more national sovereignty complicates the EU's approach and progress on the current objective for the chip industry. Nonetheless, it is commendable that the EU decided to take a step in this crucial industry, but the response should be much more decisive to achieve its established goals.

⁵¹ To visualise in numbers, TSMC might produce 10 million chips, reducing the fixed cost to just \$0.01 per chip (Miller b., 2024)

7. Further Research

This master thesis tried to provide a framework for understanding the EU's quest for autonomy in highly advanced technology. During the research, a high number of topics emerged on which future research can be done.

After publishing this thesis, further research can delve deeper into more specific aspects of semiconductor technology, such as the impact of artificial intelligence on semiconductor manufacturing or vice versa. Specific research can be conducted on specific stages of the global value chain or on specific chips. In relation to this kind of technology, it would be interesting to do research on the role of IP rights in the global semiconductor industry. The possible China-Taiwan conflict and its various social, geopolitical, historical, and economic implications are also possible to explore, especially because of the geopolitical complexity. The deeper research about the EU's dependence on foreign technology, especially the USA's technology, could also be conducted.

From an economic point of view, it would be useful to explore how much money was effectively spent on all these big industrial projects. This type of research should probably be done in the 2030s, since most of the global players, among them the EU, set that year as a sort of deadline for achieving their goals in the semiconductor industry. In Chapter 4, based on announced investments in the industry, a very simplistic analysis was conducted, so for future purposes, there should be an analysis of, for example, the return on investment for every country to see how effective measures are or the growth rate of investments to see how quickly the industry is growing or catching up to the others.

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Appendices

Appendix A

The USA has enacted the Chips Act, pledging a significant \$52 billion investment by 2026 for domestic manufacturing and R&D (European Commission b., 2023). China is pouring big resources to bridge its technological gap and their “*Made in China*” Initiative aims to invest \$150 billion by 2025, started from 2014-2015 (European Commission b., 2023; García-Herrero & Weil, 2022; Kotarski b., 2024). Japan made \$8 billion in public funding, with an additional \$13 billion release in November 2023 as a part of an economic stimulus package (European Commission b., 2023). South Korea has teamed up with its chip giants to invest a colossal \$459 billion by 2030 in R&D and domestic manufacturing (European Commission b., 2023).

Appendix B

The abbreviation BERD stands for business enterprise research and development. The figures presented in Figure 11 concern all R&D spending and are not limited to the semiconductor or ICT sectors (OECD, 2019). Source: OECD, R&D Tax Incentives database, <http://oe.cd/rdtax>.

Appendix C

Additional relevant NACE codes are the following: code 58.29 “*other software publishing*”, includes companies supplying the software for the design of chips, suppliers of machines for the manufacture of semiconductors could be classified in either 26.11 itself, or 26.51 as “*manufacture of instruments and appliances for measuring, testing and navigation*”; then 26.70 for “*manufacture of optical instruments and photographic equipment*”; 27.90 as “*manufacture of other electrical equipment*”; 28.89, as “*manufacture of other special-purpose machinery*”; 26.20 “*manufacture of computers and peripheral equipment*”; 26.30 “*manufacture of communication equipment*”, and 26.40 “*manufacture of consumer electronic*” (Joint Research Centre et al., 2022, p. 19).