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Silicon Europe? How Germany, Italy and the Netherlands are Shaping the Chip Race

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ABSTRACT

This study aims to analyze and compare the positions of Italy, Germany, and the Netherlands within the semiconductor industry. Semiconductors are essential components for any microelectronic device and their supply is an actual issue in global geopolitics. This research provides a comprehensive analysis of the complex semiconductor industry, identifying the key players and major disruptions in the supply chain. It also examines both the European Chips Act and the American Chips and Science Act, emphasizing their common objectives and outlining key differences in funding structure and forms of conditionalities.

The primary goal of this study is to contribute to the ongoing discussion on industrial policy concerning semiconductors analyzing the industrial policies of Italy, Germany and the Netherlands. European countries face a significant gap across all stages of semiconductor production and are heavily reliant on imports of resources and rare earth elements which are critical for chips manufacturing. Although the U.S. leads in chip design, it remains dependent on other countries for production and assembly, as well as for the import of essential materials. Taiwan and South Korea host the largest manufacturing facilities, and China maintains a substantial advantage in the assembly phase, which is considered the least value-added stage.

To address the significant gap with Asian countries and the U.S., Germany, Italy, and the Netherlands have adopted industrial strategies aligned with the European Chips Act goals. Germany's strategy focuses on the allocation of substantial funds to expanding its production capacity, attracting main manufacturing companies like TSMC and Intel. Italy, through the National Microelectronics Fund, has prioritized the growth of its national champion, STMicroelectronics, which is involved in the design, manufacturing, and distribution of semiconductor products. The Netherlands is home to ASML, the world's sole supplier of the machinery required for producing the most advanced chips. The Dutch government is investing in Brainport Eindhoven, where ASML and other semiconductor companies are based, to retain the presence of ASML in the country and foster the growth of the domestic semiconductor sector.

However, this study aims to answer to two key questions: How are European countries positioned within the global semiconductor industry, and which countries hold a significant power in this sector? What strategies are European countries implementing to close the gap with other developed nations in the semiconductor industry?

Throughout this thesis, it has been demonstrated that European countries are implementing interventionist policies aiming to strengthen their internal semiconductor sector. Italy and Germany have been more proactive and decisive in their efforts in terms funding size compared to the Netherlands.
However, European Union should focus on setting realistic objectives and optimizing the allocation of funds, ensuring that investments are strategically targeted and effective.
EU faces significant challenges due to the structure of its industrial policy implementation. The European Union functions more as an orchestrator, which poses risks to the success of its policies. Coordination among member states is lacking, and only a limited amount of European funds has been allocated. National governments are responsible for funding, which may exacerbate inequalities and hinder the achievement of objectives. Furthermore, it remains unclear whether the competence for industrial policy lies with the EU or the national governments.

The comparative analysis of strategies of these countries is conducted through a framework that examines key actors, objectives, policy instruments, financial commitments, and forms of conditionalities.

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INTRODUCTION

The recent chip shortage of 2021 has raised many questions about the security of semiconductor supply, pushing many governments to actively intervene with subsidies and investments to develop the sector, thereby strengthening their position. Semiconductors are now the subject of many discussions and are a central issue in the industrial policies of numerous countries.

The technological revolution has transformed the economic landscape, created new dominant players, and elevated the role of many Asian countries. European countries soon found themselves increasingly dependent on China, South Korea, and Japan, as these nations became dominant players in the field of technology.

Clearly, economic power also implies geopolitical power. However, the issue of dependency is crucial. It implies vulnerability, and in such a critical sector, it has raised many concerns. In the US, semiconductors are considered a national security issue. The reason for this is because semiconductors are fundamental components in a wide range of electronic products including cell phones, computers, electric cars, solar panels, and many other devices. Critical dependencies are dangerous as they threaten sovereignty and the ability to act autonomously.

Semiconductors are central for geopolitical stability and economic security, technological advancement and national sovereignty. This multifaceted issue encompasses many complex questions that are crucial for our future and the future of our nations.

In the actual context, semiconductors play a crucial role, affecting the global economy, competition and national security. Europe is seeking to place itself as a relevant actor in this sector dominated by few power players. However, in order to understand European position within this strategic industry it is essential to explore two key questions: How are European countries positioned within the global semiconductor industry, and which countries hold a significant power in this sector? What strategies are European countries implementing to close the gap with other developed nations in the semiconductor industry?

This study highlights the critical dependence of the European continent and the limited power of European countries in the semiconductor industry. It also emphasizes the vulnerability of the supply chain and the concentration of power in certain countries regarding specific stages of the production process. These concentrations make the entire supply chain vulnerable to disruptions, as it is affected by the internal economic conditions of dominant countries, natural disasters, and policy decisions. Consequently, the repercussions are likely to impact the entire supply chain, exposing the world to interruptions in a sector that is central to technological progress. Countries with significant power in the production process include China, North Korea, the U.S., and Taiwan. The only stage where Europe holds real dominance is in the production of machinery used to manufacture chips, particularly advanced chips. However, in the overall production process, Europe holds a 10% share[1] of the global market.

Following the significant chip shortage caused by the outbreak of the COVID-19 pandemic, semiconductors have gained global attention. As a result, national governments have begun investing and intervening to expand their domestic sectors and reduce dependencies. The European Union has also taken steps toward developing and expanding the sector. In this context, the European Commission[2] introduced the Chips Act[3], following the American initiative[4]. The Act aims at bolstering Europe's

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[1] European Commission. (n.d.). *European Chips Act*. European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

[2] The European Commission is the EU's politically independent executive arm. It is alone responsible for drawing up proposals for new European legislation, and it implements the decisions of the European Parliament and the Council of the EU.

[3] A legislative package to encourage semiconductor production in the European Union entered into force on 21 September 2023.

[4] The U.S. signed into law the Chips and Science Act in August 2022.

competitiveness and resilience in semiconductor technologies and applications and help achieve both the digital and green transition[5].

The analysis focuses on the European Chips Act as well as the American Chips and Science Act, comparing them and highlighting differences. The two Acts are similar in objectives and goals; however, the structure and amount of funding allocated is significantly different. The American government has allocated $52.7 billion for the development of the industry, whereas the EU commission has allocated only €3.3 billions and expect to leverage up to €43 billions with national governments' investments. The fragmented system of the application of the industrial policy within the Eurozone represents the major limit in the realization of the objectives pursued. The U.S., with its centralized funding system, is able to allocate major funds and promptly. The European Union is constrained by its decentralized structure and the lack of clarity regarding who holds the authority over industrial policy, whether it is the national governments or the European Commission. This confusion causes delays and limits the ability to act effectively.

In addition, the American industrial strategy in the semiconductor sector is primarily driven by the need to limit Chinese expansion. The U.S. strategy aims to contain Chinese influence in the semiconductor sector and prevent the country from achieving dominance in this vital area, as chips are not only essential for commercial products but also play a crucial role in the defense sector. In this context, the U.S. government has implemented measures such as export bans and restrictions on Chinese companies' access to key facilities. In contrast, European ultimate objective is to establish an economic power in the sector and reduce dependencies from the U.S. and Asian countries.

Within the framework of the EU Chips Act, national governments have begun adapting their industrial policies to align with European directives, reallocating significant funds to support these initiatives. The national strategies analyzed in this study are those of Italy, Germany and The Netherlands. The choice of these countries is driven by the fact

[5] European Commission. (n.d.). *European Chips Act*. European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

that these nations host many semiconductors company, and their national governments are actively investing to pursue the EU Chips Act objectives.

The study underscores the complexity of the semiconductor industry, from the multiple stages of the production process to the intricate geographic concentration of manufacturing activities. One of the primary challenges lies in the substantial investments required to enter the sector, alongside the long lead times needed for chip production and the lack of a skilled workforce. Additionally, semiconductors have become a strategic battleground where countries seek to exercise power, making the industry central to geopolitical competition, particularly between the U.S. and China. The European Union faces significant challenges in asserting its influence within this industry, prompting its member states to implement strategies aimed at gaining economic power in this critical field.

The objective of this study is to:

- Analyze the semiconductor industry and its key players, while contextualizing Europe's position and providing a comprehensive overview of the numerous dependencies in the sector
- Analyze the countries responses to the chip shortage of 2021 by comparing the EU chips Act and the American Chips and Science Act.
- Compare industrial policy of Italy, Germany and The Netherlands in the semiconductor sector

The first objective is to analyze the semiconductor industry by market shares of the main firms operating within the supply chain, particularly focusing on the production process. The results highlighted the dominance of Asian companies in the manufacturing stage, especially Taiwan and South Korea, with TSMC and Samsung, respectively. Additionally, Intel holds a considerable market share in the manufacturing sector. European companies like STMicroelectronics, Infineon, and NXP Semiconductors hold relatively smaller market shares, but they remain valuable assets for the EU's technological and industrial landscape. Regarding chip design, the U.S. companies control almost 90% of market share[6] with Intel and NVIDIA leading. Finally, the assembly stage is dominated by China alongside other countries with relatively low labor costs such as Malaysia, Vietnam, and the Philippines.

The extraction of raw material is another critical stage for Europe which relies primarily on Norway for silicon, the most common material used in semiconductors. Major exporters of silicon include China, the United States, Brazil, Norway, and Russia. The same applies to germanium and gallium arsenide[7] where China is the leading provider. In addition, China holds a dominant position in supplying many of resources, particularly REEs[8].

Therefore, the Eurozone faces numerous dependencies on foreign countries and vulnerabilities, which limit its ability to exert power and influence.

The second objective is to analyze the European and America strategies to enhance internal production and power. In response to this weak position and following the chip shortage the EU and the U.S. started some initiatives to strengthen its position. In this context, the European Commission introduced the European Chips Act which has as its main objective to double the EU's global market share in semiconductors from 10% to at least 20% by 2030. The Act is formed by 3 pillars: the first pillar of the European Chips Act is the Chips for Europe Initiative which aims to strengthen Europe's technological leadership; the second pillar aims to establish a system to secure supply by drawing in investments and boosting semiconductor production capacities and the third one aims to create a coordination framework between Member States and the Commission. The U.S. approved the Chips and Science Act, which shares similar objectives with the EU Chips Act. The package allocates substantial funds to strengthen the semiconductor industry within American borders. The U.S. government has offered significant state aid to various American companies to boost every stage of production, particularly manufacturing.

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[6] TrendForce. (2024, May 9). *Global semiconductor market forecast to grow by 5% in 2024 amid emerging technologies and increased production capacity*. TrendForce. https://www.trendforce.com/presscenter/news/20240509-12134

[7] Silicon, germanium, and gallium arsenide are the most used semiconductor materials.

[8] Rare Earth Elements, fundamental for chips components.

Additionally, many investments have been directed toward R&D and workforce development. Major beneficiaries include companies like GlobalFoundries, Intel, and Micron. Furthermore, substantial funds have also been allocated to support new facilities for TSMC and Samsung, while Polar Semiconductor, Absolics, and SK Hynix secured grants. By 2032, U.S. semiconductor capacity is forecasted to increase by 203%, with a rise in global chipmaking share from 10% to 14%[9].

The third goal of the study is comparing industrial policy in the sector of three European countries: Italy, Germany and The Netherlands. Where available, data on semiconductor fundings have been collected and incorporated into a final framework along five dimensions to describe and compare national strategies. The five dimensions are: protagonists (the main actors carrying out the industrial policy effort), goals, size/financial commitment, type of policy instruments used (e.g. subsidies, tax benefits or other forms of incentives), and the forms of conditionalities.

The main actors carrying out industrial policy effort in Italy are the Italian government and semiconductor companies within the country. Whereas, in Germany protagonists are the German government and semiconductor companies in Germany and in Netherlands, the Dutch government and the semiconductor companies within the country. As regards goals of the semiconductor policy in the three European countries, the research highlights that Italy seeks to strengthen the entire domestic semiconductor sector, attract foreign companies and support the national champion STMicroelectronics. German goals are focused on strengthen the domestic semiconductor sector particularly manufacturing, attract foreign investments and support the creation of a "Silicon Valley" in Dresden. In the Netherlands, the goal is to enhance the domestic semiconductor sector and support the national champion ASML. The final framework, under the voice financial commitments, lists the available data on the allocated funds by both national governments and companies to achieve the goals previously mentioned. In Italy financial commitments covers many areas. It includes investments by the government on R&D projects, state aid

[9] Benson, E. (2024, May). *World chips acts: The future of U.S.-EU semiconductor collaboration*. Center for Strategic and International Studies. https://www.csis.org/analysis/world-chips-acts-future-us-eu-semiconductor-collaboration

measures to STMicroelectronics worth 2€ billions that are part of the National Microelectronics Fund with a total budget of €3.292 billions, and €50 millions from the National Recovery and Resilience Plan[10]. In Germany the government total financial commitment announced is around €20 billions including State aid measure worth €5 billions to TSMC for the creation of a factory in Dresden, €10 billions announced in subsidies to Intel and a Europe-wide initiative in microelectronics and communication technologies amounting to €1.5 billion from the National Recovery and Resilience Plan. In the Netherlands, financial commitments include state investments in research projects worth € 230 millions, funds worth € 2.5 billions for the expansion of the Brainport Eindhoven region and a tax credit with a budget of 1.446 million for R&D projects. The type of instruments used to allocate state funds are Development contracts, subsidies and tax credit in Italy, mainly subsidies in Germany, and subsidies and tax credit in the Netherlands. Finally, as regards the forms of conditionality specific rules applies in Italy, Germany and the Netherlands but the general form of conditionality is the application of the regulation of the European Chips Act.

The three countries serve as examples of different industrial strategies which follows common goals. Their strategies are tailored to their internal conditions, strengths, and weaknesses. Germany's economic power enables it to allocate significant funding to strengthen the internal sector and attract foreign leader companies in the industry. Although Italy has not the same level funding capacity as Germany, it is still investing substantial amounts to strengthen the position of STMicroelectronics, which designs, manufactures and delivers semiconductors. In addition, Italy is focusing on the last stage of the production process, supported by investments from the Singapore-based company Silicon Box. The country aims to expand its role in the last stage of the production process, especially in chiplet integration, advanced packaging, and testing technologies. Lastly, the Netherlands is focusing on preserving the role of ASML and maintaining it

[10] The National Recovery and Resilience Plan (NRRP) is part of the NextGenerationEU (NGEU) programme, the EUR 750 billion package agreed by the European Union in response to the pandemic crisis. Italy's Plan includes investments worth EUR 191.5 billion, financed through the Recovery and Resilience Facility.

within the country. The country is also investing in R&D to expand its influence in other stage of the supply chain.

The remainder of the thesis is structured as follows. Chapter 1 provides an overview of the semiconductor industry, examining the key players, analyzing the supply chain, and highlighting the various issues that contribute to its instability and insecurity. Additionally, it offers a brief history of the semiconductor industry and explains why it has become so crucial**.** Chapter 2 focuses on the strategies implemented in the U.S. and Europe to develop their domestic semiconductor industries, particularly analyzing the EU Chips Act and the American CHIPS and Science Act. Also, it provides a comparison between the two, highlighting their differences and limitations. Chapter 3 presents a case study of various European countries implementing the directives of the EU Chips Act, illustrating how national governments differ in their approaches to enhancing domestic production and fostering the development of the semiconductor sector.

1. ANALISYS OF THE SEMICONDUCTORS INDUSTRY

1.1 OVERVIEW

In this chapter, I will offer an in-depth analysis of the semiconductor industry, including a comprehensive historical overview. The investigation will cover critical aspects of the supply chain and provide a detailed explanation of the factors that contributed to the severe semiconductor shortage in 2021. Additionally, this chapter will present a panoramic view of the industry, familiarizing readers with the key global actors and their strategic roles. I will contextualize the position of the European Union and leading European firms within the broader global landscape, highlighting their competitive strengths and challenges. Furthermore, I will explore the significant influence of Asian countries, illustrating how their dominance shapes the industry's dynamics. Through this detailed analysis, the chapter will shed light on the intricate interactions and geopolitical significance of the semiconductor industry.

1.2 UNDERSTANDING SEMICONDUCTORS

The semiconductor industry represents the heart of technological innovation and global economic competitiveness, playing a crucial role in a wide range of strategic applications. Chips are fundamental in every electronic component: from 5G/6G telecommunications networks to artificial intelligence systems, from cellphones and laptops to automotive and many other fields. However, the complexity of the semiconductor supply chain, characterized by high fixed costs and significant investments in research and development, has led to an extreme concentration of the market, with few companies controlling various crucial stages of the production process.

Semiconductors are materials with physical properties that are resistivity and conductivity, that make it possible to create the fundamental components of chips, including transistors, diodes, and resistors. Silicon is currently the most widely used semiconductor material in chip manufacturing. One of its key features is the ability to integrate tens of billions of basic components (such as transistors, diodes, resistors, and capacitors) onto a single chip.

Chips can be classified, primarily based on their function, into four product groups:[11]

1. Microprocessors and Logic Devices - used for data exchange and processing in computers, communication devices, and consumer, industrial, military, biomedical electronics, etc
2. Memory Devices - used for storing information
3. Analog Devices - used to convert analog signals, such as light, touch, and voice, into digital signals
4. Optoelectronics, Sensors, and Discretes (commonly referred to as O-S-D)[12]**:**

    - Optoelectronics and Sensors - primarily used to generate or detect light, such as in LED lights (light-emitting diodes) or cameras, and to detect

[11]Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[12] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

various physical quantities (thermal, mechanical, electrical, chemical, environmental).

- Discretes - including transistors, diodes, and resistors, which contain a single device per chip and are designed to perform a single electrical function[13].

The sector is characterized by a continuous race for product innovation, which focuses on the size of the technology node. Reducing the size of transistors means being able to integrate a higher number of components within a microchip, allowing for an increase in the processing power of processors and lower energy consumption per function. The goal is to develop nodes with increasingly smaller dimensions, resulting in more advanced chips. Additionally, innovation extends to the wafer size, specifically the diameter of a wafer measured in millimeters. Wafers are "discs" cut from a silicon ingot, which is the result of a purification process where the semiconductor is transformed from a molten state to a solid state. The diameter determines how many chips can be made on it. A larger diameter allows for greater amortization of fixed costs, resulting in a lower cost per chip.[14]

1.3 EVOLUTION OF THE SEMICONDUCTOR INDUSTRY

The semiconductor industry grew rapidly following the invention of the transistor[15] in 1947. The invention by Kilby of Texas Instruments and Noyce of Fairchild Semiconductor in the US of the bipolar integrated circuit (ICs)[16] gave another important impulse in the expansion of the semiconductor industry. The ICs were widely used in many electric appliances thanks to their small size and weight. From the 1980s the numerous innovations in the field of semiconductors helped the industry to become more and more large, involving an increasing number of actors and becoming one the crucial market for the future economic independence of many countries. According to the

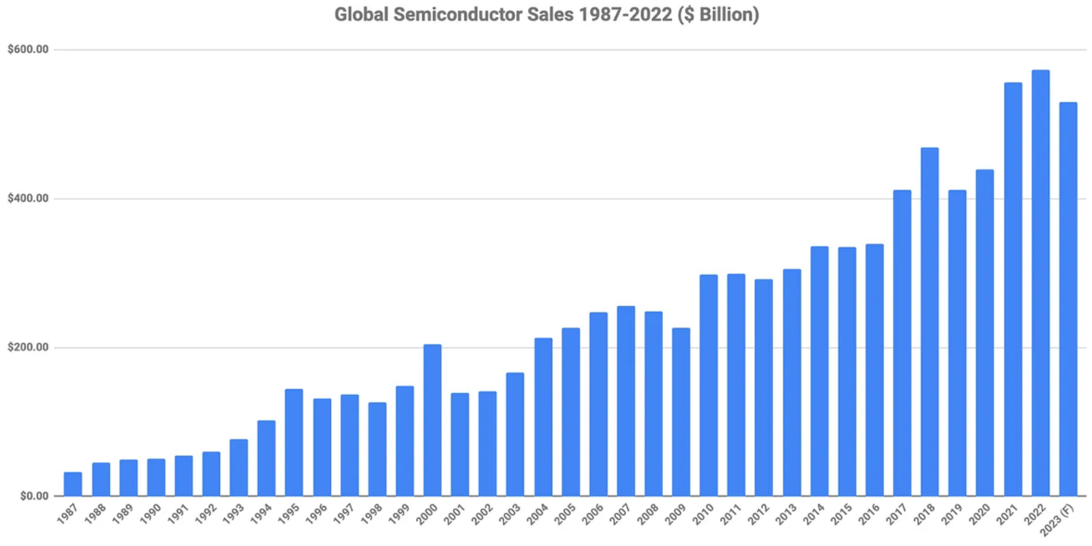
[13] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[14] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[15] A semiconductor device used to amplify or switch electrical signals and power.

[16] The main active devices of a generation of mainframe and minicomputers.

Semiconductor Industry Association (SIA), the global semiconductor sales have been continuously increasing since 1987 and the peaks had in 2020 and 2021 consolidate the relevance of the industry.



Reference: Statista (2023).

The graph shows the global semiconductor sales from 1987 to 2022, measured in billions of dollars. The significant increase in sales is attributed to the current and recent expansion of the technology sector and the growing importance of technological competitiveness. This semiconductor sector is driven by strong research into innovation with the goal of developing products with better performance, increasingly powerful and efficient. The semiconductor industry has carved out a major role in the global economy, playing a crucial role in determining the economic leadership of countries. Technological, electrical, and digital advancements have had a profoundly transformative impact on the semiconductor industry. Indeed, semiconductors are interconnected with many other sectors, which rely heavily on the production of these products. In addition, innovation and production in semiconductors directly influence these sectors' ability to evolve and thrive, highlighting the critical importance of this industry within the global technology supply chain. Consequently, any disruption or advancement in the semiconductor industry has cascading effects which significantly impacts the growth and stability of the entire global technological and industrial system.

New technologies also aim to improve energy efficiency, supporting global sustainability goals. The expansion of the technology market, with the adoption of 5G and the proliferation of electric vehicles and smart devices, has increased the demand for semiconductors, prompting companies to invest in new production capacities and technologies. Furthermore, semiconductors are crucial for automation and Industry 4.0, enhancing efficiency and reducing operational costs in manufacturing processes. Finally, the strategic importance of semiconductors also affects financial markets, with companies in this sector often being among the highest valued on the stock exchange. The industry is characterized by three main elements: significant external economies of scale have led to a strong market concentration in a small number of countries, with only a few highly specialized and capital-intensive companies, a limited number of chip manufacturers and a production capacity that cannot be quickly adjusted and a tendency to expand only when production capacity margins are fully exhausted due to high demand.[17]

Despite the general upward trend, there have been some fluctuations in the number of sales from 1987 to 2022. For instance, consistent growth was observed until the early 2000s, followed by some oscillations between 2000 and 2010, after which growth resumed steadily. Despite the peak sales in 2021 and 2022, the industry was significantly impacted by a severe shortage, which affected the number of sales and caused demand to exceed supply. The shortage of semiconductor supply, which began in 2020, is the result of a series of unforeseen factors. They have affected and continue to affect the semiconductor supply. These factors can be divided in internal and external. Internal factors are the following:

1. The chaotic evolution of semiconductor demand during the pandemic. The pandemic caused a sudden and steep increase in demand for ICT products in some markets, such as electronics, while other markets, like the automotive sector, initially experienced a sharp decline in demand followed by a vigorous recovery[18].

[17] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[18] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

2. The bullwhip effect. It refers to an inaccurate estimation of final product demand fluctuations caused by confused and indirect information along the supply chain. For instance, automotive companies typically do not work directly with semiconductor manufacturers and foundries, leading to inadequate responses to changes in final demand[19].
3. Supply Chain Management (or procurement of chips). For example, automotive manufacturers, despite semiconductor lead times of up to 26 weeks, still predominantly use just-in-time inventory strategies. Many car components are sourced from a single supplier, and contracts often enforce strict quality standards, which restrict the supply chain's ability to adjust swiftly in the face of shortages[20].

Conversely, external factors that are the causes for the shortage in semiconductor supply are the following:

1. Occurrence of natural disasters. In February 2021, a severe winter storm in Texas led to the closure of several wafer fabrication plants, including two facilities of major semiconductor suppliers for automotive applications (Infineon and NXP). Additionally, Taiwan experienced a drought, and the government implemented water rationing, which constrained production at some of the largest facilities operated by Taiwan Semiconductor Manufacturing Co. (TSMC), the world's leading chip manufacturer[21].
2. Occurrence of incidents. In March 2021, a fire in Japan destroyed 600 square meters of a 300mm wafer fabrication facility owned by Renesas, a key supplier of automotive chips[22].
3. A highly uncertain geopolitical landscape for several reasons. For instance, trade tensions between China and the U.S. Ongoing trade

[19] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[20] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[21] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[22] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

disputes between China and the U.S. continue to impact companies worldwide. Additionally, heightened tensions between China and Taiwan could further restrict trade in the semiconductor sector. Furthermore, Russia's Invasion of Ukraine had an impact on the shortage of semiconductor supply. Neon, helium, and NF3[23] are critical, non-substitutable rare gases needed for semiconductor production. The conflict has permanently damaged some production sources (about 50% of neon production was based in Ukraine before the war) and disrupted planned expansions of gas production, such as helium, which were set before the Russian invasion. Efficient procurement of these gases is strategically crucial[24].

4. Barriers to entry. There are significant barriers to entry that hinder the entrance of new companies into the semiconductor industry[25].

These factors highlight how the semiconductor sector has become a highly strategic market, significantly influencing the economy and technological development of nations. The semiconductor market is plagued by challenges in supply chain management and a volatile market. The industry is highly concentrated, with a few key players dominating, making it extremely sensitive to geopolitical tensions. Additionally, natural disasters in critical regions can severely disrupt the supply of semiconductors. Hence, the industry presents several weaknesses in the supply chain that worsen the national capacities to ensure the right number of semiconductors to their products.

In response, nations have begun to recognize the importance of this sector and are implementing policies and agreements to secure their semiconductor supply. This increased attention reflects the sector's critical role in ensuring economic stability and technological advancement.

[23] Nitrogen trifluoride.

[24] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[25] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

The semiconductor shortage has essentially underscored the need for global cooperation and coordination to address the complexities of the supply chain, as well as the importance of developing this industry and achieving production independence.

However, the decline of 2023 in sales happened because the sector has been hit by a combination of weak end-use demand, a crash in cryptocurrency prices, new supply coming on stream, and inventory accumulation during the semiconductor shortage in 2021[26]. The contraction of the sales is significantly due to the reduction in the sales of the memory chips. Revenues of these products decreased by 37% in 2023 and performed worse among chips categories. Indeed, Smartphones, PCs, and servers that are three of the main fields of application for DRAM[27] and NAND[28] memory, experienced weaker-than-expected demand levels leading to an inventory surplus, particularly in the first half of 2023.[29]

On 6th June 2024 the Semiconductor Industry Association (SIA) announced that the global semiconductor industry sales were $46.4 billion during the month of April 2024, an increase of 15.8% compared to the April 2023 total of $40.1 billion and 1.1% more than the March 2024 total of $45.9 billion.
Regionally, year-to-year sales in April increased in the Americas (32.4%), China (23.4%), and Asia Pacific/All Other (11.1%), but decreased in Europe (-7.0%) and Japan (-7.8%).

[26] Oxford Economics. (2024). Semiconductor downturn may be near a trough, but the near-term recovery is far from robust. Oxford Economics. https://www.oxfordeconomics.com/resource/semiconductor-downturn-may-be-near-a-trough-but-the-near-term-recovery-is-far-from-robust/

[27] DRAM is 100 times faster read and write speed than NAND and is used in computer memory for real-time operations.

[28] NAND is much slower but provides a large storage capacity to save data on its NAND chip permanently.

[29] Gartner, Inc. (2024). Gartner says worldwide semiconductor revenue declined 11 percent in 2023. Gartner. https://www.gartner.com/en/newsroom/press-releases/2024-01-16-gartner-says-worldwide-semiconductor-revenue-declined-11-percent-in-2023

Month-to-month sales in April increased in the Americas (4.2%), Japan (2.4%), and China (0.2%), but decreased in Asia Pacific/All Other (-0.5%) and Europe (-0.8%)[30].

Additionally, SIA endorsed the WSTS[31] Spring 2024 global semiconductor sales forecast, which projects annual global sales will grow to $611.2 billion in 2024, which would be the industry's highest-ever annual sales total. In 2025, global sales are projected to reach $687.4 billion[32].

The announcement emphasizes that the semiconductor sector is experiencing great growth with increasing global demand. However, regional variations are presents and market's growth is not homogenous. The market of semiconductors presents the characteristic of being volatile that is very peculiar of these types of industries. Future projections are extremely optimistic, suggesting that the sector will continue to expand.

1.4 MAIN ACTORS IN THE INDUSTRY AND SUPPLY CHAIN

The semiconductor industry is highly concentrated in a few countries and dominated by a small number of highly specialized, capital-intensive companies. Over the past two decades, a pattern of functional specialization has developed across different geographical regions: the United States leads in design and development, East Asia, particularly Taiwan and South Korea, focuses on manufacturing, and China specializes in assembly. The chip production sector is characterized by a small number of players with high specialization, requiring significant investments in technology and innovation.

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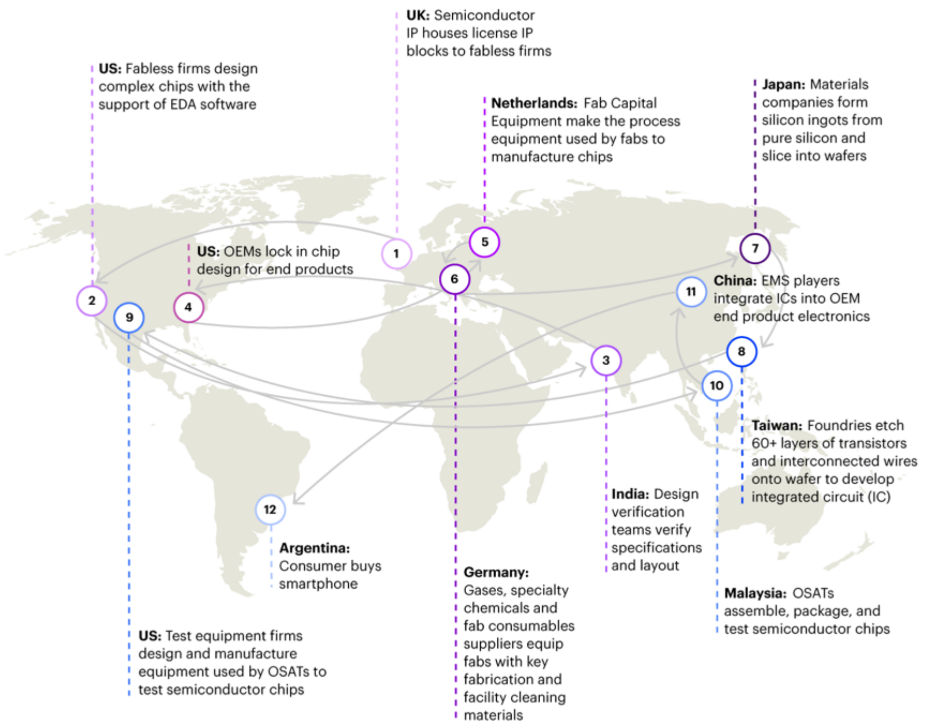
[30] Semiconductor Industry Association. (2024). *Global semiconductor sales increase 15.8% year-to-year in April; new industry forecast projects market growth of 16.0% in 2024*. Semiconductor Industry Association. https://www.semiconductors.org/global-semiconductor-sales-increase-15-8-year-to-year-in-april-new-industry-forecast-projects-market-growth-of-16-0-in-2024/

[31] World Semiconductor Statistic Trade is a non-profit mutual benefit corporation whose Charter and Bylaws define services for the world semiconductor industry, including management of the collection and publication of trade net shipments and semiconductor industry forecasts.

[32] Semiconductor Industry Association. (2024). *Global semiconductor sales increase 15.8% year-to-year in April; new industry forecast projects market growth of 16.0% in 2024*. Semiconductor Industry Association. https://www.semiconductors.org/global-semiconductor-sales-increase-15-8-year-to-year-in-april-new-industry-forecast-projects-market-growth-of-16-0-in-2024/

Additionally, the industry faces a shortage of qualified labor. These factors create significant barriers to entry, making it challenging for new companies to compete with the incumbent firms.



Reference: Pierleoni, M. R. (2023, December 3). *L'industria globale dei semiconduttori e il ruolo dell'Italia* (p. 11). MEF.

The picture shows the geographic dislocation of the entire production process of semiconductors. The result indicates that the industry operates with distinct regional roles. This division highlights a complex and interdependent global supply chain. Furthermore, the concentration of expertise and infrastructure in specific regions underlines the challenges faced by new entrants, as breaking into the market requires overcoming significant investment and developmental hurdles. This geographic specialization also implies a dependency on these regions, which could impact the supply-chain in case of geopolitical tensions or supply chain disruptions.

In the UK, IP houses provide essential IP blocks for chip design, while in the US, fabless firms design complex chips with the help of EDA software[33] and test them using specialized equipment. In India, verification teams ensure that semiconductor specifications and layouts meet quality standards. In the Netherlands, companies produce essential fabrication equipment, and in Germany, materials and consumables for fabs are supplied. In Japan, silicon is transformed into wafers, which are then processed in Taiwan's foundries. In Malaysia, OSATs[34] assemble and test the chips, while in China, EMS[35] providers integrate circuits into final products. This model of regional specialization not only accelerates innovation and improves efficiency but also highlights the vulnerability of the global supply chain to disruptions and geopolitical tensions, as dependence on specific regions can impact worldwide production in the event of crises or conflicts.

A critical element of semiconductor manufacturing is the production of the machinery used in the semiconductor production process. The Netherlands holds a pivotal role in this stage, with ASML, leading the way. ASML's equipment is indispensable for manufacturing cutting-edge semiconductors, making it a critical supplier for major chip manufacturers worldwide.

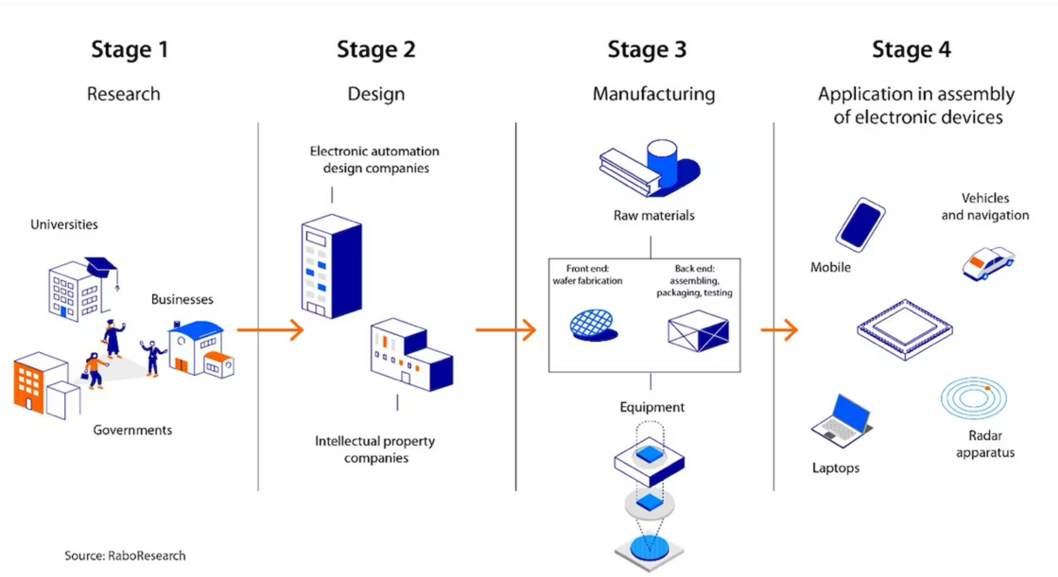
Therefore, the production process of semiconductors is divided in 3 stages: design that defines the characteristics of the product and the structure of the chip, manufacturing that involves the production of the wafer, front-end processes and front-back processes and the last stage is the assembly. The latter is linked to the verification of the proper functioning of the single chip, packing and downstream.[36] However, before design there is another important and essential step: Research and Development. The picture below shows the various stage of the production of semiconductors.

[33] Electronic Design Automation (EDA) is a specific category of hardware, software, services and processes that use computer-aided design to develop complex electronic systems like printed circuit boards, integrated circuits and microprocessors.

[34] Outsourced Semiconductor Assembly and Test.

[35] Electronic Manufacturing Services.

[36] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.



Reference: Ji, K., & Nauta, L., & Powell J. (2023, June 14). *Mapping global supply chains – The case of semiconductors* (p.6). RaboResearch

DESIGN. The structure of the market where companies engaged in semiconductor design operate varies significantly depending on the type of device being produced, namely logic devices[37], memory devices[38], and analog devices[39]. Logic devices are the largest category of semiconductors; specifically, they are the building blocks of cloud servers, information and energy transport network control nodes, logistics and mobility infrastructure, and, more generally, typical products of computing, automation, and telecommunications, such as smartphones. In this category of semiconductors, market concentration and the number of design companies strongly depend on the chip[40].

However, The United States is the world leader in semiconductor design. Almost all personal computer CPUs[41] are designed by U.S. companies, Intel, NVIDIA and AMD, although AMD relies on contract manufacturing (third-party manufacturing). However, Intel is not only specialized in the design of semiconductors, but it manufactures and sells

[37] Electronic components that are used for storing, manipulating, and processing digital information.

[38] A storage unit for recording data.

[39] Analog semiconductors condition and regulate "real world" functions such as temperature, speed, sound and electrical current.

[40] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

[41] Central processing unit which is the most important processor in a given computer.

them. The dominant leadership of American companies in the design phase allows them to exercise control over intellectual property and, therefore, over the entire production process, as companies specializing in the chip manufacturing phase must sign agreements/licenses for the use of their technologies. Hence, American companies exercise an important control over the manufacturing firms[42].

According to the latest Trendforce report of May 2024, the combined revenue of the top ten IC design companies worldwide reached approximately $167.7 billion in 2023, with a year-on-year growth of 12%[43].

RANKING	**COMPANY**	**REVENUE**			**MARKET SHARE**	
		2023	2022	YoY	2023	2022
1	NVIDIA (USA)	55,268	27,014	105%	33%	18%
2	Qualcomm (USA)	30,913	36,722	-16%	18%	24%
3	Broadcom (USA)	28,445	26,640	7%	17%	18%
4	AMD (USA)	22,680	23,601	-4%	14%	16%
5	MediaTek (Taiwan)	13,888	18,421	-25%	8%	12%
6	Marvell (USA)	5,505	5,895	-7%	3%	4%
7	Novatek Microelectronics (Taiwan)	3,544	3,708	-4%	2%	2%
8	Realtek (Taiwan)	3,053	3,753	-19%	2%	2%
9	Will Semiconductor (China)	2,525	2,462	3%	2%	2%
10	MPS (USA)	1,821	1,754	4%	1%	-

Source: Data sourced from Cytech Systems. *Top 10 IC Design Companies*. May 09, 2024. https://www.cytechsystems.com/news/top-ic-design-companies

European companies are not present in the top ten list of largest companies of IC design in the world. This reflects a vulnerability for the continent. However, some companies

[42] Pierleoni, M. R. (2023). *L'industria globale dei semiconduttori e il ruolo dell'Italia*. MEF.

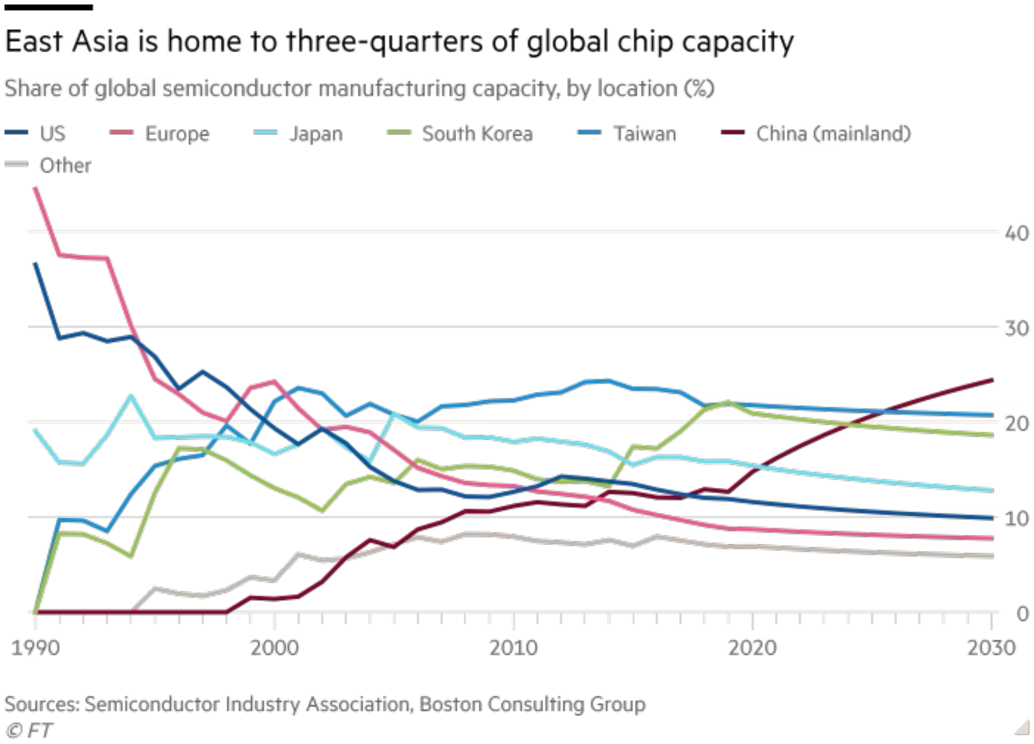
[43] Cytech Systems. *Top 10 IC design companies.* (2024, May 9). Cytech Systems. https://www.cytechsystems.com/news/top-ic-design-companies

are expanding and becoming more competitive in the market. For instance, NXP Semiconductors (Netherlands), STMicroelectronics (France/Italy), ASM International (Netherlands), BE Semiconductor Industries (Netherlands), Technoprobe (Italy) and Melexi NV (Netherlands). NXP Semiconductors' annual revenues rose from $4,194 billions in 2011 to $8,612 billions in 2020 with a peak of $ 9,498 billions in 2016. The increasing trend made the revenues to reach $11,063 billions in 2021, $13,205 billions in 2022 and $13,276 in 2023[44]. Moreover, STMicroelectronics' revenues rose from $8,510 billions in 2009 to $10,219 billions in 2020, $12,761 billions in 2021, $16,128 billions in 2022 and $17,286 billions in 2023.[45]

MANUFACTURING. A semiconductor chip is composed by numerous components, such as transistors and wiring, which are formed on a semiconductor wafer. An electronic device that incorporates many of these components is known as an "integrated circuit (IC)." The layout of these components is designed on a photomask (reticle) using computer software and then projected onto a semiconductor wafer during the manufacturing process. For many years, the chip manufacturing phase, when considered by the location of headquarters, has been predominantly based in Asia. Thus, as regards the manufacturing of semiconductors the principal firms competing are Samsung Electronics (South Korea), TSMC (Taiwan), Intel (United States) Qualcomm (United States) and Broadcom (United States).

[44] Macrotrends. (n.d.). NXP Semiconductors revenue. Macrotrends. https://www.macrotrends.net/stocks/charts/NXPI/nxp-semiconductors/revenue

[45] Macrotrends. (n.d.). STMicroelectronics revenue. Macrotrends. https://www.macrotrends.net/stocks/charts/STM/stmicroelectronics/revenue



Source: Irwin-Hunt, A. (2021, March 24). *In charts: Asia's manufacturing dominance*. Financial Times https://www.ft.com/content/2b0c172b-2de9-4011-bf40-f4242f4673cc

It is clear that Asian companies, particularly those from South Korea and Taiwan, dominate the most advanced segment. Chinese companies are unable to produce the required chips for high-end ICT products due to a lack of design expertise and high-tech machinery. Nonetheless, China is the largest producer of electronic hardware, thanks to its imports of chips. However, this dependence on imports makes China vulnerable to potential sanctions and trade restrictions but forecasts see the country become very specialized in the stage of the production process.

European companies only cover approximately 10% of the manufacturing market. This limited market share underscores the challenges Europe faces in establishing a dominant position within the semiconductor industry. The largest European companies in the industry that are specialized in the manufacturing are Infineon Technologies (Germany), STMicroelectronics (Italy\France), NXP Semiconductor (Netherlands), Analog Devices (Ireland), ASM International (Netherlands), Technoprobe (Italy), BE Semiconductor Industries (Netherlands) and Melexi NV (Netherlands). However, they are not among the largest semiconductor manufacturing companies in terms of revenues in the world.

ASSEMBLY. The final phase of production involves assembling, testing the correct functionality of each chip, and packaging them into finished products. This phase of the production process is the most labor-intensive and, compared to the others, has the lowest added value. It is often performed in countries where labor costs are relatively lower such as Malaysia, Vietnam, China and the Philippines. In this stage of the production process, Asia dominates nearly the entire market.

Europe and the U.S. are not enough competitive in this stage and rely almost entirely on Asian companies for assembly and packaging. Indeed, advanced packaging operations of the American company Intel are carried out in New Mexico and Malaysia, while Assembly and Testing are concentrated in Costa Rica and Vietnam, in Chengdu, China, and in Malaysia. In addition, the assembling process of Apple's products in concentrated in Vietnam and China. Apple Inc is a regular costumer of TSMC's semiconductors even though the chips are designed in California.

Europe holds a significant strategic advantage with its near monopoly on the production of essential machinery for semiconductor manufacturing through the Dutch company ASML. This dominant position underscores Europe's critical role in the global supply chain for advanced chips, reflecting the strategic importance of preserving the company in the industry.

Finally, the United States holds a dominant position in the global semiconductor design market, especially in the production of logic devices such as personal computer CPUs. This leadership enables American companies to exercise significant control over intellectual property and the entire semiconductor industry. In contrast, European companies are not yet among the top ten largest IC design firms globally, indicating a vulnerability for the continent.

TSMC owns an indisputable leadership in the manufacturing stage of the semiconductor supply chain. In 2023, TSMC's revenues were double those of Samsung, $70.599B[46] and

[46] Macrotrends. (n.d.). Taiwan Semiconductor Manufacturing revenue. Macrotrends. https://www.macrotrends.net/stocks/charts/TSM/taiwan-semiconductor-manufacturing/revenue

$39.9B respectively, highlighting a significant gap between the two industry giants. Additionally, TSMC's revenues were considerably higher than those of Intel that remains at $48.7B[47] (calculated only those coming from semiconductors sales), further indicating its dominant position.

The data reflects the fundamental role of the Asian countries, especially in the manufacturing stage of the semiconductors, and their continuously increasing relevance in the global market. This economic weight is strictly linked to a more imponent political weight in the global landscape.

The US and Europe are attempting to invest and strengthen their position in the industry. However, the U.S. is far more advanced and developed in semiconductor design and manufacturing. In contrast, the Old Continent holds a much smaller market share compared to the U.S. and Asia. This disparity indicates a position of subordination for Europe, which is not only challenging but also potentially dangerous.

Chips' industry development is the result of a strong globalization and a progress in the digitalization that is easily notable observing the present days. The functioning of the entire world is based on technological devices. Many jobs depend on computers and cellphones. Also, transportation, the military sector and AI rely on technological device and so chips.

The importance of the semiconductor industry attracts many countries and companies, with the U.S. and China competing fiercely for supremacy. Dominance in this sector will confer significant economic power that can be wielded globally, as well as geopolitical influence that can affect international balances. This situation exemplifies Henry Farrell and Abraham Newman's concept of "weaponized interdependence," where control over critical technologies and industries can be used as a strategic tool in global affairs.

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[47] Gartner, Inc. (2024). *Gartner says worldwide semiconductor revenue declined 11 percent in 2023*. Gartner. https://www.gartner.com/en/newsroom/press-releases/2024-01-16-gartner-says-worldwide-semiconductor-revenue-declined-11-percent-in-2023

1.5 VULNERABILITIES OF THE SUPPLY-CHAIN

The global semiconductor supply chain is extremely complex. The sector relies on a limited availability of specialized workforce that is not easily replicated, sophisticated manufacturing facilities that take years and billions of investment dollars to build, and unique geographic specialization across Asia, North America, and Europe[48]. Given the complexity of processes within the various stages of production, the materials used, and the type of research and development required to sustain the industry, no single company integrates all production processes internally. Instead, the industry is characterized by a strong regionalization of production, with companies specializing in one or several stages of production.

The geographical distribution of production sites and the strong regional monopolies in each stage of production represent the most critical weakness. However, it may also serve as the greatest advantage for the industry, allowing it to leverage cost efficiencies, know-how, and production capabilities. Nevertheless, it introduces significant fragility into the supply chain. The supply chain of semiconductors is extremely sensitive to the closure of strategic factories due to various disruptive events. In recent years, several leading companies in the sector have experienced disruptions due to fires, caused by the flammable properties of many materials used in semiconductor manufacturing, including combustible plastics and explosive chemicals, as well as the constant high-voltage electricity required by these facilities. Such incidents have led to factory closures and subsequent interruptions in chip component supplies. Notable examples include extensive fires at facilities owned by Renesas Electronics, ASML, and Wuxi Welnew, which have compromised production and triggered broader supply chain disruptions affecting the semiconductor, electronics, and automotive sectors. Additionally, strikes and labor shortages have further disrupted chip supplies.

The obsolescence of components is another factor that can be categorized as a disruption within the supply chain. Semiconductor life cycles have gradually shortened over the past

[48] Michael Mariani (2024). *The Five Biggest Disruptions to the Semiconductor Supply Chain in 2024.* https://www.z2data.com/insights/5-disruptions-to-the-semiconductor-industry

few decades. As consumers, electronics manufacturers, and other business clients demand more advanced capabilities and competition intensifies among leading chip companies to push the boundaries of technology, the longevity of individual generations has decreased. Indeed, the average life cycle of a semiconductor in 1970 was projected to be around 30 years. By 2014, the typical life cycle had shrunk to just a decade. The result of these shorter life cycles is an increase in component obsolescence and related end-of-life (EOL) notifications from suppliers[49]. This makes it extremely challenging to create lasting stockpiles, as the risk of obsolescence presents a significant obstacle. Therefore, inventory management becomes one of the most critical disruptions in the supply chain. Hence, maintaining optimal inventory levels is difficult due to the constant risk of components becoming obsolete before they are used. Rapid technological innovation in the semiconductor industry necessarily shortens the lifespan of chip components, leading to increased costs as companies frequently update their technology and redesign existing systems.

Another significant weakness in the supply chain is logistics. The quality of shipments can be affected by factors such as temperature and humidity during transportation, making it essential to have a reliable logistics system which can transport semiconductor chips and components safely and securely[50]. However, chip and component transportation is subject to the challenges of global maritime traffic. Up to 90% of all goods are transported by sea, underscoring the deep dependence of the global economy on rivers, canals, seas, and oceans as part of our shared maritime trade network. Despite the vastness of this network, the maritime transport industry relies heavily on a few strategically positioned critical chokepoints around the world. In a world increasingly affected by a steady stream of climate-related natural disasters and multilateral armed conflicts, these maritime chokepoints are becoming increasingly fragile single points of failure. The ongoing crisis in the Red Sea vividly illustrates this issue. The Red Sea is one of the world's busiest

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[49] Michael Mariani (2024). *The Five Biggest Disruptions to the Semiconductor Supply Chain in 2024.* Z2DATA. https://www.z2data.com/insights/5-disruptions-to-the-semiconductor-industry

[50] DHL. (2023, June 22). The critical role of semiconductor logistics in the global supply chain. DHL Singapore. https://www.dhl.com/discover/en-sg/logistics-advice/logistics-insights/semiconductor-supply-chain-logistics

trade routes, with 20% of all container shipments and 10% of global trade passing through the narrow waterway that separates North Africa from the Middle East.

In the weeks following Israel's invasion of the Gaza Strip in the fall of 2023, Iranian-backed Houthi rebels began targeting merchant ships traversing the waterway. The effects of these makeshift maritime attacks on shipping have been substantial. According to the Center for Strategic and International Studies, traffic through the Suez Canal, which is accessible only via the Red Sea, dropped by nearly 40% in 2024[51].

Additionally, the numerous restrictions imposed by American companies regarding the sale of chips designed by U.S. companies represent a significant supply vulnerability, particularly for countries like China, which the United States is limiting in its access to advanced chips. China, lacking cutting-edge chip manufacturing facilities, is especially affected by this U.S. initiative aimed at weakening it in the ongoing chip war. This influence of American companies also extends to European firms, which are pressured to refrain from selling their products to China. For instance, ASML has been prohibited from selling advanced chip-manufacturing machinery to China following extensive pressure from the U.S. government on the Dutch government.

Another critical stage in the supply chain is the extraction of silicon, germanium, and gallium arsenide. These materials are essential for producing semiconductor circuits. Silicon is primarily extracted from quartz sand, and the extraction and production of silicon require complex industrial processes involving high temperatures and significant energy. Raw materials play a central role in the development of the industrial sector and the creation of modern green technologies. They are defined as critical, due to their primary importance for the economy and industrial production that will continue to grow and due to their potentially high-risk supply chain. Moreover, most of them are extracted using methods that have a significant environmental impact, and the countries holding substantial reserves are often marked by high political and social instability, or are key

[51] Michael Mariani (2024). *The Five Biggest Disruptions to the Semiconductor Supply Chain in 2024.* Z2DATA. https://www.z2data.com/insights/5-disruptions-to-the-semiconductor-industry

players in global competition, which could lead to these resources being used as instruments of conflict rather than international cooperation. Chips rely on various critical minerals, metals, and rare earth elements, all essential for their components.

Major exporters of silicon include China, the United States, Brazil, Norway, and Russia. Similarly, for germanium and gallium arsenide, China is the leading producer. Although silicon, germanium, and gallium arsenide are abundant in the Earth's crust, the purification and production of high-quality silicon wafers require advanced infrastructure and technology. In addition, the extraction and refining of silicon are costly industrial processes with a significant environmental impact. China has a dominant role in supplying many of resources, particularly REEs. In fact, China controls 80% of the global supply of REEs, making it the leading provider. The United States is especially reliant on these imports, being 100% dependent on foreign sources for REEs.

Currently, the U.S. imports about 80% of its REEs directly from China. The remaining 20% comes from other countries, but even those supplies often originate from China before being exported elsewhere, making China's influence even more pronounced. This dominance gives China considerable leverage in the global semiconductor supply chain, highlighting a critical vulnerability for the U.S. and other countries reliant on these materials. Several critical minerals are essential for semiconductors, and the U.S. heavily relies on imports for these materials[52]:

- Germanium: The U.S. is over 50% import-dependent, with major sources being China (58%), Belgium (21%), and Germany (10%).
- Gallium: The U.S. is 100% import-dependent, primarily sourcing it from China (55%), the UK (11%), and Germany (10%).
- Arsenic: The U.S. is also 100% import-dependent, with China (58%) and Morocco (38%) as key suppliers.

[52] Business executives for National Security. (n.d.) *The Global Semiconductor Supply Chain: Key Inputs.* Business executives for National Security. https://bbnc.bens.org/semiconductors---page-3-key-inputs

- Copper: The U.S. is 30% import-dependent, with China (59%), Canada (24%), and Mexico (11%) as primary sources[53].

This data highlights an important dependence of the US by China and represent a vulnerability for the entire technological process of the nation.

As regards Europe, China supplies about 98% of rare earth elements to the European Union, Turkey provides 98% of boron, South Africa supplies 71% of platinum and an even higher percentage of platinum group materials: iridium, rhodium, and ruthenium. Lithium is 78% sourced from Chile, while the supply of certain critical raw materials like hafnium and strontium depends on individual European companies[54].

Although, rare earth elements are not essential for the direct manufacturing of semiconductor chips, which primarily depends on materials like silicon, germanium, and gallium arsenide, they are critical for many technologies and components that rely on semiconductors, particularly in advanced electronics and communication technologies. Examples includes magnets and electronic components, displays and lighting and catalysts.

In conclusion**,** the global semiconductor supply chain is marked by its intricate complexity and pronounced regional specialization, which create both opportunities and vulnerabilities. The industry's reliance on specialized expertise, advanced manufacturing facilities, and geographically concentrated production underscores its susceptibility to disruptions. The regional monopolies in various stages of production, combined with logistical hurdles and geopolitical tensions, exacerbate these vulnerabilities. Additionally, the rapid pace of technological advancement leads to shorter product life cycles and complicates inventory management, driving up costs. The reliance on critical materials such as silicon, germanium, and gallium arsenide further boost the fragility of the supply

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[53] Business executives for National Security. (n.d.) *The Global Semiconductor Supply Chain: Key Inputs.* Business executives for National Security. https://bbnc.bens.org/semiconductors---page-3-key-inputs

[54] Council of the European Union. (n.d.). *An EU critical raw materials act for the future of EU supply chains.* Council of the European Union. https://www.consilium.europa.eu/en/infographics/critical-raw-materials/

chain. To navigate these challenges, the semiconductor sector must focus on strategic diversification, enhance supply chain resilience, and adopt proactive risk management strategies to ensure stability and continued growth amidst evolving global dynamics.

1.6 THE IMPACT OF COVID-19 ON THE SUPPLY- CHAIN

The pandemic has severely impacted the semiconductor supply chain, revealing all its critical vulnerabilities. The semiconductor shortage has caused significant supply shortfalls across various sectors due to the widespread use of these components.

Firstly, although many companies did not completely shut down, they experienced partial interruptions in their operations. Restrictions affected production capacity, with temporary reductions in the workforce and production due to government-imposed restrictions and lockdown measures. Additionally, these closures caused significant delivery disruptions. There were delays in shipments and port congestion due to transportation restrictions and reduced services. Moreover, safety protocols and restrictions reduced factory production capacity, leading to slowdowns in production and decreased semiconductor availability.

The pandemic also impacted the semiconductor sector by increasing the demand for electronic devices. This surge was driven by the rise in remote work, remote learning, and home entertainment. Consequently, additional pressure was placed on an already fragile supply chain. The increased demand led to semiconductor shortages in various sectors, including automotive, consumer electronics, and telecommunications.

All this also led to increased raw material costs, such as metals and rare earth elements widely used in the electronics industry.

The chip shortage phenomenon was also influenced by a miscalculation: at the beginning of the pandemic, companies involved in semiconductor production cut their sales forecasts. However, the outcome was entirely different: the start of remote learning and smart working caused an exponential growth in demand for electronic devices such as smartphones, tablets, and computers. The fundamental problem was that with these forecasts, companies reduced semiconductor production. Semiconductor production, however, requires between 4-6 months and sometimes even more. Therefore, when orders resumed, production times were excessively long, leading to a backlog of demand.

Automotive companies, for example, were particularly affected by this market crisis. The shortage of semiconductors, increasingly essential components for completing a modern vehicle, resulted in delivery times doubling or even tripling, causing significant economic losses. The consumer electronics industry was also hit hard by the semiconductor shortage.

In conclusion, the COVID-19 pandemic has highlighted the vulnerabilities of the global semiconductor supply chain, demonstrating how critical partial business operation interruptions, transportation restrictions, and sudden increases in electronic device demand are. The miscalculation by companies in sales forecasts exacerbated the situation, slowing semiconductor production when it was most needed.

The semiconductor shortage has significantly impacted various sectors, particularly the automotive and consumer electronics industries, leading to production delays, increased costs, and economic losses. This crisis has underscored the importance of accurate planning and greater resilience in the supply chain to face future global challenges.

What emerges from this analysis is the necessity for companies and governments to work together to build a more robust and flexible supply chain capable of withstanding unexpected shocks and responding quickly to market changes.

1.7 BRIEF CONCLUSION

This analysis defines the context in which firms, institutions and national governments are operating. Semiconductor industry is characterized by a high degree of complexity and a fragile supply-chain. Production is slow and costly, as well as challenging and demanding in terms of specialized machinery and highly skilled personnel. Due to the concentrations of the stages of the production process in few countries no single national country or firm has a dominant power in the entire industry.

Different regions of the world simply hold hegemony over few stages of the production process making everyone vulnerable to disruptions. There is a complex network connecting countries and firms worldwide, highlighting how deeply the semiconductor industry is influenced by events in individual nations. Any event in a single country can have ripple effects throughout the semiconductor industry, impacting the supply chains of other countries as well.

The U.S. holds a dominant position in the design market, especially in the production of logic devices such as personal computer CPUs. Taiwan and South Korea lead in manufacturing, while China specializes in assembly. Europe focuses on producing specialized machinery that manufactures state-of-the-art semiconductors. This global distribution of roles means that internal politics, natural disasters, and economic circumstances in any one region can have significant repercussions on other stages of the supply chain.

The recent chips shortage brought in light the numerous vulnerabilities of the supply chain and the need for national government to start implementing strategies to fix vulnerabilities and reduce dependencies. The COVID-19 pandemic played a crucial role in revealing these vulnerabilities and served as a turning point, leading global authorities to recognize semiconductors not merely as a future driver of progress and technological independence, but as a crucial and immediate factor in shaping global influence and geopolitical power.

2. SEMICONDUCTOR INDUSTRIAL POLICY IN US AND EU

2.1 OVERVIEW

This chapter describes the trends and the measures taken by the European Union and the US regarding the development of the semiconductors sector. This chapter will offer a comparison between the European and American strategies, analyzing differences and common aspects.

In the first chapter, it has been clear that semiconductors constitute a race in which the most powerful economies are scrambling for control over the market. Thus, recognizing that semiconductors nowadays represent a form of power that every nation seeks to wield, it is essential to explore how this power is sought to be achieved.

In response to the growing strategic significance of semiconductors, both the EU and the U.S. have recently taken steps further through the implementation of plans to promote internal production and self-sufficiency. The United States enacted the Chips and Science Act in 2022, which provides substantial financial incentives to promote semiconductor research, development, and production within the country. As a consequence to the enactment of the legislation in the US, the European Union introduced the EU Chips Act, which was approved on July 25, 2023. This legislation is designed to enhance the EU's semiconductor manufacturing capabilities and strengthen its technological sovereignty.

These legislative actions by both the EU and the U.S. underscore a broader global trend of governments seeking to secure and expand their influence in the semiconductor industry, preserve national security and contain China’s expansion.

2.2 NATIONAL SECURITY, TRENDS IN US AND THE US CHIPS ACT

The American approach to industrial semiconductor policy has been significantly influenced by national security concerns and the urgent need to mitigate the threat of China emerging as a leader in a sector crucial for global dominance. The fragility of semiconductor supply and the numerous geopolitical tensions that have escalated since 2022 with Russia's invasion of Ukraine, have led to an increased urgency, particularly for the United States, to develop industrial policies that ensure secure access to these strategic components. In this context, an executive order on export controls not only prohibited US companies from exporting or developing highly advanced chips for China[55] but also extended the restrictions to lower-tech chips. While older chips were previously allowed for export after a new generation of processors was released, the new regulations imposed more restrictions to curb China's semiconductor capabilities. These limitations on US companies were further tightened through agreements with Dutch and Japanese companies in March 2023, which introduced export controls on the most advanced chips and production equipment.

The U.S. semiconductor policy was supported not only by the bipartisan effort to revitalize American industry and generate well-paying jobs in key areas of the U.S., but also in the shared belief among Democrats and Republicans that China posed an immediate threat to U.S. national security. This perception justified the development of an American industrial policy focused on producing critical infrastructure, including semiconductors, domestically. These observations highlight a shift towards a more self-sufficient and technologically dominant approach, aiming to lead in semiconductor manufacturing and reduce reliance on other countries in the supply chain. This consensus also influenced the way the EU and its member states considered granting chips and ICT infrastructure as a matter of national security.

In 2018, the Trump administration implemented Section 301 tariffs, imposing a 25% duty on various imports, including Chinese semiconductors, under the pretext of national

[55]Gupta K., Borges C., Palazzi A.-L. (2024, July 9). *Collateral damage: The domestic impact of U.S. semiconductor export controls.* Center for strategic and international studies. https://www.csis.org/analysis/collateral-damage-domestic-impact-us-semiconductor-export-controls

security. The following year, in 2019, the administration introduced export restrictions on chips intended for Huawei, the Chinese telecom giant known for exporting smartphones and 5G equipment. This time, the national security concerns regarded specifically the potential spyware threats, as evidenced by the administration's actions against the Chinese social media platform TikTok[56].

American pressure on European countries, centered on fears that Huawei's 5G technology, despite being cost-effective and highly advanced, might expose companies, governments, and individuals to risks of surveillance, industrial espionage, and cyberattacks orchestrated or demanded by the Chinese government. Both the Trump and Biden administrations expressed these concerns, viewing Chinese 5G infrastructure in Europe as a significant security threat. They worried that sharing sensitive information with allies could inadvertently lead to surveillance by non-allies[57].

American steps to preserve national security are visible in the significant industrial policy investments made by the Chips and Science Act which aim to restore American leadership in the manufacturing of advanced semiconductors, reducing dependence on foreign countries along the supply chain. With a total budget of $280 billion, the Act designated $54 billion specifically for semiconductor initiatives. Of this, $39 billion was allocated by the Department of Commerce to support the construction of manufacturing and packaging facilities, while $11 billion was set aside for research and development, also managed by the Department of Commerce. This funding includes the establishment of a National Semiconductor Technology Center, a National Advanced Packaging Manufacturing Program, a Manufacturing USA Semiconductor Institute to enhance public-private collaboration, and a Microelectronics Metrology program at the National Institute of Standards and Technology. Additionally, $2 billion was allocated to the Department of Defense to facilitate coordination and information sharing. Beyond these allocations, a manufacturing investment tax credit was introduced to help American companies offset the cost gap between domestic and foreign chip production. Recipients

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[56] Donnelly, S. (2023). Semiconductor and ICT industrial policy in the US and EU: geopolitical threat responses. *Politics and Governance*, *11*(4), 129-139.

[57] Donnelly, S. (2023). Semiconductor and ICT industrial policy in the US and EU: geopolitical threat responses. *Politics and Governance*, *11*(4), 129-139.

of this support are prohibited from manufacturing in countries deemed to pose a national security risk, such as the China[58]. The US Chips Act is notable for its centralized framework. All funding is provided directly by the federal government, with the administration taking the lead in determining investment priorities. This centralized approach allows for a relatively swift allocation of funds.

The Chips Act's implementation gained momentum in late 2023 and throughout 2024 with significant awards from the U.S. Commerce Department. Key highlights include $35 million to BAE Systems[59] for defense device production, $162 million to Microchip Technology[60] for semiconductor production, and the creation of the National Center for the Advancement of Semiconductor Technology[61]. The department also allocated $3 billion to expand U.S. advanced packaging capabilities. Major investments include $1.5 billion and $1.6 billion for GlobalFoundries, $8.5 billion for Intel, and $6.14 billion for Micron. TSMC and Samsung received $6.6 billion and $6.4 billion, respectively, for new facilities, while Polar Semiconductor, Absolics, and SK Hynix also secured grants. By 2032, U.S. semiconductor capacity is forecasted to increase by 203%, with a rise in global chipmaking share from 10% to 14%. Workforce development and research into advanced packaging also received substantial funding.

2.3 TRENDS IN EU AND EU CHIPS ACT

In response to the 2021 semiconductor shortage, the European Union started to particularly prioritize the question of semiconductors, especially after the introduction of the Chips Act in the US. The European Union's ambitions, as evident from the European Chips Act, aim to reinforce the region's technological sovereignty and innovation

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[58] Donnelly, S. (2023). Semiconductor and ICT industrial policy in the US and EU: geopolitical threat responses. *Politics and Governance*, *11*(4), 129-139.

[59] British multinational aerospace, defense and information security company.

[60] American corporation that manufactures microcontroller, mixed-signal, analog, and Flash-IP integrated circuits.

[61] A public-private consortium dedicated to semiconductor research and development in the United States.

capacity. These measures include substantial investments in research and development, as well as initiatives to foster public-private partnerships that drive forward the semiconductor ecosystem.

Moreover, the EU’s engagement in international agreements has been pivotal in diversifying its supply chain and mitigating future disruptions. The ultimate goal is to double the EU’s global market share in semiconductors from 10% to at least 20% by 2030.

From 2013 to 2019, the European Union adopted a liberal stance on semiconductors and 5G technology, fostering investments without significant security concerns, as evidenced by the provision of state aid for chip research. However, from 2018 onwards, the EU began to shift its focus towards geopolitical security in response to the growing influence of China and escalating trade tensions with the United States. By the year 2020, the European Union embarked on a course of action to increase the amount of chips produced on the territory of the Union and accelerated this process with the proposal of the EU Chips Act on February 9, 2022, and its subsequent approval on July 25, 2023. This initiative was necessitated also due to the numerous supply chain disruptions exacerbated by the Covid-19 pandemic. In 2021, the European Commission unveiled a plan to augment chip production capacity and mitigate dependency on foreign suppliers, with an emphasis on transatlantic cooperation.

In 2022, the enactment of the Chips and Science Act in the United States prompted concerns within the European Commission regarding the potential attraction of European firms, talent, and investments to the U.S. market, driven by subsidies for semiconductor research, development, and production. The EU also expressed apprehension about similar initiatives from China, Japan, Taiwan, and South Korea. Furthermore, the intensified U.S. focus on fields in which semiconductors are essentials like the military and technological security and the ongoing conflict in Ukraine, added to these concerns. In response, the EU proposed the EU Chips Act on February 9, 2022, and secured its approval on July 25, 2023, with the aim of enhancing chip industry capacity and counteracting the competitive edge of the United States. The EU's plan included €11 billion in subsidies directly from the EU and sought to attract an additional 32 billion euros in national subsidies.

The EU Chips Act is formed by 3 pillars. Each of the pillar aims to achieve objectives that are part of a broader engagement of EU in reaching high level of internal production, security of supply and a system of monitoring and crisis response.

The first pillar of the European Chips Act is the Chips for Europe Initiative[62]. This initiative aims to strengthen Europe's technological leadership by facilitating the transfer of knowledge from research to production, bridging the gap between research, innovation, and industrial activities, and promoting the industrialization of innovative technologies by European businesses[63].

Furthermore, The Chips for Europe Initiative will combine investments from the Union, Member States, and the private sector through a strategic reorientation of the Key Digital Technologies Joint Undertaking[64] (now renamed 'Chips Joint Undertaking[65]'). The Initiative will be supported by €6.2 billion in public funds, including €3.3 billion from the EU budget for the period up to 2027. This funding will complement the €2.6 billion already planned for semiconductor technologies. The €6.2 billion will support activities such as developing a design platform and establishing pilot lines to accelerate innovation and production[66]. In addition, the Initiative is supported by funding from the Horizon Europe[67] and the Digital Europe programs[68].

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[62] A policy instrument that aims to increase Europe's autonomy in the area of microchips.

[63] European Commission. (2023, April 18). *Commission Welcomes Political Agreement on the European Chips Act*. European Commision - Press Release.

[64] A public-private partnership for research, development and innovation.

[65] A European partnership program under Horizon Europe and a further development and expansion of Key Digital Technologies JU.

[66] European Commission. (n.d.). *European Chips Act*. European Commission. https://www.european-chips-act.com/

[67] It is the EU's key funding programme for research and innovation.

[68] An EU funding programme focused on bringing digital technology to businesses, citizens and public administrations.

The Initiative will also assist in the establishment of competence centers across Europe, providing access to technical expertise and experimentation, which will help companies, particularly SMEs[69], enhance design capabilities and develop skills. Alongside centers of excellence, these will become hubs for innovation and new talent. Additionally, to support start-ups and SMEs, access to finance will be ensured through a Chips Fund and a dedicated semiconductor equity investment facility established under InvestEU[70].

The second pillar of the European Chips Act aims to establish a system to secure supply by drawing in investments and boosting semiconductor production capacities. It introduces a framework for Integrated Production Facilities and Open EU Foundries, which are pioneering within the Union. These initiatives are designed to bolster supply security and contribute to a robust and resilient semiconductor ecosystem in the European Union. To achieve this, the EU Chips Act allows member states to offer subsidies to companies interested in establishing new semiconductor foundries within the EU. Additionally, member states can provide administrative assistance by expediting the permit approval process. If the European Commission approves the proposals submitted by the member states, the designated foundries can receive this support as an exception to the usual state aid rules[71].

In its third pillar, the European Chips Act aims to create a coordination framework between Member States and the Commission to enhance collaboration both within and across Member States. This framework will monitor semiconductor supply, project demand, predict potential shortages, and, if necessary, initiate a crisis response. To manage such scenarios, the Act provides a specialized set of measures that can be implemented[72].

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[69] Small and medium-sized enterprises.

[70] European Commission. (2023, April 18). *Commission Welcomes Political Agreement on the European Chips Act*. European Commision - Press Release.

[71] Bulfone, F., Di Carlo, D., Bontadini, F., & Meliciani, V. (2024). *Adjusting to new geopolitical realities: Semiconductors industrial policy in the US and EU*. Istituto Affari Internazionali.

[72] Bulfone, F., Di Carlo, D., Bontadini, F., & Meliciani, V. (2024). *Adjusting to new geopolitical realities: Semiconductors industrial policy in the US and EU*. Istituto Affari Internazionali.

Since the introduction of the European Chips Act proposal and the ongoing assessment of the second Important Project of Common European Interest (IPCEI) in microelectronics, which involves 20 Member States and several stakeholder investment plans, industrial deployment investments have already reached between €90 and €100 billion. The enactment of the European Chips Act accelerated the implementation of these projects and encourage further investments to strengthen Europe's semiconductor supply chain[73].

However, Europe is making significant progress in the semiconductor sector with major investments and international collaborations, driven by the EU Chips Act and public funding. Intel has announced $88 billion in investments across Europe, including projects in Germany, Ireland, and Poland, supported by substantial government subsidies. Other key players include GlobalFoundries and SMicroelectronics, who are building a plant in France with government aid, and Wolfspeed, which plans to invest $3 billion in Germany. Additionally, TSMC, Infineon, Bosch, and NXP are collaborating on a €10 billion facility in Dresden. Infineon is also planning a new €5 billion plant, while Italy has approved €2 billions grants for a STMicroelectronics facility in Catania. The EU continues to promote research with €325 million for new initiatives.

2.4 COMPARING EU CHIPS ACT AND US CHIPS ACT

The enactment of the EU Chips Act and the US Chips Act and Science were dictated by similar needs and prospectives. However, they differ in the strategy of implementation.

The European Chips Act has drawn significant attention to the semiconductor industry. Before 2020, there was limited awareness of key technologies and roles played by major global players like ASML, ZEISS, and leading chip producers. There was also a limited knowledge of the importance of the semiconductor sector and its future role in the

[73] Bulfone, F., Di Carlo, D., Bontadini, F., & Meliciani, V. (2024). *Adjusting to new geopolitical realities: Semiconductors industrial policy in the US and EU*. Istituto Affari Internazionali.

geopolitics and economic dynamics[74]. However, global chip shortages and the introduction of the Chips Act have changed this.

The Act has launched several initiatives, including: a strategic mapping of the semiconductor sector; a virtual design platform to lower entry barriers for SMEs and startups; equity and debt solutions under the Chips Fund; competence centers in each member state; and the establishment of a European Semiconductor Board to advise the European Commission. The Act aims to support chip manufacturing, design, R&D, and access to finance, but lacks a clear articulation of its objectives and success metrics. nevertheless, the legislation aims at doubling the EU's global market share in semiconductors from 10% to at least 20% by 2030.

Other developed countries are implementing strategies to enhance semiconductor production and taking into consideration an Asian foreign country like Japan it is clear that its strategy of "strategic indispensability" seeks to ensure its companies remain crucial in global value chains. Recent acquisitions, like that of JSR[75] by the Japan Investment Corporation, aim to enhance Japan's competitiveness in semiconductor materials.

The EU could benefit from Japan's approach by focusing not just on global production capacity but also on managing dependencies and ensuring European technology providers remain essential in the global semiconductor supply chain[76].

The United States, through the CHIPS and Science Act, focuses on technological rivalry with China, aiming to reduce costs, create jobs, and strengthen supply chains. U.S. regulations prevent subsidized companies from expanding manufacturing in China and monitor success by maintaining or widening the technological gap with China. The U.S.

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[74] Kleinhans, J.-P. (2024, July 30). *The missing strategy in Europe's chip ambitions: Member states must drive the next steps*. Tech Analysis and Policy Ideas for Europe Interface.

[75] A leading global supplier of photoresists, a crucial chemical for semiconductor production.

[76] Kleinhans, J.-P. (2024, July 30). *The missing strategy in Europe's chip ambitions: Member states must drive the next steps*. Tech Analysis and Policy Ideas for Europe Interface.

strategy is centrally managed at the federal level, with substantial financial support directly from the federal budget.

The difference in the funding structure between the EU and US Chips Acts highlights the limitations of the EU's industrial policy. Due to the lack of direct fiscal authority, the European Commission is reliant on funding from individual member states, whereas the United States can offer centralized subsidies. Member states need the Commission's approval for their funding plans and the Commission is clearly constrained in its ability to set and follow industrial policy priorities. This complex system could exacerbate economic inequalities among member states and jeopardize the European single market.

In response to these challenges, the IPCEI (Important Project of Common European Interest) in microelectronics and communication technologies emerges as a crucial tool for the EU. Approved in June 2023, the IPCEI encompasses 68 projects involving 56 companies and 30 associated partners. With public funding of €8.1 billion and an expected additional €13.7 billion in private investment, this initiative aims to support Europe's digital and green transformation. It also includes a claw-back mechanism for received aid, which helps ensure the effectiveness of the support.

While the United States manages the semiconductor sector with centralized governance and direct funding, the EU takes on a role as a coordinator of industrial policy, facilitating national aid and promoting cross-border collaboration. In terms of industrial policy tools, the U.S. has implemented direct subsidies to boost semiconductor manufacturing. In contrast, the EU has focused on adjusting its regulatory framework, particularly within state aid rules, to enable member states to support strategic investments. This includes leveraging the IPCEI framework and fostering collaboration among member states, businesses, and research institutions across the EU's single market to build transnational production networks.

The Chips and Science Act has allocated $52.7 billion to the semiconductor industry, while the EU plans to mobilize €43 billion for the same purpose. Unlike the US, the EU will not be introducing new funding; instead, the €43 billion will be sourced from existing EU funding programs. The reliance on existing funds may limit the scope and scale of investment compared to new funding sources and the process of reallocating existing funds might be complex and time-consuming, potentially delaying the intended impact.

Both legislations primarily focus on the third phase of the digital value chain, which is the enhancement of capacity for intermediate products.

When it comes to conditionality, the U.S. Chips Act imposes strict requirements on companies that receive public funding, such as domestic production commitments, job creation targets, profit-sharing mandates, and restrictions on expanding manufacturing capacity in rival nations. The EU Chips Act also incorporates conditions, including a mechanism for recovering public funds through profit-sharing and empowering the European Commission to prioritize EU semiconductor orders during supply chain disruptions. However, these conditions are generally less stringent than those imposed by the U.S.

The differences between Europe and the United States have profound implications, given the United States' strict position on independence and its stance on relations with China. The U.S. demands that Europe align its policies accordingly. In contrast, European responses are characterized by a slower pace and reduced impact, attributable to the EU's relatively weaker authority compared to its member states in foreign policy matters, coupled with more limited resources. This disparity is further compounded by a division in the foreign policy orientations of EU member states.

Another key difference between the two acts is that the U.S. Chips Act offers significant new federal tax incentives for investments in semiconductor manufacturing facilities, whereas the EU Chips Act does not. The U.S. incentives are notably generous, offering up to 25 percent tax credits for investments made by the end of 2026.

The divergent approaches of the EU and the United States towards semiconductor policy reflect deeper geopolitical and strategic dynamics that extend beyond mere industrial interests. The U.S. strategy, with its centralized funding and aggressive tax incentives, underscores a commitment to maintaining a technological leadership position and counterbalancing China's influence by limiting its power and attracting talents and investments in the American territory. This approach highlights the U.S.'s ability to mobilize substantial resources swiftly and impose stringent conditions on recipients, aligning closely with its broader geopolitical objectives.

Conversely, the EU's strategy, constrained by decentralized fiscal authority and reliance on existing funding mechanisms, reveals the complexities of coordinating industrial policy across member states. The EU's approach, while fostering collaboration and leveraging existing partnerships, faces challenges in achieving the same effectiveness and immediacy as the U.S. due to its fragmented policy implementation and slower decision-making processes. The emphasis on managing dependencies and maintaining a strategic position in global supply chains is crucial, yet the EU's capacity to effect rapid and substantial change remains limited.

2.5 BRIEF CONCLUSION

The European Union and the United States have recently ramped up their industrial policy strategies with a focus on bolstering the semiconductor sector. The EU Chips Act is the major initiative from the European Union designed to strengthen the continent's semiconductor industry. It seeks to develop and position European firms as critical players in semiconductor value chain doubling European market share within the industry by 2030. This act follows the U.S. Chips and Science Act, which was enacted to stimulate the American semiconductor sector with a clear goal of reducing dependence on foreign, particularly Chinese, manufacturing.

For both Republicans and Democrats, China’s economic and trade power is seen not only as an economic issue but also as a matter of national security. The Chips and Science Act provides substantial funding and incentives to encourage semiconductor research, development, and manufacturing within the U.S., aiming for technological independence across the supply chain, especially in the manufacturing stage.

In addition to domestic investments, the U.S. government has taken measures to limit China's access to advanced semiconductor technologies, particularly machines that are essential for producing cutting-edge chips. The restriction signals a strategic move to slow China's progress in developing state-of-the-art semiconductor technologies.

However, the EU’s reliance on national governments for funding and decision-making highlights the complexities of coordinating industrial policy across the Union. This decentralized structure has its advantages in providing flexibility and innovation, but it also risks slower implementation compared to the U.S.'s more streamlined approach.

The real limitation of Europe in the race for semiconductors lies in its chronic structural and political obstacles, which prevent the exercise of unified and effective power. The issue is both political and institutional: instead of acting as a centralized authority capable of providing strategic direction, the European Commission often functions more as a regulator, coordinating but not leading decisive action.

In this fragmented system, wealthier or more capable member states are likely to move forward with investments, while those with fewer resources will lag behind, risking a widening of economic and technological disparities within the Member states. Moreover, without a centralized approach, real coordination within the EU becomes nearly impossible. Countries will approve their own national legislation and primarily support their national champions, leading to a fragmented European strategy. This lack of coordination undermines Europe's ability to compete effectively on the global stage.

In contrast, countries like the United States have a centralized industrial policy that mobilizes large-scale funding and sets clear strategic priorities. If Europe continues to prioritize national interests over collective ones, it risks exacerbating differences and inequalities between member states, making future governance of these disparities more challenging. The semiconductor sector is too important for Europe’s future, demanding unity and integration to secure a competitive position in the global chip race. A coordinated and collective effort is essential to ensure that all member states can equally benefit, and that Europe may establish itself a key player in this vital industry.

3. NATIONAL STRATEGIES IN ITALY, GERMANY AND THE NETHERLANDS

3.1 OVERVIEW

In this chapter I will study the national strategies and actions of Italy, Germany and The Netherlands in line with the European Chips Act.

In the previous chapter, the analysis of the Chips Act emphasizes the need for member states to actively contribute to the development of the semiconductor sector by mobilizing national resources.

This chapter explores how the three governments are allocating resources and how their strategies differ based on their unique economic conditions and the current state of their internal semiconductor industries. Thus, the extent of development in the semiconductor sector, along with the broader economic context, plays a key role in shaping each country's industrial policy and approach to meeting the objectives of the Chips Act.

2.2 ITALY'S NATIONAL STRATEGY

Italy is one of the major semiconductor's producers within the European Union. In line with position, Italian government has undertaken steps towards independence, self-sufficiency and secure supply chain.

The government is pursuing an interventionist policy, in line with the European Chips Act. Significant investments have been made between 2023 and 2024. By the end of 2023, the National Microelectronics Fund was approved, totaling €3.292 billion, distributed over several years: €50 million for 2022, followed by €487 million for 2023, €456 million for 2024, €336 million for each year from 2025 to 2027, €341 million for 2028, and €475 million for both 2029 and 2030. These funds are intended to drive research and development in microprocessor manufacturing and foster industrial innovation. Companies in this sector can also benefit from Development Contracts[77] and the tax credits. Also, a portion of the funds will support research projects under the European Chips Joint Undertaking partnership.

In 2022, Italy announced the Chips Fund, a multi-billion-euro national fund aimed at supporting industrial and research activities in the semiconductor sector. Additionally, the National Recovery and Resilience Plan earmarks €50 million for semiconductor research and development on a national scale.

It is important to highlight that semiconductor industry in Italy is characterized by a company of global relevance: STMicroelectronics. The company is Italo-French and has 12,000 employees in Italy, and the same number in France. It counts Tesla, BMW, Apple and Renault among its customers. STMicroelectronics Holding N.V. is an unlisted parent company that exerts control over STMicroelectronics with a 27.5% stake. The Italian Ministry of Economy and Finance holds a 50% share of the holding company, thereby giving the state indirect control over the publicly listed company. MEF acquired this stake in 2010 from Cassa Depositi e Prestiti. Whereas the remaining 50% is owned by the

[77] All agreements, instruments or understandings made up of one or more investment projects and any research, development, and innovation projects, which are interconnected and work together.

French state through Bpifrance, the public investment bank, which is part of the Caisse des Dépôts group.

At the end of May 2024, the EU approved the Italian state aid measure worth €2 billion for the creation of a new semiconductor manufacturing plant by STMicroelectronics in Catania, Sicily. Italian Minister of Economic Development Urso highlighted that since the beginning of the year, €9 billion in investments have been announced for semiconductor production in Italy, including €2 billion for STMicroelectronics for the Catania facility. Under this initiative, STMicroelectronics has committed to prioritize EU orders in the event of supply chain shortages, invest in next-generation microchip development, and continue strengthening Europe's semiconductor ecosystem. Production in Catania is scheduled to start in 2026.

The Italian policy strategy also includes attracting foreign investments into the country. In this context, the Italian Minister Urso announced in March 2024 that Silicon Box will invest €3.2 billion in Italy for a new production plant, the first of its kind in the European Union. The Singapore-based company specializes in chiplet integration, advanced packaging, and testing technologies. This project has an important significance since represents the first European investment in this specialized sector. This facility will help meet the demand for semiconductor assembly, primarily in the European market, and will enable new technologies such as next-generation applications in artificial intelligence, high-performance computing, and components for electric vehicles. At full capacity, the investment is expected to create 1,600 new direct jobs, in addition to the indirect jobs generated both during the construction of the plant and later within the broader supply and logistics ecosystem. The factory will be located in Novara, Piedmont.

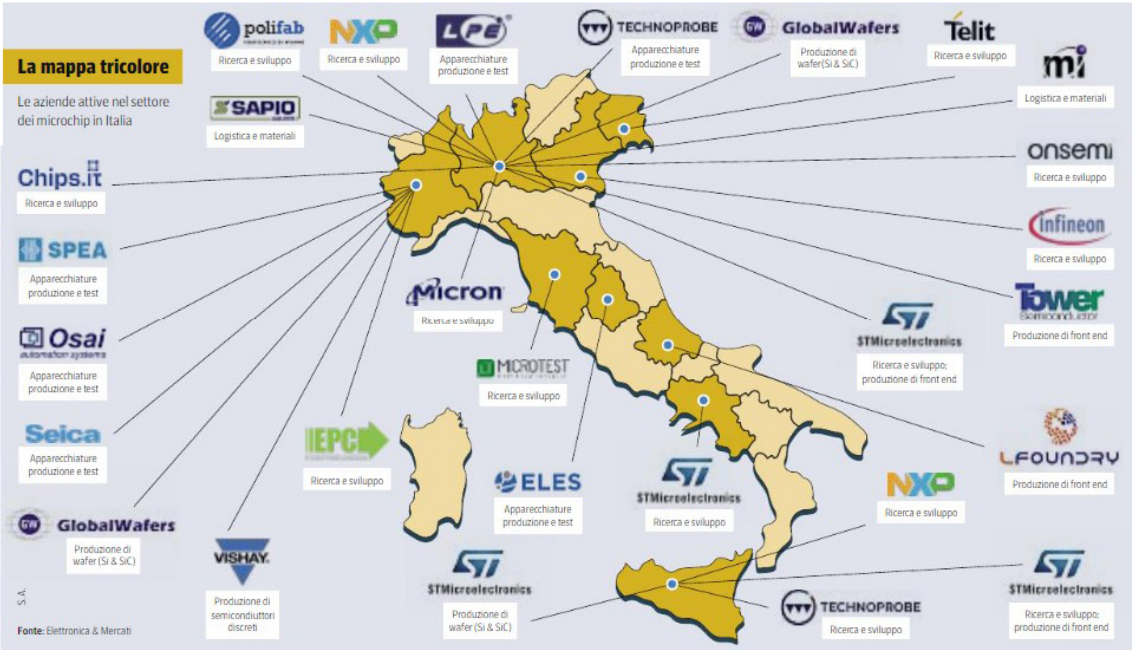
The Italian government's industrial policy aims to forge and strengthen relationships with other countries through numerous official visits. For example, In March 2024, during his visit to Tokyo, Minister Urso met with Japanese Minister of Economy, Trade, and Industry Yasutoshi Nishimura to initiate a strategic dialogue aimed at fostering investments between the two countries. This dialogue will focus on enhancing collaborations between businesses and startups and advancing cooperation in key sectors such as semiconductors, biotech, energy, and mobility, including through industrial research projects[78]. Furthermore, in July 2024, Minister Urso has engaged in discussions with Dutch ministers regarding the European agenda on industrial policy and potential synergies in strategic sectors, including semiconductors and defense industries[79]. Additionally, in January 2023, Urso visited Germany to strengthen similar collaborations and partnerships.

These international efforts underscore Italian Government's commitment to not only advancing industry through corporate agreements but also through institutional partnerships that facilitate collaboration and coordinate the development of these critical sectors.

Italy hosts highly specialized small and medium-sized enterprises. These companies have acquired advanced expertise in machinery and machinery component manufacturing, used for various production phases, from clean room equipment to testing. As for the design phase, Italy has a landscape of still underdeveloped companies, but there are promising entrepreneurial realities with high potential. In particular, in November 2023, the Italian government approved an investment plan of 225 million euros to establish the Italian Center for Semiconductor Integrated Circuit Design in Pavia, the Chips.IT Foundation, with the aim of coordinating research and design activities with public and private actors, providing state-of-the-art equipment and software. Moreover, it will serve as a competence centre, helping to train new generations of talent in the sector. The creation of the Chips.IT Foundation is a key milestone part of a broader national strategy in the semiconductor sector and in the process of the Italian implementation of the European Chips Act. In addition, there are several partnerships between Italian universities and companies working in the microelectronics and semiconductor sectors.

[78] Ministero delle Imprese e del Made in Italy. (2024). Urso: da domani in missione in Giappone. MIMIT. https://www.mimit.gov.it/it/notizie-stampa/urso-da-domani-in-missione-in-giappone

[79] Ministero delle Imprese e del Made in Italy. (2024). Intesa Italia-Olanda su nuova politica industriale Ue: semiconduttori e industria difesa. MIMIT. https://www.mimit.gov.it/it/notizie-stampa/intesa-italia-olanda-su-nuova-politica-industriale-ue-semiconduttori-e-industria-difesa



Reference: Dell'Aguzzo, M. (2024, March 24). *Non solo Silicon Box: Tutte le aziende di microchip in Italia*. Startmag https://www.startmag.it/innovazione/fabbriche-microchip-italia-dove-sono/

The figure above shows the main companies which operates in Italy in the semiconductor and microelectronics sector. The Regions in which many companies are concentrated are Lombardy, Piedmont and Sicily. The Italian semiconductor sector is characterized by numerous foreign companies alongside Italy-based firm. Despite the substantial number of companies in Italy, as acknowledged by the Ministry of Economy, there are no firms specializing in the "most advanced nodes" of the microchip value chain. This represents a significant limitation in Italy's ability to assume a prominent and influential role on the global stage. In this line, the key agreement with Silicon Box and the substantial investment by the Italian government in STMicroelectronics are crucial steps to address the gap in advanced technologies and enhance competitiveness, not just for Italy but for the entire EU on a global scale. Thus, Minister Urso has expressed the necessity of a strategic state that can foster the growth of European champions aiming to become international leaders.

However, the Italian government has announced that Intel's planned investments in Italy will not materialize. In 2022, Intel had shown interest in establishing chip production facilities in Europe, driven largely by the semiconductor crisis that emerged post-pandemic. The company had intended to invest billions of euros in new manufacturing plants and R&D centers across Germany, Poland, Ireland, Spain, France, and Italy.

However, after reporting $7 billion in losses in 2023, Intel decided to reassess its European expansion strategy. Despite this, Intel has not completely withdrawn from Europe and remains focused on its ongoing production projects in Ireland, Germany, and Poland.

Overall, Italy's semiconductor policy is proving to be proactive. Significant investments have been made to advance the sector and reduce dependencies for both Italy and Europe. The country is heavily investing in research and development. However, there are still major gaps in chip design, which poses a serious risk of dependency on foreign countries, particularly the United States due to its dominance on this stage.

Naturally, Italian industrial policy on semiconductor is heavily influenced by the presence of STMicroelectronics, the leading Italian company in the sector. STMicroelectronics is the primary recipient of state aid, receiving €2 billion out of the total funds allocated for the development of the semiconductor industry in the country by the Italian government. It is crucial to maintain a proactive and investment-oriented industrial policy. The semiconductor sector, as previously highlighted, involves extremely high fixed costs and long production and research timelines. Therefore, state support and the need to secure investments to subsidize startups or existing companies must remain a priority. The expansion of the semiconductor sector will not only ensure Italy and Europe's independence and sovereignty in this field, but it will also be vital for job creation. This development will generate employment opportunities in various areas, offering positions for highly qualified professionals and creating a positive ripple effect throughout the labor market.

3.3 GERMANY'S NATIONAL STRATEGY

Germany is the beating heart of the European semiconductor industry. The country hosts a vast density of world-leading device manufacturers and suppliers for materials, components, and equipment across the entire value chain[80]. Chip giants investing in Germany include TSMC, Wolfspeed, Intel, Bosh, Globalfoundaries, Infineon.

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[80] GTAI. (2023, February 7). GTAI. https://www.gtai.de/en/invest/industries/chip-manufacturer-wolfspeed-to-build-usd-3-billion-factory-in-saarland-956656

In August 2023, the Taiwanese company announced that it had approved the plan that regards the creation of a European Semiconductor Manufacturing Company (ESMC) in Dresden. The German government has allocated €5 billion to finance the construction of the factory, with the funds coming from the federal Climate and Transformation Fund (KTF). TSMC stated that it will invest up to €3.5 billion in its subsidiary and will retain 70% ownership of the facility. German companies Bosch and Infineon, along with the Dutch company NXP, will each hold a 10% stake[81]. Once operational in 2027, the plant will produce up to 40,000 wafers per month for use in automobiles, industrial products, and home appliances. However, while the factory is a boost for Europe's microchip production capabilities, it poses potential geopolitical risks, particularly concerning Germany's delicate relationship with China, its largest trade partner[82]. China considers Taiwan a breakaway province and is highly sensitive to any diplomatic or economic ties with the island. Germany has strategically presented the investment as a purely business initiative, rather than a political statement, to prevent worsening relations with Beijing. Thus, Germany must navigate both economic and diplomatic challenges with great care. The construction of the factory in Dresden represents not only a significant financial undertaking but also requires intense diplomatic effort to avoid geopolitical conflicts. By emphasizing the business aspects of the venture and maintaining a low political profile, Germany aims to advance its technological capabilities while minimizing potential friction with China[83].

In 2023 the American semiconductor manufacturer Wolfspeed has announced plans to build the world's largest silicon carbide semiconductor factory in Ensdorf, Saarland[84]. The North American chip company would have built a $3 billion chip production and R&D facility on the former site of a coal-fired power plant. Wolfspeed planned to invest

[81] Calabresi, G. (2024). Germania e il dominio cinese sui microchip: aiuto a Taiwan. Europa Today. https://europa.today.it/economia/germania-dominio-cinese-microchip-aiuto-taiwan.html

[82] Pieter Haeck (2024). Germany's Taiwan chip plant risks riling partner China. Politico. https://www.politico.eu/article/germany-taiwan-chip-plant-risks-partner-china-tsmc-dresden/

[83] Pieter Haeck (2024). Germany's Taiwan chip plant risks riling partner China. Politico. https://www.politico.eu/article/germany-taiwan-chip-plant-risks-partner-china-tsmc-dresden/

[84]GTAI. (2023, February 7). GTAI. https://www.gtai.de/en/invest/industries/chip-manufacturer-wolfspeed-to-build-usd-3-billion-factory-in-saarland-956656

up to three billion euros in a state-of-the-art chip factory at the Ensdorf site, with project partner automotive supplier ZF investing $ 185 million in the landmark deal[85]. However, Wolfspeed has delayed plans to build the plant in Germany. The planned facility in Saarland, intended to produce computer chips for electric vehicles, has not been completely abandoned, and the company is still pursuing funding. However, after reducing capital expenditures due to a downturn in the European and U.S. EV markets[86], Wolfspeed, is now concentrating on increasing production in New York. Construction in Germany won't begin before mid-2025 at the earliest, a delay of two years from the initial target date[87].

In 2022, Intel announced that it will spend more than 30 billion euros to develop two chip manufacturing plants in Magdeburg, the largest foreign investment ever made in the country. The American company will receive nearly 10 billion euros in subsidies from German's government and the entire project is estimated to reach a total cost of 30 billion euros. However, according to the latest news from late summer 2024, the construction of the semiconductor gigafactory in Magdeburg might be at risk. The American company was hit hard by the losses suffered in 2023, which forced it to lay off 15,000 employees and reconsider its investments. Although no official confirmation has been given by Intel, there are growing concerns about a potential reversal. Should Intel decide to scale back or even abandon the project, it would deal a significant blow not only to Germany but to Europe as a whole, which had seen this investment as a fundamental step towards achieving technological self-sufficiency in semiconductors.

GlobalFoundries, which has been present in Dresden for decades, is expanding its production capacity in the same city. However, the American company has voiced significant concerns about the construction of TSMC's facility in Dresden.

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[85] GTAI. (2023, February 7). GTAI. https://www.gtai.de/en/invest/industries/chip-manufacturer-wolfspeed-to-build-usd-3-billion-factory-in-saarland-956656

[86] The markets for electric vehicles.

[87] Sterling, T., Steitz, C., & Ersen, H. (2024, June 20). *Wolfspeed plant delayed as EU's chipmaking plans flounder*. Reuters. https://www.reuters.com/technology/wolfspeed-plant-delayed-eus-chipmaking-plans-flounder-2024-06-20/

GlobalFoundries also points out that, over 25 years, its Dresden site has received less than half of the state funding compared to what has been allocated for TSMC's entry.

Infineon is the largest German company in the semiconductor industry alongside with Bosch, which also holds a significant position. Both are involved in the major investment plan for the construction of the European Semiconductor Manufacturing Company.

Principal companies operating in Germany are indicated in the figure below:

Source: Chazan, G. (2023, December 4). *Germany's budget crisis threatens chipmaking ambitions*. Financial Times. https://www.ft.com/content/898454ba-8fc2-4b00-a14f-5f9ee152d127

Most of firms operate in the south of Germany, but the region where the semiconductor industry has the most significant hub is Saxony, particularly the city of Dresden. It is often referred to as "Silicon Saxony" due to the vast semiconductor industrial district that has developed there. The city is home to a growing ecosystem of both German and foreign companies, creating the largest semiconductor cluster in Europe. Several globally significant foreign companies are planning to set up operations in Dresden, further contributing to the expansion of the industrial district. With the support of state funding, Silicon Saxony is poised to evolve into "Silicon Europe," key hub of technological innovation in Europe. The region also plays a crucial role in reducing Europe’s reliance on semiconductor imports, positioning itself as a vital contributor to the continent's technological sovereignty.

Source: Priyadarshi, K. (2024, March 7). *How does Rise of Far Right hinder German Semiconductor Ambitions.* Technovedas. https://techovedas.com/how-does-rise-of-far-right-hinder-german-semiconductor-ambitions/

The figure illustrates the numerous companies operating in Dresden within the sector.

However, a crucial question could undermine investment plans in Germany: the increased sovereign debt and the recession of 2023 that the German state is grappling with. By the end of 2023, doubts about state support have intensified following a startling ruling by the German Constitutional Court, which has thrown the government's spending plans for 2024 into turmoil. There is a widespread fear that the semiconductor projects might fall victim to this budgetary crisis, a situation they warn could severely damage Germany’s reputation and pose a significant threat to Europe as a whole.

The crisis began when Germany’s top court ruled that the government had breached the constitution by reallocating €60 billion in credit lines, originally designated for managing the Covid-19 pandemic, into the "climate and transformation fund", an off-budget mechanism used for financing Germany's industrial modernization. The subsidies for

Intel and other chipmakers, including Taiwan-based TSMC, were intended to be sourced from this climate fund. The court's ruling has caused widespread concern among companies, not only chipmakers but also other major industries, such as steelmakers investing heavily in carbon-neutral production[88].

Germany's economy currently finds itself in a far from comfortable position. After facing a significant period of stagnation in 2023, the country saw its GDP decease by 0.3%, making it the only G7 nation to experience negative growth[89]. The manufacturing sector, which accounts for nearly 85% of the industrial economy (excluding construction), also faced a downturn, shrinking by 0.4% during the same year.

By July 2024, the debt-to-GDP ratio in Germany stood at 63.4% for the first quarter, marking a two percentage points decrease compared to the end of 2023. However, growth forecasts remain bleak. According to July's Consensus Forecasts, Germany is projected to grow by a mere 0.2% in 2024. Moreover, the IMF reported that the country's GDP per capita declined by 1% between 2019 and 2023, placing it 34th out of 41 high-income economies. Within the G7, only Canada performed worse.

Unemployment in Germany rose to 6.0% by August 2024[90]. Although this remains below the eurozone average, experts warn that the situation may be worse than the headline figures indicate. Economists and legal analysts argue that the data conceal a sharp decline in high-skilled, well-paying manufacturing jobs. Compounding this, industrial sector

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[88] Chazan, G. (2023). Germany's budget crisis threatens chipmaking ambitions. Financial Times. https://www.ft.com/content/898454ba-8fc2-4b00-a14f-5f9ee152d127

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[90] Trading Economics. (n.d.). Germany unemployment rate. Trading Economics. https://it.tradingeconomics.com/germany/unemployment-rate

continues to struggle with high energy costs, weak export demand, and rapid technological change.

Manufacturing output dropped 4.6% in June 2024 compared to the same period the previous year, highlighting the ongoing challenges in the sector. The automotive sector, in particular, is facing a crisis, largely driven by the enforced transition to electric vehicles.

This data, combined with the losses sustained by foreign companies in 2023, particularly Intel, is undermining both Germany's and the European Union's plan to build a "Silicon Europe." The economic challenges Germany is facing now, threaten not only the nation's technological future but also that of the entire European continent. The ambitious goal of reducing reliance on non-European semiconductor producers may falter if Germany, as Europe’s largest economy, cannot stabilize its industrial base.

The German government is currently grappling with its own economic challenges, including stagnation, rising unemployment, and increasing debt. Given these issues concerns have arisen regarding whether Germany still have the financial capacity to support its ambitious projects in Dresden.

In conclusion, Germany has initiated a series of strategic projects and secured key partnerships with some of the largest firms in the semiconductor industry. The successful execution of these plans holds the promise of significantly advancing Europe’s technological independence. Given that no other European country can match Germany’s scale of investment, the stakes are high. The main concern now is whether Germany can navigate its current economic challenges. Even a delay, rather than a full cancellation, of these investment plans could have serious repercussions. Europe is already behind the U.S. and China in this critical sector, and any further setbacks could further jeopardize the continent’s competitive position on the global stage. It is urgent for the European Union to intervene by ensuring Germany the necessary resources to maintain its attractiveness to global companies and continue driving these key projects.

3.4 THE NETHERLANDS’ NATIONAL STRATEGY

The Netherlands is home to one of the most critical companies in the industry: ASML. It specializes in the development and manufacturing of photolithography machines which are used to produce computer chips. ASML is the largest supplier for the semiconductor industry and the sole supplier in the world of the extreme ultraviolet lithography photolithography machines that are required to manufacture the most advanced chips. ASML’s equipment is indispensable for manufacturing leading-edge semiconductors, making it a critical supplier for major chip manufacturers worldwide. Intel, Samsung Electronics and TSMC are ASML's biggest customers. The crucial aspect of ASML's most advanced machines is that they can work at tiny scales by generating super fine extreme ultraviolet light: just 13.5 nanometers.

Although Europe is not a major player in the production process of semiconductors referring to design, manufacture, and assembly, it is home to a firm whose supremacy is recognized worldwide: without ASML’s machines no cutting-edge chips would be produced.

However, the semiconductor sector in the Netherlands is well developed. The country houses other companies that have global relevance like NXP Semiconductors with its headquarters nestled in the city of Eindhoven and BE Semiconductor Industries headquartered in the confines of Duiven. NXP Semiconductors is specialized in design and manufacturing of chips while BE Semiconductor Industries in the back end of the semiconductor business. Also, the company ASM International which is specialized in the design, manufacturing, sales and service of semiconductor wafer processing equipment for the fabrication of semiconductor devices has it headquarter in the Netherlands. Although the Dutch semiconductor industry is developed, in terms of volume it lags behind the U.S. and Asian countries.

As regards Dutch government's interventions to stimulate the semiconductor sector and align with the objectives of the EU Chips Act, it has taken significant steps. For example, in April 2022, the national government announced that it will invest €230 million in strategically important research projects in the field of semiconductors and photonics, as part of its Technology and Innovation Strategy, an amount that is far below the sums allocated by other European countries[91]. In July 2023, Smart Photonics, a company based in Eindhoven specializing in photonic chips, is set to receive a €100 million investment from a consortium that includes the Dutch government, banks, and semiconductor companies[92]. NXP is receiving parts of the € 230 millions for two projects. One project focuses on developing new chips for (mobile) 6G technology[93].

However, the fear that ASML may leave the Netherlands appears to have shaken the Dutch government. At the beginning of March 2024, ASML is reportedly considering options for expansion abroad as it looks to dramatically increase its production capacity in the next few years. The problem is that the Dutch government has moved to tighten migration laws, which could mean that ASML faces more difficulties hiring appropriately skilled talent in the country[94]. Around 40% of ASML's 23,000 employees in the Netherlands are not Dutch[95]. In this context, in order to keep ASML at home, Netherlands government announced, at the end of March 2024, that is set to invest €2.5 billion in the Brainport Eindhoven region[96]. This initiative, known as "Project Beethoven," addresses issues related to personnel, space, and energy constraints, aiming to maintain the Netherlands' competitive edge in the global chip industry. ASML is, also, receiving funds

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[96] Lahiri, I. (2024, March 7). Dutch government tries to stop ASML from moving out. Euronews. https://www.euronews.com/business/2024/03/07/dutch-government-tries-to-stop-asml-from-moving-out

within the Ipcei framework to make a "next generation" chip production machine available to European partners. This will allow the partners to gain more knowledge and make smaller chips that save on material and energy consumption[97].

R&D in semiconductor in the Netherlands is a central question for the government and for universities. From 26-30 august 2024, Eindhoven University of Technology ran the five-day program, named Semiconductor Summer School, for a second year. 60 students from around the world spent days visiting some of the leading players in the semiconductor and photonics industries, attending talks by industry specialists and visiting professors, and working on a team challenge, as the global race to attract talent heats up[98]. Dutch government also offers tax credit that reduces costs for companies. An example can be the WBSO[99] which provides reduction in wage costs for companies engaged in R&D activities. It can be used to lower the wage tax paid by companies for employees working on R&D projects, including semiconductor innovation and research. WBSO budget is € 1.446 million. In addition, Dutch government offers the Innovation Box which is special tax regime that allows companies to benefit from a lower corporate tax rate on profits generated from innovative activities. The corporate income tax rate for profits derived from qualifying intellectual property developed through R&D is reduced from the standard rate to 9%**.** Companies in the semiconductor industry, which generate substantial IP from the design and production of chips and photonics, can benefit from the reduced tax rate.

Nevertheless, Netherlands above every European country has earned a relevant place in the Chip Race. Housing ASML, the country has become an important player in the fight

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[99] WBSO stands for Wet Bevordering Speuren Ontwikkelingswerk and is a tax scheme for stimulating technical innovations.

between China and US. In this context, national Dutch government must deal with the restriction on ASML’s exports imposed by the US government due to national security. From 2018 the US government has pressured the Dutch government to block ASML from exporting its EUV machines to China. The Dutch initially complied, but later tensions rose as the U.S. sought to further restrict ASML's exports, even older machines, without equally limiting American companies’ technology sales to China. From 2023 the company is also not allowed to sell certain models of the second newest generation to China because the US fears China's military could become too strong with the latest modern chip technology. However, it is noteworthy that large part of the turnover of the ASML came from sales to China and despite the restrictions, Chinese companies are still investing heavily in machines to produce chips from older generations.

China being one of ASML's most important clients may represent a problem, given that the Dutch company is unable to sell its most advanced and expensive products to the country. Furthermore, the most problematic aspect of the story is that the EU's role has been minimal despite exports being a matter of national governments. ASML’s importance is essentially vital for the European Union not only for the Netherlands. It seems to be the only European advantage over the USA and China, that keeps us seriously from being left out of the game.

Overall, the ongoing restrictions pose a significant risk, and the potential loss of the Chinese market for ASML could jeopardize the Netherlands' leadership in the semiconductor industry. This situation could also complicate diplomatic relations between China - U.S. and China - the Netherlands, with possible repercussions for the broader European landscape. It is unlikely that China will passively accept these constraints and may seek alternative suppliers, or the trade conflict may escalate.

Therefore, the Dutch government faces the critical challenge of not only ensuring ASML’s dominance but also developing a comprehensive strategy for the entire chip supply chain. Additionally, it must navigate the complexities of diplomatic relations with China while safeguarding national interests and sovereignty.

3.5 BRIEF CONCLUSION

The European Union is striving to secure a place in the global technology race, with European countries working to strengthen their internal semiconductor sectors and address their shortcomings. National governments are allocating billions in investments to the sector. Among the three countries analyzed, Italy is home to one of the most important semiconductor companies in Europe which has reported $17.057 billions as revenues[100] in 2023. Despite this, Germany's strength lies not only on the high number of companies operating in the sector but also on its economic power, which inspires confidence and reliability, capable of attracting and funding projects with leading semiconductor firms. However, the economic stagnation it is currently facing casts a shadow over the realization of these projects. It is crucial to ensure that companies receive the allocated funds and European institutions must intervene. The semiconductor industry will broaden Germany's influence in the global market and this expansion will not only stimulate economic growth but also create numerous job opportunities for workers across various skill levels. Additionally, it will attract new businesses and foster innovation within the sector.

Although the Netherlands has not allocated as many funds as Germany, it holds a position of leadership. The presence of ASML makes the Netherlands a valuable player in the industry. It is important for the European Union to protect this position, especially until it achieves independence in chip design, production, and assembly. Therefore, maintaining its dominance and sovereignty is essential to truly capitalize on this advantage. EU currently seems to lack power in this regard, and perhaps individual national governments are too weak compared to powers like the USA and China. Thus, a supranational intervention is necessary to protect the Netherlands and support the entire process towards European technological independence.

[100] Gartner. (2024). Gartner says worldwide semiconductor revenue declined 11% in 2023. https://www.gartner.com/en/newsroom/press-releases/2024-01-16-gartner-says-worldwide-semiconductor-revenue-declined-11-percent-in-2023

4. CONCLUSION AND COMPARATIVE ANALYSIS

This study has explored the theme of semiconductors and their significance in the current industrial policy of countries. The objective of this work is to offer a deep analysis of the semiconductor industry and the response of nations to the chip shortage cause by a negative exogenous shock like the covid-19 that brought in light all the vulnerabilities of the supply chain. Throughout the analysis, several key aspects have been examined, including dominance in the stage of the production process in terms of nations and companies, the analysis of European and American Chips Act and lastly a comparison between the industrial policy implemented in Italy, Germany and the Netherlands. Considering the findings, it is now possible to draw final conclusions that summarize the main outcomes achieved, as well as reflect on the practical and theoretical implications of these results.

The semiconductor industry is at the center of a global race, with countries vying to secure their own share of this critical sector. The complexity of the supply chain is exacerbated by the several dominances in every stage of the production process. This aspect makes the entire supply-chain vulnerable to a large number of number of events that influence the supply of every country. Following the breakout of the COVID-19 pandemic that caused the notorious chip shortage, national governments have implemented policies in order to reduce dependencies and prevent future supply crisis.

The U.S., through the semiconductor sector, is seeking to decelerate the expansion of China's commercial power especially within the domestic burdens. The American government has designated the semiconductor production as a national security problem. Especially, the central question is to secure supply chain, reduce the reliance on foreign countries, in particular those that may pose geopolitical risks, and containing Chinese power. Several Asian countries have based their national economies on the technological sectors and for this reason they hold power in many technological fields including semiconductors. Nevertheless, the U.S. continued to keep power in the most valuable stage of the production process through many investments in R&D and robust intellectual property protection. However, semiconductors are only part of an anti-China American policy which includes imports bans to China, deny to access to key facilities for Chinese companies and imposing tariffs on Chinese products.

European countries are strictly dependent from foreign countries for the supply of technological products, and this is the reason why many Member States have been increasing their investments in semiconductors in line with the Chips Act. The policy strategies outlined by the European Commission are heading in the right direction. However, it is essential to act swiftly in order to keep pace with the rapid rate of technological innovation in the sector. Cooperation on chip supplies between countries, companies, supply chain monitoring efforts, and strengthening the EU's trade policy regarding the procurement of critical raw materials could represent effective solutions. Nevertheless, expanding manufacturing capacity will still take time.

The objectives of the Chips Act are certainly highly beneficial. Nevertheless, the real obstacle is not in the objectives of the industrial policy but in how they are implemented. The fragmentation of the industrial policies among the member states and the lack of a unified European fiscal authority poses significant challenges. A coordinated approach is essential for maximizing the benefits of this initiative. Without harmonized policies and stronger financial governance at European level, achieving the desired technological independence and semiconductor self-sufficiency will remain difficult. The limit of this approach relies also in the danger of further disintegration among member states in an already difficult process of integration.

The approach outlined by the European Chips Act risks also to exacerbate economic disparities among member states. it is clear that countries with less ability to allocate significant funds due internal economic or social conditions risks falling behind. This disparity could lead to uneven development within the EU, with more affluent countries benefiting disproportionately from advancements and investment opportunities in the semiconductor sector. As a result, these imbalances could hinder overall cohesion and collaborative progress within the Union. In addition, it is important to acknowledge that no single European country likely has the capability to allocate substantial funds on the scale of the U.S., regardless of the circumstances. This limitation underscores the need for a coordinated European effort to pool resources and enhance collective investment in order to effectively compete with global leaders in the technological sector.

Another key issue must be outlined. This fragmented approach in the implementation of the Chips Act is time-consuming and less effective and poses challenges in establishing a unified European power capable of competing with the technological giants. To build a robust and competitive semiconductor industry in Europe, a more coordinated and streamlined strategy would be beneficial. However, competition with the U.S. and Asian countries is further complicated by the significant gap between them and member states. As previously mentioned, these countries possess substantial influence in the technological industry due to their extensive past investments, while European nations have not made comparable investments. This substantial detachment in technological capability makes it challenging for Europe to compete effectively on the global stage.

In contrast, advocates of a fragmented industrial policy may argue that allowing national governments the freedom to decide how and when to allocate their resources can be advantageous. They may contend that this approach provides greater flexibility and enables countries to tailor their investments to their specific circumstances, potentially fostering sectoral development in a manner that is more suited to their individual needs.

It is important to highlight that the decision-making process for industrial policy within the European Union is not very clear. While industrial policy is largely the responsibility of national governments, actions in this area require approval from the European Commission, which can be a lengthy process. In addition, it is widely spread the belief that national governments should minimize their intervention in the economy and that companies should operate independently. Consequently, subsidies to companies are rare and almost exceptional.

The free-market ideology has been prominent in Europe for the past 40 years. Similarly, the U.S., which has long defended free market principles, has historically minimized government intervention in the market. However, following the chip shortage in 2021, this perspective has faced increasing scrutiny in U.S. Despite its free market stance, United States has begun imposing tariffs on Chinese products and has allocated substantial funds to expand its semiconductor sector.

The approach to industrial policy in both the U.S. and Europe has shifted significantly. Numerous external shocks like the Covid-19 pandemic and ongoing geopolitical tensions, have exposed vulnerabilities and dependencies in global supply chains. These factors have driven governments to reconsider the need for greater control over critical sectors to ensure economic and political independence, as well as national security.

Advocates of the noninterventionist policy may fear of 2 main possible negative outcomes. The first concern is the risk of wasting public resources due to too many governments investing in the sector, potentially leading to an industry overload at the expense of other similar sectors. The second relates to the risk that these numerous state interventions, often through subsidies, are part of a protectionist policy that is harmful to global trade.

While the policy that implies interventions to develop the internal sector may be considered protectionist strengthening the semiconductor sector is necessary. Currently, European countries find themselves in a decidedly vulnerable position in this field. The goal should not achieve the same level of technological dominance as the U.S. or Asian countries, which have already established significant advantages. Instead, Europe Union should focus to ensure a secure supply chain and developing a sufficiently resilient internal sector to avoid succumbing to external influences and to facilitate technological, ecological, and digital progress. Moreover, concerns about an overload of investments remain premature. Europe is not enough competitive at any stage of production in the semiconductor and broader technology sectors, so investments are crucial to avoid falling behind. These investments would not only develop the semiconductor industry but also drive growth in related sectors, creating new jobs, expanding employment opportunities, and fostering innovation. Nevertheless, it is crucial to ensure that the promised funds are delivered to companies to maintain credibility. In addition, selecting high-value projects is essential to avoid wasting public resources. European Union should focus on setting realistic objectives and optimizing the allocation of funds, ensuring that investments are strategically targeted and effective.

However, the EU's lack of a clear vision on how to position itself within the semiconductor industry has been exacerbated by delayed interventions, limited coordination, and an unclear long-term strategy. The EU's delayed response to the semiconductor sector challenges can be attributed to its institutional structure, confusion over the allocation of powers, and a prevailing commitment to free market principles, coupled with a lack of long-term planning.

Since 2020, national governments worldwide have been increasing their interventions in industrial and commercial policy. Italy, Germany, and the Netherlands, in particular, have been implementing strategies aimed at strengthening the position of their national champions and attracting foreign companies to establish subsidiaries within their countries.

The table provides a comparative overview of how Italy, Germany, and the Netherlands are approaching their semiconductor strategies, highlighting their respective protagonists, goals, financial commitments, and forms of conditionality.

ANALYTICAL DIMENTIONS	ITALY	GERMANY	THE NETHERLANDS
PROTAGONISTS	Italian Government and semiconductors companies in Italy.	German Government and semiconductors companies in Germany.	The Netherlands Government and semiconductors companies in The Netherlands.
GOALS	Strengthen the domestic semiconductor sector, attract foreign investment and support the national champion STMicroelectronics.	Strengthen the domestic semiconductor sector, especially manufacturing, attract foreign investment and support the creation of a "Silicon Valley" in Dresden.	Strengthen the domestic semiconductor sector and support the national champion ASML.

FINANCIAL COMMITMENTS	National Microelectronics Fund worth €3.292 billion which includes state aid measure worth €2 billion to STMicroelectronics. €530 million allocated for R&D projects which includes 225 million euros for the Chips.IT Foundation and €50 million from the National Recovery and Resilience Plan.	The total financial commitment announced is around €20 billions including State aid measure worth €5 billion to TSMC, €10 billion in subsidies to Intel (announced, not approved yet). €1,7 billions from the National Recovery and Resilience Plan.	€230 million in research projects (announced), part of the €100 million investment to Smart Photonics, €2.5 billion in "Beethoven Project", WBSO with a budget of € 1.446 million.
POLICY INSTRUMENTS	Development Contracts, subsidies, tax credit.	Subsidies.	Subsidies, tax credit.
FORMS OF CONDITIONALITY	Development contract may be requested for development programs with eligible expenses of €50 million or more, and those for which, regardless of the investment size, the company seeks to apply the regulations of the Chips Act, may enjoy tax credit companies resident in the territory of the State and permanent organizations in the territory of the State of non-resident subjects, companies resident or located in other member states of the European Union, in states adhering to the agreement on the EEA.	Company seeks to apply the regulations of the Chips Act.	Company seeks to apply the regulations of the Chips Act, may enjoy tax credit (WBSO) if the research or development project is carried out within the EU and if the company develops a product, production process, or software programme or performs technical scientific research.

Source: Own elaboration based on data from Chapter 3.

While Italy, Germany, and the Netherlands share the overarching goal of enhancing their semiconductor sectors, their strategies reveal significant differences in scope and focus. Each country is home to a national champion: STMicroelectronics (Italy), Infineon (Germany) and NXP Semiconductor (Netherlands). These companies are crucial resources for the European Union, as they design and manufacture chips. Among them, STMicroelectronics leads in revenue, while the others also rank among the largest within the EU.

Italy is heavily investing on strengthening STMicroelectronics, its national champion, by channeling substantial investments into the company and supporting R&D initiatives. Italy's strategy aims to boost almost every stage of the supply chain, from R&D to design, to manufacturing, to advanced packaging, and testing technologies. This approach aims to expand STMicroelectronics' market relevance and attract additional foreign investments in the country. The Italian government is making comprehensive investments in every stage of the production process, aiming to achieve excellence and specialize in sectors where they can gain a competitive advantage, such as advanced packaging and testing technologies.

In contrast, Germany aims to expand a major semiconductor hub in Dresden. The German strategy primarily focuses on developing the manufacturing stage. This stage is very capital-intensive and requires many investments in terms of qualified labor workforce and equipment. The German government has committed substantial funds to support and attract semiconductor companies, particularly those specialized on manufacturing. Hence, the country has established many partnerships with industry giants such as TSMC and Intel. This approach is designed to position Germany as a central player in the global semiconductor manufacturing, leveraging significant financial commitments to build a robust and competitive ecosystem and expanding European production capacities.

The Netherlands, on the other hand, is centered around preserving its leading semiconductor company, ASML, ensuring that it remains based within the country. Alongside this, the Netherlands is making considerable investments in R&D to support ongoing innovation and maintain its technological edge. The national government is supporting the other national champion NXP Semiconductor through national funds with the objective to boost technological process and innovation. This strategy highlights the Netherlands' focus on reinforcing its current strengths while fostering future advancements in the semiconductor sector.

The European Commission has so far approved four semiconductor projects: two in Italy, one in France, and one in Germany. Of these, three projects are focused on funding for STMicroelectronics, two based in Italy and one in France. The remaining project involves state aid for the joint venture in Germany, which includes TSMC, Bosch, NXP, and Infineon. Thus, many projects have been announced but few have been approved.

The numerous interventions indicate that national governments are striving to strengthen their positions and recognize the critical role of semiconductors in ensuring their independence and preserving national sovereignty.

To achieve its objectives, the new EU industrial strategy must focus on several key areas. Firstly, there is a need for a substantial increase in funding across the European Union to support industry-wide initiatives effectively. Secondly, enhancing coordination among member states in their investment efforts is crucial to ensure that resources are allocated efficiently and strategically. Finally, the European Commission should work on streamlining regulatory processes to reduce bureaucratic hurdles for cross-border investments and projects. Simplifying these procedures will not only expedite approval and implementation but also make Europe a more attractive destination for global investors and businesses. By addressing these areas, the Commission can significantly boost the effectiveness and impact of the EU's industrial strategy. The possibility of creating a "Silicon Europe" is feasible but the primary goal should be to build a resilient supply chain and reduce dependencies. Cooperation between member states is essential to meet today's global challenges, as no single member state can succeed on its own. The adoption of a coordinated strategy between Germany, Italy, the Netherlands and other member states represents the only viable path to developing a "Silicon Europe" which is autonomous, competitive and prepared to tackle future geopolitics challenges.

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