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The Silicon Dream: Europe's Bid in the Semiconductor Race

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Abstract

Semiconductors are the backbone of today's digital world. From smartphones and laptops to medical devices, automotive systems, and missiles, semiconductors are an essential part of every electronic and digital product.

Semiconductors are also at the centre of geopolitical competition, with several great powers seeking to prevent competitors from controlling their value chains, while at the same time pursuing industrial and technological policy plans to increase their competitiveness in the sector and make them less vulnerable to external interference.

Taking stock of these developments, this working paper focuses on four aspects: first, it attempts to give a historical perspective to the semiconductor debate. Second, it maps the semiconductor value chain. Third, it focuses on the competition between the US and China in this sector. The fourth and final section reflects on the implications for Europe.

Keywords: Semiconductors – Market – Europe – Competition – Technology

1. Introduction

Since the invention of the first transistor in 1947, semiconductors have quietly and increasingly become the backbone of modern technologies. Through a series of key steps that led to the advent of so-called chips and the invention of integrated circuits (IC), semiconductors have become increasingly indispensable to modern societies, and today their value chain is more complex and interconnected than ever before. In fact, the semiconductor value chain is a complex ecosystem of diverse and highly specialized processes and steps distributed across the globe, from North America to East Asia. No single firm can seamlessly operate across the entire value chain end-to-end due to the specialized knowledge, technologies, and resources required at each stage. Designing semiconductor components requires unique expertise, that is distinct from the intricacies of manufacturing, testing, and assembly. Specialized equipment and facilities are essential for manufacturing, and these are often provided by dedicated semiconductor foundries. In addition, the global nature of the industry necessitates collaboration, with different companies specializing in specific components or stages of production from software design to final packaging, assembly, and distribution.

Semiconductors are also at the centre of the current geopolitical competition. The United States has long been a semiconductor powerhouse, home to technology giants and cutting-edge manufacturers. Washington is realizing the importance of semiconductors and, for this, reason, it is trying to reduce the external dependencies and to expand its semiconductor manufacturing capacity through initiatives such as the CHIPS and Science Act. At the same time, the US aims to slow down Beijing's attempts to achieve self-reliance in chip manufacturing through the employment of export control policies, domestic incentives, sanctions and preventing firms from making investments in China. China has invested aggressively in the semiconductor industry to reduce its dependence on foreign technology and to respond to US export controls. Most semiconductor production takes place in Taiwan and South Korea, with companies in many countries specialising in a niche of this complex and technologically advanced value chain. Meanwhile, European countries are striving to regain prominence in semiconductor manufacturing and research, where they're currently lagging behind both the US and China, the importance of semiconductors is therefore not only technological but also geopolitical. Chips have become an essential tool in the economic and strategic arsenal of nations, and the race for leadership in the semiconductor industry is shaping global relationships and international competition.

Taking stock of these developments, this working paper focuses on four aspects: first, it attempts to provide a historical perspective to the semiconductor debate. Second, it maps the semiconductor value chain and its key players. Third, it focuses on the competition between the US and China in this sector. This analysis lays the ground for a detailed reflection in the fourth and final section on the implications for Europe. As the European Union actively positions itself in the semiconductor ecosystem, this segment scrutinizes the region's endeavours, challenges, and opportunities related to the semiconductor global value chain (GVC).

2. From Silicon Dreams to Technological Frontiers

In 1947, with the invention of the transistor, first presented at the Bell Laboratories, scientists and engineers embarked on a journey that would forever change the landscape of modern electronics. [3] This technological 'leap forward' laid the foundation for the semiconductor industry and ultimately led to the microchip revolution. The first transistor was invented by John Bardeen, Walter Brattain, and William Shockley and was made using a semiconductor material, specifically germanium. In detail, a semiconductor can be defined as any class of crystalline solids intermediate in electrical conductivity between a conductor and an insulator.[4] Accordingly, germanium was chosen in 1947 for its properties, which allowed for the controlled flow of electrical current. Before the transistor, electronic devices relied on vacuum tubes for amplification and switching. However, vacuum tubes were bulky, consumed a lot of power and were prone to failure.[5] The search for a more efficient alternative led to the invention of the transistor. The first transistor consisted of a small piece of germanium with two closely spaced gold contacts. This design allowed electrical currents to be manipulated through the semiconductor material. Put simply, when a small voltage was applied to one of the gold contacts (the base), an electric field was created in the germanium. The brilliant idea was the use of a razor-cut edge of gold foil, which created extremely close contacts. This made it possible to precisely control the flow of electrons.[6]

While the transistor was being invented at Bell Labs, Morris Chang was taking his first steps in the United States before becoming a seminal figure in the semiconductor industry. Born in China in 1931, Chang attended Harvard University before transferring to the Massachusetts Institute of Technology (MIT) in 1950, where he first saw a computer and learned programming.[7] He went on to earn a bachelor's degree in 1952 and a master's degree in 1953, both in mechanical engineering. Chang came into contact with the nascent semiconductor industry and started his tenure at Texas Instruments (TI) between 1958 and 1983. During his 25 years at TI, he played a pivotal role in the development of the company's semiconductor business, particularly in the area of silicon transistors. In addition, the enthusiasm for this field and the industrial competition that arose in those years led to the creation of other important companies in the US such as Fairchild Semiconductors, where people such as Robert Noyce, who later co-founded Intel with Gordon Moore, worked and contributed to the development of the sector. The company was founded in San Jose, California, in what was then called Silicon Valley, precisely because of the concentration of high-

[3] For more info about Bell Labs history see Gertner, Jon, "The Idea Factory: Bell Labs and the Great Age of American Innovation," Penguin Publishing Group, 2013, ISBN 10: 9780143122791.
[4] Definition from the Encyclopedia Britannica.
[5] Miller, Chris, "Chip War: The Fight for the World's Most Critical Technology", New York, Scribner, 2022, ISBN-10:1982172002, p. 7.
[6] Riordan, M., Hoddeson, L., & Herring, C., "The invention of the transistor", Reviews of Modern Physics, ***71***(SUPPL. 2), S336-S345, 1999, https://doi.org/10.1103/revmodphys.71.s336. See also Riordan, M., Hoddeson L., "Crystal Fire: The Invention of the Transistor and the Birth of the Information Age", W. W. Norton & Company, 1998, ISBN 10: 0393318516;
[7] Aresu, Alessandro, ***Il Dominio del XXI Secolo. Cina, Stati Uniti e la Guerra Invisibile sulla Tecnologia***, Milano, Feltrinelli, 2022, pp. 15-16.

tech companies that had proliferated there since the 1950s. Despite a very active research community, and a large number of talented people who were working in the industry at that time, there was no mass market for them, and companies struggled to get the funding they needed.

Despite some initial problems, the tide turned in the 1960s when the military became the primary patron of semiconductor technologies in the US. Indeed, as the Cold War rivalry between the US and the Soviet Union fuelled the arms race, the US military sought innovations that could provide a decisive edge in critical technologies such as communications, air defence systems, ammunitions, missile guidance systems and aerospace.[8] Semiconductors held great promise for a wide range of military applications.[9] In fact, the miniaturization made possible by transistors and later integrated circuits was particularly attractive for a wide set of applications in space exploration, aviation, and defence and communication systems in general. In the 1960s, the National Aeronautics and Space Administration (NASA) and the US armed forces required chips to power the computers equipped on the Apollo spacecraft and the Minuteman II intercontinental ballistic missiles.[10] The first military contract for transistor technology was signed in 1949, and within a few years, the US was using chips in a wide range of weapons and military technologies, including torpedoes, missile guidance systems, sonar, radar, satellites, and telemetry systems.[11] The economic support provided by the US government in the mid-1960s laid the foundations for a 'golden age' in the industry, but at this stage, US companies still needed to find a way to turn chips into a mass-market civilian product to make the sector more durable and profitable.

As the technological juggernaut of Silicon Valley gained momentum, Moscow tried to catch up, but the Soviets ended up copying what was being done in the United States, falling behind and condemned to backwardness, first chasing Washington and soon after the East-Asian states. Indeed, the 1970s and 1980s saw the emergence of Asia as a formidable player in the semiconductor arena. Japan, in particular, emerged as a technological powerhouse, dominating the market with companies, such as Sony and later Toshiba, producing excellent products using US-made circuitry technology. The Japanese government was able to support the development of the semiconductor industry through major government programmes[12] and the creation of competitive vertically integrated companies, which in turn were interlinked through the so-called ***keiretsu*** system.[13] Japan's rise in semiconductors was heavily dependent on the US and intertwined with its complex ecosystem of firms operating in the sector. However, the same was true for the US, with Tokyo and Washington having become increasingly interdependent to the point that "each country relied on the other for supplies and customers."[14] This interdependence soon led to increased competition when the US was about to lose its dominance in the sector. In fact, by 1980, made-in-Japan electronics were seen as a high-quality, cheaper alternative to American products. The era marked a paradigm shift as Asian nations, driven by rapid industrialization, became synonymous with

[8] Leese, Bryan, "The Cold War Computer Arms Race", Journal of Advanced Military Studies, Vol. 14, 2023, pp. 102-120. DOI: 10.21140/mcuj.20231402006.
[9] Specifically, Gordon Moore's law, predicting the doubling of transistor density every two years, has been crucial for military applications. The continuous miniaturization of transistors enabled significant enhancements in processing power, leading to the development of compact and lightweight electronics.
[10] Miller, Chris, "Chip War: The Fight for the World's Most Critical Technology", New York, Scribner, 2022, p. 29.
[11] Holbrook, Daniel. "Government Support of the Semiconductor Industry: Diverse Approaches and Information Flows." Business and Economic History, vol. 24, no. 2, 1995, pp. 133–65. JSTOR, http://www.jstor.org/stable/23703131. Accessed 17 Jan. 2024.
[12] The best-known example of this is the VLSI [Very Large Scale Integrated circuit] Technology Research Association, set up in 1976 to stimulate innovation in semiconductor technology.
[13] Aoyama, Y. (2000). Networks, keiretsu, and locations of the Japanese electronics industry in Asia. *Environment and Planning A*, *32*(2), 223-244.
[14] Miller, Chris, "Chip War: The Fight for the World's Most Critical Technology", New York, Scribner, 2022, p. 49.

semiconductor manufacturing excellence. Besides Japan, South Korea entered the scene, in the 1980s with companies such as Samsung and LG making significant strides in semiconductor manufacturing.

Fast forward to the present, the landscape has undergone further transformation. The Silicon Valley remains a global innovation hub, but the centre of gravity has shifted. As will be discussed in the next section, private companies around the world, not just in the US, are driving advances in semiconductors. Asia, particularly Japan, South Korea, China, and Taiwan, is at the forefront of semiconductor manufacturing.

3. Global Landscape of Semiconductor Industry

Recent global crises, such as the COVID-19 pandemic and the Russian-Ukrainian war, have underscored the critical importance of securing semiconductors. The pandemic disrupted the global microchip supply chain and negatively impacting various industries and causing delays in the production and delivery of electronic devices. Globally, car manufacturers, including Volkswagen, Nissan, Ford, Honda, Fiat Chrysler, Audi, and Daimler, had to temporarily shut down or reduce production due to semiconductor shortages.[15] According to a CSIS report, "analysis by the U.S. Department of Commerce found that the [chip] shortage shaved an estimated $240 billion off U.S. GDP in 2021 [and] The auto industry alone produced 7.7 million fewer cars in 2021 due to lack of chips."[16]

3.1 Market Trends

Despite a post-pandemic decline in demand for semiconductors, chip shortages persist, and demand is set to increase with the advent of new AI applications, prompting efforts by the US and China to decouple and onshore the semiconductor value chain. Both countries are seeking greater independence in semiconductor production, which currently relies on Taiwanese and other East Asian firms. Notably, the Taiwan Semiconductor Manufacturing Company (TSMC) produces microchips that are critical to military applications, including Lockheed Martin's F-35 fighter jets.[17] In addition, Taiwan has nearly monopolised the manufacturing sector, accounting for more than 63% of global manufacturing income in 2020.[18]

China, despite its launch of ambitious initiatives, still lags behind the US in semiconductor capabilities, which remains the "unchallenged world leader in semiconductor design".[19] However, both superpowers are planning to decouple this critical value chain in the medium-long term. This attempt to decouple semiconductor value chains, spurred by geopolitical tensions and the quest for autonomy, presents a complex web of challenges that extend across various facets of the semiconductor industry. This intricate landscape requires the unravelling of interconnected processes, supplier relationships and dependencies cultivated over years of globalisation. As nations strive for self-sufficiency, several critical issues emerge.

[15] Sharma Ashim, "Not just Covid-19, automobile sector's other problem: Microcontroller shortage", Forbes, 13 March 2021.
[16] Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023.
[17] Matthew Fulco, "How Aerospace Can Improve Its Supply Of Semiconductors", ***Aviation Week***, 13 June 2023.
[18] Yen Nee Lee, "2 charts show how much the world depends on Taiwan for semiconductors", ***CNBC***, 15 March 2021.
[19] Shivakumar, Sujai and Wessner, Charles, "Semiconductors and National Defense: What Are the Stakes?", ***Center for Strategic & International Studies (CSIS)***, June 8, 2022.

The semiconductor industry's complex landscape and mechanisms rely on a global network of suppliers of materials and chipmaking equipment that stretches from America to East Asia, including Europe. Decoupling efforts confront the challenge of finding reliable alternatives, especially for critical materials and cutting-edge manufacturing tools. This reliance on a limited set of suppliers amplifies vulnerability to geopolitical tensions, trade disputes, and supply chain disruptions. Moreover, semiconductor manufacturing is a highly specialized and interdependent process, with different stages distributed across countries and continents. Attempts to decouple raise the spectre of disruptions in the flow of materials and components, affecting production efficiency.

3.2 Semiconductors' Global Value Chain (GVC)

The journey of a semiconductor from raw materials to the finished product is a meticulous and intricate process, and different countries play crucial roles at different stages of this production cycle. It is possible to simplify the semiconductor GVC by dividing it into three main steps: design, fabrication, and assembly & testing.

The first step regards the design of semiconductors. This segment sees the US at the forefront with American firms capturing "more than 40% of global IC design market share."[20] Furthermore, the US holds around 85% of the global market share for electronic design automation (EDA) tools, which are essential for creating the most sophisticated chips.[21] Single crystals are grown, with leading semiconductor manufacturing countries like Taiwan, South Korea, and the US excelling in this crucial stage with Europe and China representing smaller players. Chip design is becoming more and more important to power AI systems. AI software is characterised by intensive data processing and therefore requires very powerful semiconductors. Central processing units (CPUs) are therefore gradually being replaced by graphics processing units (GPUs), which contain a large number of faster, smaller, and more efficient transistors. Given the importance of semiconductors in powering modern AI, it is no coincidence that NVIDIA (the leading producer of GPUs) is one of the most highly valued companies in the world.

The subsequent wafer fabrication phase sees a concentration of expertise in countries known for their semiconductor industry prowess. For instance, the CSIS claims that the US accounts for 44% of the worldwide market share in wafer fabrication equipment (WFE) sales.[22] However, the manufacturing process requires different inputs, from silicon wafers to photomasks, photoresists, and chemicals. Taiwan, as said above is home to TSMC, a global semiconductor giant, which leads in wafer and very small components (such as the 3-nanometers microchips) fabrication and captures the largest slice of the market. The US, South Korea, Japan, and China also boast advanced fabrication facilities. However, in 2021 China as well as Europe captured the smallest slice of the market in the semiconductor fabrication segment.[23] Then, thin film deposition, photolithography, and other front-end processes are often conducted in technological hubs. Here, it is very important to highlight the role of critical materials, such

[20] Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023, p. 3.
[21] Shivakumar, Sujai and Wessner, Charles, "Semiconductors and National Defense: What Are the Stakes?", ***Center for Strategic & International Studies (CSIS)***, June 8, 2022.
[22] Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023, p. 8.
[23] Specifically, in 2021 Europe captured the 9% of market share, while China the 15%. See Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023, p. 4.

as silicon. Critical materials are mainly extracted in China, Russia, and Brazil, and then refined in the US or Japan.

As the manufacturing process progresses to the back-end stages, including assembly and packaging, China re-emerges as a significant player. Its robust electronics manufacturing industry, characterized by cities like Shenzhen and by firms such as Huawei HiSilicon and the Semiconductor Manufacturing International Corporation (SMIC) above others, contributes to the assembly of semiconductor devices. However, Japan plays a key role in the market of test equipment and remains the largest supplier of assembly equipment in the Indo-Pacific, "moving over $2 Billion worth in 2021."[24] Generally, when the factories complete the process for wafers, each chip is sliced, separated, tested, and assembled before being integrated into the final product. This segment of the chain is known as ATP (assembly, test, and packaging) and is dominated by the Indo-Pacific countries that possess 95% of ATP facilities in the world.[25]

Finally, a special mention goes to the Dutch firm ASML which is among the world's leading manufacturers of chip-making equipment or semiconductor manufacturing equipment (SME), such as lithography machines.[26]

To conclude, two more key aspects must be taken into consideration. The semiconductor industry thrives on the exchange of intellectual property. Decoupling raises concerns about the protection and sharing of IP, potentially hindering collaborative research and innovation. Stricter IP restrictions may slow down technological advancements and disrupt the collaborative spirit that has fuelled the industry. In particular, the spotlight is on China and speculation about possible security risks and information theft related to Beijing's commercial and intelligence practices.[27] In this regard, the case of 4G/5G equipment and infrastructure is telling with Chinese firms accused by the US of being a threat to the national security of the countries in which they operate.[28]

Second, semiconductor development relies on a global talent pool. Decoupling efforts may impede the free flow of knowledge and expertise, affecting the industry's ability to address evolving challenges. For this reason, the outcomes of the so-called 'talent war' will be crucial in the upcoming years to maintain and foster cutting-edge capabilities in the sectors.[29] According to McKinsey & Company, "For semiconductor companies, prioritizing talent as a top strategic objective is no longer an option—it's a necessity."

However, other critical issues could arise in the future, related to economic efficiency, market competition and technological innovation. In fact, the attempt to decouple semiconductor value chains is not a straightforward endeavour. It will require a nuanced approach that acknowledges the intricate interdependencies within the industry, the need for collaboration, and the imperative of fostering innovation.

[24] Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023, p. 8.
[25] Allen, Gregory C., "Thadany, Akhil, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region", CSIS, May 2023, p. 11.
[26] See ASML official website.
[27] Bradshow, Tim, and Gross, Anna, "ASML chief warns of IP theft risks amid chip sanctions", ***Financial Times***, 8 March, 2023. (Last access: 19/01/2024)
[28] The Economist, "Huawei is at the centre of political controversy", 27 April 2019.
[29] Cheng Ting-Fang and Lauly Li, "Chip talent war: Taiwan faces critical staffing shortage", Nikkei Asia, 18 February 2022; See also Kulik et Al., "The global semiconductor talent shortage", Deloitte, 2022.

4. Silicon Diplomacy: US-China Competition in Semiconductors

Semiconductors are the backbone of the digital age and have reached an enormous level of technological complexity, leading to increasing specialisation in chip design, manufacturing, and assembly. Given their economic importance, it is no coincidence that semiconductors are at the centre of geopolitical competition between the US and China. Both countries are trying to boost domestic production and innovation, but they are also trying to weaken their opponent.

4.1 Ramping Up Domestic Production: Two Models Compared

In 2022, the Biden administration launched the CHIPS and Science Act to boost US semiconductor research, development, and manufacturing capabilities with a budget of around $280 billion, making it one of the largest five-year federal R&D investments in US history. The US is resorting to economic statecraft, which can be defined as the strategic use of economic tools for geopolitical ends, to improve its position in the design and manufacturing of semiconductors. However, as other scholars have pointed out, this is not the first time that US industrial policy has targeted the semiconductor sector. In fact, between 1987 and 1997, the Defense Advanced Research Projects Agency (DARPA) distributed some $870 million in federal support to Semiconductor Manufacturing Technology, a grouping of the top 14 largest chipmakers.[30]

On the other side, since 2006 China has started to improve its position in the semiconductor GVC with its indigenous innovation campaign, appealing to its national pride and the need to overtake the West in the technology race.[31] In 2015, Beijing launched its national strategic plan and industrial policy "Made in China 2025" (MIC), which aims to bolster key national capabilities and increase autonomy with an estimated budget of $300 billion.[32] Specifically, China has used this plan to subsidise companies operating in strategic sectors such as semiconductors.[33] The plan promotes a new approach to research and manufacturing that focuses on quality rather than quantity and increases the domestic content of core components and materials to 70% by 2025.[34] However, some experts argue that the MIC plan efficacy may

[30] Yadong Luo and Ari Van Assche, "The rise of techno-geopolitical uncertainty: Implications of the United States CHIPS and Science Act", Journal of International Business Studies (2023) 54, 1423–1440.
[31] James McGregor, "China's Drive for 'Indigenous Innovation' A Web of Industrial Policies", ***US Chamber of Commerce***, 2010.
[32] Jason Fang and Michael Walsh, "Made in China 2025: Beijing's manufacturing blueprint and why the world is concerned," ABC News, April 29, 2018.
[33] Yadong Luo and Ari Van Assche, "The rise of techno-geopolitical uncertainty: Implications of the United States CHIPS and Science Act", Journal of International Business Studies (2023) 54, 1429.
[34] Kennedy, Scott, "Made in China 2025", ***CSIS***, June 1, 2015.

have been overestimated given, the significant costs to the Chinese economy so far due to rising trade tensions and restrictions.[35] Interestingly, according to Intel CEO Patrick Gelsinger, despite these initiatives China is still struggling to catch up in microchip production. Specifically, during a speech at the World Economic Forum in Davos, he claimed that there is a 10-year gap between Beijing and the rest of the world and that this gap will persist for at least the next decade, partly due to the US export control policies.[36] Other experts, on the contrary, argued that the US has actually lost ground to China in the period between 2000 and 2020. In particular, the US dropped from 37% of the global share of semiconductor manufacturing capacity in 1990 to 12% in 2020 and was overtaken by China, which reached 15% in that year.[37]

4.2 US Export Control

The US is trying to boost its domestic chip production, while at the same time imposing tariffs and sanctions on Beijing. Since 2022 Washington has imposed chip sanctions on China, aimed at reducing its chance to catch up with the most advanced chips. However, these sanctions were prone to loopholes, and it was quite easy for Chinese companies to circumvent them and maintain access to advanced technologies.[38]

As a result, in 2023 the US government tightened its measures on the export of chips and chip-making equipment. The Biden administration's chip initiative imposed very stringent conditions and restrictions on Chinese companies, to the point that the New York Times has provocatively called the new sanctions "an act of war" against Beijing.[39] Specifically, the new regulations were issued in order to tighten restrictions on the sale of sophisticated chip-making equipment and graphics chips for artificial intelligence applications to Chinese companies.

Officially, Washington's main concern was that the Chinese could use those specific components and graphics chips, such as the chipmaker Nvidia's A800 and the H800 chips, for military development purposes. However, according to Chinese business leaders, this initiative could have backfired and had the opposite effect. Specifically, Chloe Wang, a partner and vice-president at the Guangzhou-headquartered Yang Cheng Fund, argued that in reaction to these restrictions, Chinese companies would be reinvigorated in response to these restrictions, creating the conditions for a more innovative ecosystem.[40]

[35] Lee Branstetter and Guangwei Li, "The actual effect of China's "Made in China 2025" initiative may have been overestimated", The Centre for Economic Policy Research (CEPR), August 11, 2023.
[36] Intel CEO Pat Gelsinger speaks at the World Economic Forum in Davos, Switzerland – 1/17/2024, CNBC, available at https://www.youtube.com/watch?v=hw-kesm-ktl&t=32s&ab_channel=CNBCTelevision
[37] Jeremy Mark and Dexter Tiff Roberts, "United States–China semiconductor standoff: A supply chain under stress", Atlantic Council, February 23, 2023.
[38] Knight, Will, "The US Just Escalated its AI Chip War With China", ***Wired***, 17 October 2023.
[39] Palmer, Alex, "'An Act of War': Inside America's Silicon Blockade Against China", ***The New York Times Magazine***, July 12, 2023.
[40] Handley, Lucy, "U.S. chip export ban is 'great news,' says partner at Chinese tech investment fund", ***CNBC***, October 23, 2023.

4.3 The Chinese Counter-Offensive

Scholars have debated the effectiveness of US export restrictions towards China. Historical patterns indicate that rising powers, when faced with disruptions, tend to respond by investing in industrial development and promoting self-sufficiency.[41] In line with this trend, President Xi Jinping has actively supported the development of Chinese indigenous research and production capabilities.[42] The case of Semiconductor Manufacturing International Corporation (SMIC) is instructive in this regard. In fact, SMIC has been able to achieve excellent results in the production of chips used in Huawei smartphones, despite being hit by sanctions for about a decade. For instance, since the debut of Huawei's Mate 60 Pro in August 2023, the company's stock has seen a 22% increase, equivalent to approximately $5 billion, making it the "third best-performer on the benchmark gauge for Chinese companies listed in Hong Kong."[43] The structure of GVC for semiconductors also allows rising powers to adapt and upgrade their industrial capabilities in response to disruptions.[44] The US need also to involve its allies to ensure the effectiveness of its economic statecraft. Interestingly, in 2022, the United States relied on the involvement of the Netherlands and Japan to impose additional export restrictions on China. These measures expanded existing foreign direct investment rules under US export control laws, specifically targeting certain US-listed Chinese entities, and extended US export control jurisdiction to key third-country suppliers critical to China's semiconductor industry.[45]

In 2024, the competition between the US and China has intensified with Beijing launching its counter-offensive through the employment of blocking laws and other countermeasures. In January 2024, China imposed sanctions on five American defence-related companies as a retaliatory measure against US arms sales to Taiwan and American sanctions on Chinese entities. The sanctions, announced by China's Foreign Ministry, involve freezing the assets of these companies in China and prohibiting any business transactions between them and Chinese organizations or individuals. The companies that will be sanctioned are BAE Systems Land and Armaments, Alliant Techsystems Operations, AeroVironment, Viasat, and Data Link Solutions.[46] Although the actual impact on these companies remains uncertain, such sanctions represent a political response to US recent initiatives. According to the Chinese Foreign Ministry, the US actions were deemed as harmful to China's sovereignty and security interests as disruptive to peace and stability in the Taiwan Strait, thereby violating the rights and interests of Chinese companies and individuals.[47]

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[41] Chen, L. S., & Evers, M. M. (2023). "Wars without Gun Smoke": Global Supply Chains, Power Transitions, and Economic Statecraft. *International Security*, *48*(2), 164-204.

[42] Davidson, Helen, "Xi Jinping urges China to greater self-reliance amid sanctions and trade tensions", ***The Guardian***, March 6, 2023.

[43] "How Huawei's Chipmaker Turned US Sanctions into a China Success Story", ***Bloomberg***, November 21, 2023.

[44] Miles M. Evers, "Why the United States Is Losing the Tech War With China", ***Lawfare***, January 14, 2024.

[45] Zhang Jing at al., "Japan And The Netherlands Agree To New Restrictions On Exports Of Chip-Making Equipment To China", ***Mayer Brown***, February 28, 2023.

[46] "Foreign Ministry Spokeperson's Remarks on Countermeasures on US Arms Sales to China's Taiwan Region and Sanctions on Chinese Entities", Ministry of Foreign Affairs of the People's Republic of China, Official Website, January 7, 2024.

[47] Moritsugu, Ken, "China sanctions 5 US defense companies in response to US sanctions and arms sales to Taiwan", ***APNEWS***, January 7, 2024.

5. The EU's Role in Semiconductors

5.1 Europe: What Has Done in The Past

Europe's problems in semiconductors became particularly evident in the late 1980s. Indeed, as shown in the previous sections, US companies were the undisputed leaders in the 1960s and 1970s, taking advantage of military demand (and hence government contracts) and the increasingly strong demand from the nascent computer industry. Things began to change in the 1970s when Japan entered the semiconductor market. In the 1980s, Korea (mainly through the development of Samsung) and Taiwan (with the creation of TSMC in 1987) also began to gain increasing market shares in semiconductors.

By the early 1980s, therefore, Europe was lagging behind the US and Japan in the production of integrated circuits and was threatened by advances in semiconductor production in South Korea and Taiwan. Indeed, by the early 1980s, Japan had overtaken Europe in semiconductor production (30% to 17%).[48] A critical juncture, seen by Europeans as a possible cartelisation of the global semiconductor market, was the 1986 US-Japan agreement, in which Japan agreed to limit its exports of dynamic random-access memory (DRAM) chips to America in exchange for the integration of Japanese manufacturers into the US-led semiconductor value chain. The European Commission protested that the agreement violated international trade rules and agreements under the General Agreement on Tariffs and Trade (GATT). The European chip industry complained that Japan was already dumping cheap microchips in Europe and that this agreement would make matters worse. By 1991, Europe's share of semiconductor production had fallen to 10%, compared with 48% for Japan and 36% for the US.

What are the reasons for Europe's underperformance in semiconductor manufacturing? There are certainly a number of reasons. We identify here three particularly relevant reasons. First, there was a major problem with semiconductor production costs in Europe. In 1992, the EU had an overall unit cost disadvantage of 9.1% over the US and 13.8% over Japan. Labour cost disadvantage (due to comparatively lower working hours and higher social costs) was the main factor contributing to the high costs in Europe.[49]

Second, the European strategy of the 1960s and 1970s, based on the possibility of creating national champions, had produced unsatisfactory results. France launched its Plan Calcul in 1966 to develop its computer industry. The semiconductor industry benefited from Plan Calcul, but also from two specific government-led support for microelectronics programmes.50 Germany received more than Deutsche Mark 800 million in government support between the late 1960s and early 1980s. The UK concentrated

[48] Cobby, Roy. "The EUROCHIP." ***Phenomenal World***, 5 Apr. 2023, www.phenomenalworld.org/analysis/the-eurochip/.
[49] Gruber, H. (1996). Trade policy and learning by doing: the case of semiconductors. ***Research policy***, ***25***(5), 723-739.
[50] Kuo, L. (2022). Plan Calcul: France's National Information Technology Ambition and Instrument of National Independence. ***Business History Review***, ***96***(3), 589-613.

on developing ICL, the national champion company, which received continuous government subsidies. However, the industrial plans of these three countries were not ambitious enough to compete with the strong domestic demand for semiconductors in the US and Japan.51 The picture was further complicated by the fact that the most competitive players at the time, Siemens in (West) Germany and Philips in the Netherlands, were not based in France and the UK, the two largest European states. To avoid being absorbed by German and Dutch companies, Paris and London therefore began to favour mergers with non-European companies, which had the effect of reducing competition in the face of penetration by American subsidiaries and creating champions that were unable to compete with global players.

The third problem was that there was not much demand for integrated circuit technology in Europe. The most competitive German and Dutch companies were based in countries with relatively low military spending. Military demand for semiconductors reached 10% only in France and the UK. With little military demand, the European industry relied on consumer demand, which absorbed large quantities of transistors. Accordingly, European companies continued to produce and specialise in the old germanium discrete technology. As Malerba noted, germanium was "considered more suitable than silicon for small-signal semiconductor devices and mesa technology was considered a very efficient and economical process".[52] The European market, because of the composition of its demand, was moving in a different direction from the US market, which was concentrating all its R&D on replacing germanium with silicon. The silicon transistor was more expensive, but the stability of its electrical properties over a wider temperature range made it superior for military applications.

Faced with the failure of industrial policy to support national champions, European policymakers decided to change their strategy. Inspired by Japanese industrial policy plans, the Europeans sought to emulate MITI's mission-oriented approach to technology.[53] In 1980, Etienne Davignon, then the European Commissioner for Industry, brought together 12 of Europe's largest information technology companies and invited them to work together. The European companies, led by Siemens and Philipps, called for a greater European, and not only national, effort in semiconductors.[54] In 1985, European countries created EUREKA (the European Research Cooperation Agency), which included a programme to stimulate R&D and production of semiconductors. EUREKA's strengths were to be its emphasis on market-oriented R&D and the direct involvement of the major European companies in its activities. The Commission's work continued with the launch of the ESPRIT programme (European Strategic Programme for Research and Development in Information Technologies), which aimed to create synergies between the various semiconductor manufacturers in Europe.[55] In 1989, the Joint European Submicron Silicon Initiative (JESSI) was launched to strengthen Europe's position in semiconductor manufacturing by focusing on submicron technology and manufacturing research.[56]

The results of these European programmes have been mixed. On the one hand, they have had positive effects. These European programmes have contributed to the development of a European IT community

[51] Sandholtz, W. (1992). ESPRIT and the politics of international collective action. ***J. Common Mkt. Stud.***, ***30***, 1.
[52] Malerba, F. (1985). Demand structure and technological change: The case of the European semiconductor industry. ***Research Policy***, ***14***(5), 283-297.
[53] Peterson, J. (1991). Technology policy in Europe: explaining the framework programme and Eureka in theory and practice. ***JCMS: Journal of Common Market Studies***, ***29***(3), 269-290.
[54] Cobby, Roy. "The EUROCHIP." ***Phenomenal World***, 5 Apr. 2023, www.phenomenalworld.org/analysis/the-eurochip/.
[55] Sandholtz, W. (1992). ESPRIT and the politics of international collective action. ***J. Common Mkt. Stud.***, ***30***, 1.
[56] Gruber, H. (1996). Trade policy and learning by doing: the case of semiconductors. ***Research policy***, ***25***(5), 723-739.

and to a gradual but much-needed process of industry consolidation. STMicroelectronics (the result of a Franco-Italian merger), Infineon and NXP have all benefited from these pan-European schemes.[57]

On the other hand, these plans have certainly not produced the desired results. There are several reasons for this failure. First, these plans to support the semiconductor industry proved to be unambitious. In fact, the European Commission set strict limits on direct government support for business activities, favouring pre-competitive research and limiting commercial considerations in projects. As Malerba notes, Western governments decided to support policies designed to reinforce companies' existing strategies, but if 'existing strategies had had many possibilities of success, public support would not have been nearly so necessary'.[58]

Second, these programmes suffered from one of the classic problems of industrial policy, namely that of picking winners and being captured by the interests of large companies. For example, the ESPRIT programme funded a very limited number of well-known companies, rather than trying to broaden the funding to the development of innovative new companies. As Peterson points out, "more than 80 per cent of all Esprit contracts in its first pilot phase of 1983 were awarded to Big 12 firms, most of whom were represented on the IT Task Force".[59]

Finally, there were also structural problems in the European economy, which missed the computer revolution and fell behind in digital products. This had a negative impact on the demand for advanced semiconductors in Europe, giving private companies little incentive to invest in new semiconductor research.

5.2 Europe: What is Doing Now

Partly as a result of the failures of previous decades, Europe is lagging behind in semiconductors. Today, Europe produces only 9% of the world's chips, mainly for industrial and automotive applications, while it has limited capacity to produce advanced computer chips, especially in chip design, where it has only 2% of the market.[60] The European situation is complicated by the fact that Europe appears to be caught in the middle of the competition between China and the United States in this field (which we discussed in the previous section). Indeed, after months of dialogue and 'persuasion', the Netherlands has finally agreed to a US request to tighten its export controls on chip manufacturing equipment to China. Europe maintains niches of excellence in some segments of the value chain. The Dutch ASLM has a virtual monopoly in the production of lithography machines, the tools needed to produce advanced semiconductors. Infineon, NXP and Microelectronics are integrated manufacturers active in the production of semiconductors for industrial applications. AMEC in Belgium is a leading research centre for advanced semiconductors. German companies such as Zeiss, Trumpf and Aixtron supply key machinery and chemicals for manufacturing.

[57] Calcara Antonio and Csernatoni Raluca, "From Ambition to Action in Europe: Chips, the Smaller, the Better", in The Comeback of Industrial Policy: The Next Geopolitical Great Game, ***ISPI***, 2023.
[58] Malerba, F. (1985). Demand structure and technological change: The case of the European semiconductor industry. ***Research Policy***, ***14***(5), 283-297.
[59] Peterson, J. (1991). Technology policy in Europe: explaining the framework programme and Eureka in theory and practice. ***JCMS: Journal of Common Market Studies***, ***29***(3), 269-290.
[60] García-Herrero A. and N. Poitiers, 'Europe's promised semiconductor subsidies need to be better targeted', Bruegel Blog, 17 October 2022.

Europe therefore finds itself in a complicated situation: on the one hand, it is lagging behind in both design and semiconductor manufacturing, even if it maintains niches of excellence. On the other hand, it is forced to respond to American and Chinese initiatives. For these reasons, Europe wants to reassert its role in the semiconductor market. That is why the European Commission has launched its Chips Act, a plan for €43 billion of public and private investment to support the chip industry.

Member States, especially those where semiconductor production is concentrated, have been supportive of European initiatives in this sector: France and Germany have always been in favour of an EU-wide industrial policy to support semiconductor production[61], as well as countries such as the Netherlands or Italy, where there are niches of specialisation in this market. In December 2020, 22 European member states signed a declaration to strengthen the semiconductor ecosystem.[62] The following year, the European Commission identified semiconductors as "one of the key enabling technologies that are strategically important for the EU's industrial future".[63] In her 2021 State of the Union address, von der Leyen emphasised that Europe has to become a leader in the semiconductor industry, as a matter of "technological sovereignty".[64] In March 2022, EU leaders adopted the Versailles Declaration, highlighting that reducing the EU's strategic dependencies on semiconductors was key to building a strong economic base, with the aim of reaching 20 % of the global market share by 2030.[65]

Based on the convergence of Member States' preferences and those of the Commission, the latter finalised the EU Chips Act in July 2023, which is divided into three main pillars: first, the "Chips for Europe" initiative, which supports large-scale technological capacity building and innovation. Second, a framework to ensure security of supply and resilience by attracting more investment. Third, a monitoring and crisis response system to anticipate shortages and coordinate action in crisis situations. The Chips Act aims to reverse the decades-long decline in Europe's share of the global semiconductor value chain and increase it to 20% by 2030.

To better understand the EU Chips Act, it is necessary to unpack two related but separate issues: the institutional context in which the Chips Act fits and the resources that the institutions and Member States are committing to support European efforts in semiconductors.

As far as the institutional context is concerned, the EU Chips Act works in synergy with other European initiatives. The European Commission has indeed launched the European Alliance for Processors and Semiconductors, with a twofold objective: on the one hand, it aims to strengthen the European semiconductor design ecosystem and bring together the relevant R&D organisations to develop leading-edge nodes and open-source hardware solutions. On the other hand, it aims to support manufacturing capacity in the EU, in particular for 10-nanometre chips, and to prepare the ground for the production of 5nm, 2nm and beyond.[66] The Commission is also encouraging the development of EU-wide chip projects in the context of the Important Project of Common European Interests (IPCEIs).[67] Back in 2018, the

[61] Federal Ministry of Education and Research, "Microelectronics from Germany – Driver of innovation for the digital economy The German Federal Government's Framework Programme for Research and Innovation 2016-2020", *Division for Electronics*, November 2018.
[62] European Commission, "Joint declaration on processors and semiconductor technologies", Official Website, December 07, 2020. The five countries that were not signatories were Bulgaria, Denmark, Lithuania, Luxembourg and Sweden.
[63] EU New Industrial Policy
[64] European Commission, "2021 State of the Union Address by President von der Leyen", Official Website, Speech, September 15, 2021.
[65] European Council, "Informal meeting of the Heads of State or Government. Versailles Declaration", Official Website, March 11, 2022.
[66] European Commission, "Industrial Alliance on Processors and Semiconductor Technologies", Official Website, undated.
[67] European Commission, "State aid: Commission adopts revised State aid rules on Important Projects of Common European Interest", Official Website, November 25, 2021.

European Commission already approved an IPCEI to support the development of innovative microelectronics with €1.75 billion from member states and €6 billion from the private sector. The first IPCEI involved France, Germany, Italy, and the UK. In December 2023, a new IPCEI on microelectronics was proposed by Germany on behalf of 20 Member States as part of the EU's economic recovery plan. In addition, semiconductors are at the top of the 10 technology areas identified by the European Commission as priorities in the context of the European Security Strategy.[68]

Regarding the financial effort, as mentioned above, the Commission had set a target of €43 billion by 2030 The financial part of the EU effort in semiconductors has been a politically sensitive issue for member states. One group of states, led by France and Italy, argued for the creation of a European sovereignty fund. which could also have been used to support semiconductor production. However, another group of states, led by Germany and the Netherlands, preferred to rely solely on national funds, fearing that this could have led to additional debt for Europe after the European Economic Recovery Fund.[69] There was also a debate about whether or not research funds should be used to support the semiconductor industry.[70] In the end, European countries agreed on a mix of European and national funds. In terms of research funding, EU governments have agreed that €75 million of unspent Horizon money can be used for the semiconductor initiative.

In terms of the chips to be subsidised, the EU Chips Act revolves around the concept of "first of a kind". This concept allows state aid to be authorised if a production facility "goes beyond the state of the art in the Union, for example in terms of technology node, substrate material such as silicon carbide and gallium nitride, and other product innovations."[71] The definition of first-of-a-kind facilities was at the heart of the Council negotiations, as there was widespread concern among medium-sized and smaller member states that chips' "mega fabs" would only benefit those member states with deeper pockets, able to subsidise these costly facilities.[72] By leveraging the "first of a kind" principle, the European Commission approved, under EU state aid rules, a French aid measure to support STMicroelectronics and GlobalFoundries in the construction and operation of a new microchip facility in France. In October 2022, the Commission approved, under EU state aid rules, an Italian measure to support STMicroelectronics in the construction of a chip plant in Sicily.

[68] Regarding semiconductors, the Commission emphasizes that "Due to their huge enabling and transformative nature and their use for civil and military purposes, remaining at the forefront of building and further developing these technologies is crucial for economic security". See European Commission, "COMMISSION RECOMMENDATION of 3.10.2023 on critical technology areas for the EU's economic security for further risk assessment with Member States", Official Website, October 3, 2023.

[69] Carrel Paul and Murray Miranda, "No new European debt to fund competitiveness drive", ***Reuters***, December 5, 2022.

[70] Naujokaitytė Goda, "€75M to be diverted from Horizon Europe budget, as deal is reached on the Chips Act", ***Science Business***, April 20, 2023.

[71] European Commission, "European Chips Act", Official Website, undated.

[72] Duchâtel, 2022. Semiconductors in Europe: The Return of Industrial Policy, ***Institute Montaigne***. p.29; Bertuzzi Luca, "EU institutions reach agreement on European Chips Act", ***Euroactiv***, April 19, 2023.

6. Scenarios for Europe

6.1. Opportunities

The ambitious European plans are part of a wider strategy to make Europe strategically autonomous, or at least to 'de-risk' the European continent from dangerous dependencies and vulnerabilities on third countries. These plans could therefore have a positive impact on the revitalization of European strategic sectors. More specifically, this catch-up plan could serve to reposition Europe in the most technology-intensive sectors of the value chain. Semiconductors are essential to power all the other sectors identified as priorities by the European Commission, from cloud computing to artificial intelligence. The most advanced semiconductors are used to power the large data centres that underpin the cloud infrastructure. The big cloud computing players, including Amazon Web Services, Microsoft Azure and Google Cloud Computing, are big consumers of very advanced chips, investing huge sums of money to design and tailor their chips to their specific needs in terms of load, performance, power, compute efficiency, latency, and density.[73] Europeans are starting to have their own cloud providers, such as OVHcloud, and if they are to have any chance of catching up with the American (and Chinese) cloud players they need to have access to sophisticated chips. Investment in semiconductor design and production would certainly help these efforts. The same is true for artificial intelligence. Companies involved in generative AI have a huge need for very advanced semiconductors. To take just one example, it has been reported that the training of this application requires around twenty-five thousand Nvidia A100 GPU deep learning chips - at a cost of $10,000 each - running for around one hundred days.[74] Semiconductors are also useful for maintaining Europe's competitiveness in other sectors, including the automotive industry. Currently, car manufacturers mainly use legacy chips between about 45nm and 90nm. Electric vehicles (EVs) use a combination of older legacy and advanced chips for innovative features and other electric mobility equipment. However, the cars of the future will be increasingly energy-efficient and software-defined, with features enabled by high-performance computing and myriads of lines of code. According to some, cars will become powerful "supercomputers on wheels".[75]

The ambitious European investments also represent an opportunity because, as mentioned above, the Europeans are not starting from scratch. The European industry already has very large players (Infineon, NXP and Micro-Electronics), which could be used to set up joint ventures or partnerships with major semiconductor designers and manufacturers and to persuade them to set up on European soil. European

[73] Dashveenjit Kaur, "Cloud giants are customizing their own chips – here's why", ***Tech HQ,*** June 14, 2021.
[74] Condoleezza Rice, John B. Taylor, Jennifer Widom and Amy Zegart, "THE STANFORD EMERGING TECHNOLOGY REVIEW 2023 A Report on Ten Key Technologies and Their Policy Implications", ***Stanford University***, California, 2023.
[75] Latré Steven and Placklé Bart, "Enhanced Collaboration between Car Manufacturers and Semiconductor Industry Promises Significant Advancements in Road Safety", imec, April 6, 2023.

investment plans could thus act as a driver for partnerships with other like-minded countries and reduce economic vulnerabilities, as highlighted in the European economic security strategy.[76] Europe also has niches of excellence that are difficult to undermine. Just as Europe is dependent on US design companies and production in Taiwan and South Korea, the latter are dependent on, for example, the lithography machines produced by ASLM. Interdependence is a two-way street. Europe can then benefit from important semiconductor clusters such as Silicon Saxony in Germany, High Tech NL in the Netherlands, and Minalogic in France. European investment could act as a key driver in connecting these disparate centres of excellence across Europe and as a factor in integrating a value chain that is as European as possible.

6.2 Challenges

However, European investment in the semiconductor sector could also pose challenges. We mention here four that could be very relevant and certainly deserve further reflection.

The first European challenge is to reconcile short-term with long-term needs. Europe seems to want to position itself in the production of all types of semiconductors, from the legacy ones to the most advanced ones. It may be difficult to do both. Indeed, there is currently a lack of internal demand for advanced chips in Europe, as the chips that Europe consumes are mainly legacy chips, especially in the important and competitive automotive industry. As the academic literature on the subject has noted in the past, efforts in the 1980s and 1990s were negatively affected by a lack of demand in Europe, and the situation has not improved since.[77] There is another side to Europe's opportunity to position itself in the most technologically advanced digital sectors by focusing on semiconductors: Europe does not currently have a vibrant and technologically advanced industrial base in the digital sectors. Of the world's top 50 technology companies by market capitalisation, only two are European.[78] In addition, a recent report found that Europe's digital investment gap is at least €174 billion.[79] While semiconductors could serve as a starting point to try to develop this, semiconductor production also requires there to be domestic demand in Europe that can support these efforts.

Second and relatedly, it is questionable whether the European effort in semiconductors is sufficient. The semiconductor industry is very capital-intensive. If the European Chips Act mobilises €43 billion, this effort still seems far from the firepower of giants such as China or the United States. The latter, for example, will spend $280 billion on new chip capacity. Moreover, specialising in semiconductor design and manufacturing, and doing both at the same time, is very expensive. According to TSMC, opening a new mega-fab can cost up to $10 billion.[80] Several experts suggest a different strategy: specialising in chip design and the higher end of the value chain, rather than subsidising semiconductor manufacturing.[81] This

[76] European Commission, "An EU approach to enhance economic security", Official Website, June 20, 2023.
[77] Malerba 1985
[78] Gilli Andrea, "Beyond Vilnius: NATO Dealing with New Technologies", ISPI, July 5, 2023.
[79] European Commission, "Investment and funding needs for the Digital Decade connectivity targets", Official Website, July 12, 2023.
[80] Deutsch Jillian and Nardelli Alberto, "TSMC Plans for First German Chip Fab With Cost Up to €10 Billion", ***Bloomberg***, May 3, 2023.
[81] Niclas Frederic Poitiers and Pauline Weil (2021). A new direction for the European Union's half-hearted semiconductor strategy. Bruegel Issue n 17/21 (July). https://www.bruegel.org/sites/default/files/wp_attachments/PC-2021-17-semiconductors-.pdf; Jan-Peter Kleinhans and John Lee (2021) China's rise in semiconductors and

might still leave Europe vulnerable to supply chain disruptions, but it could give it a prominent position in the most technologically advanced sectors and have positive spill-over effects for all European efforts to increase its digital capacity. Critics of European efforts to become self-sufficient across the value chain point out that the new European factories will still be dependent on chemical imports from outside Europe.[82]

Third, there is a risk that European industrial policy will repeat the mistakes of the past, i.e. it risks 'picking winners' and favouring some actors over others. If this has happened in the past with European programmes, it could happen again. Industrial policy could also change the level playing field between large and small states that has characterised the creation of the European single market. Large or less indebted countries would have more resources to subsidise their companies and try to attract the most competitive companies in the semiconductor ecosystem to move to Europe. During the negotiations on the EU chips act, there were talks between Germany and TMSC, and Germany and Intel (which later led to the announcement of the construction of a mega-fab in Magdeburg, Germany, while at the same time setting up R&D divisions in France).[83] Smaller Member States or those with higher public debt therefore have fewer resources to attract these global players.

Finally, a lack of resources and specialised personnel could hamper European plans. Energy costs, exacerbated by Russia's invasion of Ukraine, could rise significantly, making investment in factories much more expensive than anticipated. This is compounded by Europe's difficulties in accessing key raw materials needed for this production. In addition, building factories would require large amounts of water, which may not be sustainable in some parts of Europe. For example, the proposed STMicroelectronics and GlobalFoundaries factory in the south of France led to protests over the facility's water consumption and environmental impact.[84] In addition, Europe does not appear to have the skilled workforce to support its large investments. By comparison, Japan's and Taiwan's strategy to compete with the US has been to combine public investment with policies to attract electrical engineering graduates from US Ivy League universities. If Europe is serious about catching up, it needs to strengthen its skills and talent policies and address the underlying causes of the brain drain.

Europe. Recommendations for policy makers. Stiftung Neue Verantwortung (December). https://www.stiftung-nv.de/sites/default/files/chinas_rise_in_semiconductors_and_europe.pdf

[82] In fact, TSMC asked Taiwan Specialty Chemicals Corp. to set up facilities in the US to support TSMC's plan to build a 5nm fab in Arizona.

[83] Intel Repor, "Intel Plans Investments in Europe", ***Intel***, June 16, 2023.

[84] "Water: hundreds of demonstrators opposed to STMicroelectronics", News in France,

7. Conclusions

This working paper had four main objectives: firstly, it sought to place semiconductors within a long-term and historical process. Second, it sought to map the semiconductor value chain. Third, it focused on the competition between China and the US in this sector. The final part focused specifically on Europe and proposed a reflection on the challenges and opportunities for Europe in this context.

This analysis is certainly not exhaustive. Further reflection is necessary and desirable, and we mention here three issues that should be explored: first, to continue to monitor the geopolitical competition between China and the United States, but also to understand the role that key players in the supply chain, such as Taiwan, South Korea, or the Netherlands, will play. Second, to understand the implications of this geopolitical competition on the configuration of the value chain. The global value chain has been facilitated by the process of globalisation, but this could change given the major industrial policies and the reshoring plans of the major powers. Finally, more thought needs to be given to understanding Europe's ambitions in this area. As noted above, semiconductors are and must be a priority for a technologically advanced, economically prosperous and, why not, politically relevant Europe.

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