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# Elcano Policy Paper

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# Policies and tools for strengthening the European semiconductor ecosystem

## Contents

# Summary

The value chain of semiconductors is deeply fragmented at the global level. For decades, governments of major countries worked on the design and implementation of their Digital Agendas, but chips and semiconductors were not central to almost any of these strategies. However, the aftermath of the COVID-19 pandemic changed political priorities around the world. Except for a few relevant actors, some of which have a geopolitical meaning such as the Dutch company ASML, the share of the EU in chip manufacturing has steadily declined over the past few decades, dropping from 25% in 2000 to 8% in 2022. In order to revert this situation, the EU has developed a full-fledged Semiconductor Strategy with the EU Chips Act at its centre. However, the role of EU Member States is critical for the success of the European semiconductor policy. There is neither a big central budget allocated by the EU (except €3 million for the Chip Research Joint Undertaking) nor control over all the projects by the European Commission (apart from its conformity with the EU State-Aid framework). Consequently, there seems to be a race between EU Member States to capture private investment from leading companies, which is creating an unlevel playing field and leading to inefficiencies. In this paper, a set of policy recommendations are presented for the areas of design (licences and tools), manufacturing, equipment, talent and coordination efforts at the EU level.

# 1 Introduction

The value chain of semiconductors is deeply fragmented at the global level: private expenditure on Research and Development mostly comes from the US; Intellectual Property companies are based mainly in the UK and the US, high level chip design companies in the US and low level ones in India; as for materials and gases, silicon wafers mainly come from Japan with other elements being provided by a variety of companies from the US, Germany and France, amongst others; equipment like EUV machines comes from EU companies, most prominently the Dutch company ASML, although Japanese and US companies are relevant in other manufacturing processes; fabless companies are mainly from the US, while the most important and edge foundries are based in Taiwan and South Korea; finally, chip testing and packaging services are outsourced to jurisdictions like Malaysia and Taiwan.

For decades, governments of major countries have worked on the design and implementation of their Digital Agendas, but chips and semiconductors were not central in almost any of these strategies. However, the aftermath of the COVID-19 pandemic changed political priorities around the world regarding the approach to the semiconductor ecosystem: a succession of events during the confinements and the first months of the so-called 'new normality' produced a shock on the semiconductor supply-chain and several industrial sectors began to experience a scarcity of the chips needed for their final products. The scarcity was exacerbated by several natural catastrophes and other accidents that disrupted operations in chip manufacturing plants. By the end of the first semester of 2021 major economies, and the EU among them, started to be fully conscious of the need to count on trustworthy semiconductor supply-chains for the sake of their strategic autonomy.

The US Chips Act proposed in May 2021, and approved in August 2022 with few conceptual differences in the Congress and the Senate, was conceived as an instrument to incentivise the investment in semiconductor manufacturing through generous grants.

On 15 September 2021 the President of the European Commission took advantage of the State of the Union address to announce a forthcoming Chips Act for Europe. In February 2022 the European Commission presented the proposal for the European Chips Act. It took little more than a year for the legislative powers to reach a political agreement and it is foreseen that it will enter into force in the last semester of 2023. Except for a few relevant actors, some of which have a geopolitical aspect such as ASML, the share of the EU in chip manufacturing has steadily declined over the past few decades, dropping from 25% in 2000 to 8% in 2022. That is why the EU has set a strategic ambition to more than double its share of semiconductor manufacturing to 20% by 2030. At the centre of this effort is the EU Chips Act, which is based on three pillars, namely the Chips for Europe Initiative, a framework to ensure security of supply, and a monitoring crisis and response mechanism.

However, the role of EU Member States is critical for the success of the European semiconductor policy. There is neither a big central budget allocated by the EU (except €3 million for the Chip Research Joint Undertaking) nor control over all the projects by the European Commission (except the necessary approval within the state-aid framework). Therefore, national semiconductor strategies and pledges of grants and public investments by Member States need to be sketched to have a complete overview of European efforts to revitalise the ecosystem, particularly those in the four largest Member States.

Despite the EU drive towards strategic autonomy on semiconductors, the complexity of the semiconductor supply chain makes it impossible to achieve full self-reliance in the area, making the case for international cooperation with strategic partners. This has been the case with countries such as the US, Japan, South Korea and Taiwan. However, bilateral cooperation is not enough to build up a trustworthy and resilient supply chain, particularly if de-risking from countries of concern needs to be added to the formula. Multilateral forums are another scenario where the EU has pushed towards agreements in this area to reduce dependencies from countries of concern and reduce technology transfers to them. This has been one of the topics of discussion at the G7 meeting held in May 2023. An additional challenge to the EU's strategic autonomy does not derive from third partners or from Member States' coordination. It also derives from the very innards of each country and the role of sub-regional actors in the semiconductor ecosystem. Given the reality in countries such as Spain, of a geographical diversity with regionalised industrial clusters, it is strategic to make visible the role of the regions as industrial and governance entrepreneurs.

In this paper we delve into the details of these elements and put forward a set of policy recommendations in the areas of design (licences and tools), manufacturing, equipment, talent and coordination efforts at the EU level.

# 2 Taxonomy of semiconductors, global value chain and the role of the EU and Spain in the semiconductors' value chain

## *2.1. Taxonomy of semiconductors*

Before presenting the main features of the global value chain of semiconductors, it is advisable to list a simple taxonomy of the ecosystem. According to the Semiconductor Industry Association,[1] semiconductors are an essential component of electronic devices, enabling advances in communications, computing, healthcare, military systems, transportation, clean energy and countless other applications. From the perspective of their application functions, semiconductors can be classified in six main categories:[2]

1) Memory chips, which include short-term memory (DRAM), used for instance in personal computers, and long-term memory (NAND), found in storage devices such as USB flash drives or digital cameras and in industrial electronics. In terms of the human body, memory chips would be equivalent to the human cerebral cortex, where the memory is lodged. The largest memory chips manufacturer by far is Samsung Electronics.
2) Microprocessor chips, which encompass central processing units (CPUs), graphic processing units (GPUs), Digital Signal Processors (DSPs) and Microcontrollers (MCUs). If compared with the human body, microprocessor chips would be the brain, in charge of analysis and calculations. Commercially, Intel is the world's leading company in CPUs, although other companies also rank high, such as AMD, IBM and Qualcomm. Regarding GPUs, Intel, Nvidia and AMD are the top companies, whereas Microchip, TI, AI and ARM are representative companies for DSPs and Renesas Electronics, NXP and ST are relevant for MCUs.
3) Power chips, which provide power, for instance, to CPUs and DSPs, among others. In human body-wise terms, power chips would be equivalent to the heart. Top manufacturing companies in this field are Broadcom, Toshiba, Mitsubishi Electric, Renesas, Qualcomm, NXP and Infineon.[3]
4) Sensor chips, which refer to CMOS image sensors (CIS), with relevant quotas from companies such as Sony and Samsung or touch chips. In terms of the human body, sensors would be the five senses.
5) Communication chips, such as very well-known Bluetooth chips or wireless chips (Wi-Fi). If compared with the human body, communication chips would be similar to human nerves, in charge of transmitting information.

1 Dcadmin. (2023, April 3). *About Semiconductors* | SIA | *Semiconductor Industry Association. Semiconductor Industry Association.* https://www.semiconductors.org/semiconductors-101/what-is-a-semiconductor/

2 Huang, H. (n.d.). Classification of chips. www.linkedin.com. https://www.linkedin.com/pulse/classification-chips-hedy-huang/

3 Rajan, Y. (2023, June 9). Top 7 power semiconductor manufacturers producing industry-specific products. *Verified Market Research*. https://www.verifiedmarketresearch.com/blog/top-power-semiconductor-manufacturers/

6) Interface chips, such as High Definition Media Interface Chips (HDMI), which is a digital video and sound transmission interface that can be wired to laptops and TVs, among others.

Semiconductors or chips can also be classified according to size, measured in nanometres, which equal one billionth of a metre (or 0.000000001m).[4] The race by companies to reduce the size of chips is already overcoming Moore's Law,[5] according to which the number of transistors in an integrated circuit, ie, in a chip, will double every two years, whereas costs will halve over the same time span.[6] At the time of writing, the Taiwanese company TSMC and the South Korean company Samsung are the leading manufacturers of edge chips, with the latter having presented a roadmap to mass produce 2 nanometre chips for mobile devices by 2025 in an attempt to catch up with TSMC.[7] However, it seems that not only TSMC is a year ahead in the quality of the 2 nanometre products, but the Taiwanese company has also planned to start the mass-production of 1.4 nanometre items in 2027.[8]

## *2.2. The global value chain of semiconductors*

The value chain of semiconductors is highly complex and composed of nine different layers, which are globally fragmented:[9]

1) Research and development.
2) Intellectual property. To design a chip, blocks of intellectual property (IP) are needed and they are licensed by prop companies, ie, software design companies, which provide pre-designed circuits of varying complexity that can be used as-is or adapted for a particular application. Thus, chip designers can massively reduce design times and become more efficient. The top five IP core licensing companies are ARM (a British company with a market share in 2020 of over 40%), Synopsys, Cadence and Microchip Technology (all of them US companies), and Imagination Technologies (British).
3) Chip design around IP cores. Based on IP cores and Electronic Design Automation (EDA) tools, companies design chips in a large engineering process that can take up to three years and where several steps need to be taken, such as system specification, architectural design, functional and logic design, circuit design, physical design and physical verification. Top companies in chip design tools are

4 Versus. (2020). What is semiconductor size? VERSUS. https://versus.com/en/glossary/semiconductor-size

5 Gopani, A., (2022). The race to reduce nanometers in chips. *Analytics India Magazine*. https://analyticsindiamag.com/the-race-to-reduce-nanometers-in-chips/

6 Tardi, C. (2023). What Is Moore's Law and Is It Still True? *Investopedia*. https://www.investopedia.com/terms/m/mooreslaw.asp

7 Kharpal, A. (2023, June 28). Samsung to begin making world's most advanced mobile chips in 2025 as battle with TSMC heats up. CNBC. https://www.cnbc.com/2023/06/28/samsung-lays-out-2-nanometer-semiconductor-roadmap-to-catch-up-to-tsmc.html

8 Hong Youfang. (2023, June 27). 台積電1.4奈米用地計劃曝光 拚2026年提供建廠. https://ec.ltn.com.tw/article/breakingnews/4345357

9 Zaman, R. (2022, December 17). Semiconductor Value Chain - globally distributed ecosystem - THE WAVES. THE WAVES. https://www.the-waves.org/2022/03/17/semiconductor-value-chain-globally-distributed-ecosystem/

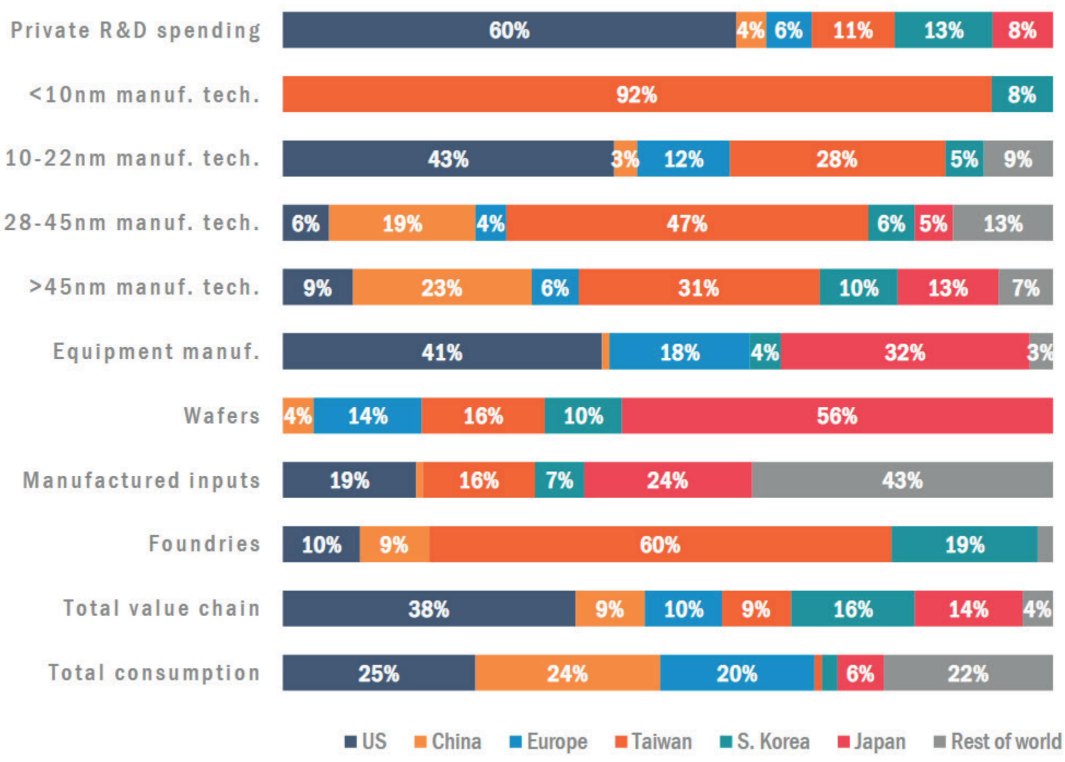
Mentor Graphics, Cadence and Synopsys, all of them US-based. Nevertheless, India also plays a role in chip design, especially when it comes to low-end chip design and verification for third parties, due to the relative cost advantages in India.

4) Specialised materials and gases. To physically produce chips, several materials, gases and chemicals are needed. These are, for instance, silicon wafers, which are the base for chips, with Japan so far being the world leader in the field, with a market share slightly below 60%; ultra-pure gases, including bulk (eg, oxygen and nitrogen) and exotic/toxic gases (eg, fluorine, nitrogen trifluoride and arsine); and fluids like photoresists and top coats. Companies involved in the provision of these types of materials and gases are Tok, Sumitomo, Fujifilm, Shin-Etsu and Sumico (all of them Japanese), Dupont (in the US), Merck (Germany) and Air Liquide (France), among others.
5) Equipment. Physical manufacturing of chips also requires sophisticated equipment. The production of chips requires the participation of several types of them for different purposes and treatments of wafers: the application of chemicals, the lithography of the circuits, etching and cutting, metrology and optical measurement of quality, and so on. The main actors in the equipment manufacturing area are ASML, Tokyo Electron, Applied Materials, KLA and LAM Research. The proof of the importance of semiconductor manufacturing equipment in the global supply chain is seen in the efforts of the US government to limit the access to them to rival countries and its agreement in this area with the other main actors in the segment: Japan and the Netherlands.
6) Fabless chip companies. The fabless chip model was developed in the 1980s, when smaller chipmakers were left with a surplus. The term 'fabless' means that the company designs and sells or uses for its own purposes the semiconductor hardware and chips, but does not manufacture the silicon wafers or chips used in its products, outsourcing instead the manufacturing to a fabrication or foundry plant. Some of these fabless companies use the chips exclusively in their own devices, such as Apple, Google and Amazon, whereas others such as AMD, Nvidia, Qualcomm and Broadcom sell the chips externally.
7) Foundries. Foundries are necessary for the business model of fabless companies to function. They appeared hand in hand with the fabless model back in the 1980s and provide fabless chip companies with manufacturing services. Foundries are a business model highly intensive in capital expenditure, thus becoming very concentrated in a few companies, among which TSMC and Samsung are the most prominent. The geopolitical relevance of the Taiwanese company TSMC could be behind the recent tensions with China.
8) Integrated Device Manufacturing (IDMs). IDMs are the alternative and pre-existing model to the fabless-foundry tandem. They vertically integrate designing and manufacturing in their own fabs and they sell their own chips. Despite having fabs, they do not make chips for other fabless companies. Although they have their own fabs, they may also resort to third-party foundries. For example, Intel sources 7nm services from TSMC. The strategic advantage of IDMs is increasingly eroding vis-à-vis the fabless-foundry model.

9) Chip testing and packaging services. At the end of the value chain, wafers reach packaging and testing service delivery nodes. Outsourced Semiconductor Assembly and Test (OSAT) companies package and test the chips manufactured by foundries and IDMs. These services are mainly provided by facilities in Malaysia and Taiwan. Packaging services, especially those based on the most advanced techniques, are growing in importance in the value chain as a means of overcoming the physical limits of the Moore Law in the development of AI chips.

All in all, the value chain of chips is global and highly fragmented. In very general terms, it could be argued that private spending in Research and Development mostly comes from the US; Intellectual Property companies are mainly based in the UK and the US, with high level chip design companies in the US and low level ones in India; as for materials and gases, silicon wafers mainly come from Japan with other elements being provided by a variety of companies from the US, Germany and France, amongst others; equipment like EUV machines comes from EU companies, most prominently the Dutch company ASML, although Japanese and US companies are relevant in other manufacturing processes; fabless companies are mainly from the US, while the most important and advanced foundries are based in Taiwan and South Korea; finally, chip testing and packaging services are outsourced to jurisdictions such as Malaysia and Taiwan. Similar conclusions can be drawn from Figure 1 below.

**Figure 1. Global semiconductor market shares, 2020**




Source: European Strategy and Policy Analysis System, 2020.

## 2.3. The role of the EU in the semiconductor value chain

Following the order of the value chain as presented above, the EU is home to a number of leading corporations:[10]

1) Research and development. The most important institutes for research in the semiconductor field are Imec in Leuven, Belgium (with a yearly revenue of €680 million in 2020), CEA-Leti in Grenoble, France (€330 million) and Fraunhofer in Munich, Germany (€276 million).
2) Chemicals. Two German companies are leaders in the provision of chemicals for semiconductor manufacturing, namely BASF in Ludwisgshafen (with a yearly revenue of €78.6 billion) and Merck in Darmstadt (€19.7 billion).
3) Wafers. Two German companies play a key role in wafer production: Siltronic in Munich (with a yearly revenue of €1.2 billion) and GloFo.
4) Equipment. The most important company in the EU in this field, which also plays a key role at a global level, is Dutch company ASML, based in Eindhoven and which produces extreme ultraviolet (EUV) lithography machines (with a yearly revenue of €18.6 billion). The German company Zeiss SMT, based in Oberkochen, is also a producer of equipment (with a yearly revenue of €2.3 billion).
5) Foundries. The EU also has several foundries. The most important are based in Germany: Bosch Semiconductors for Automotive in Gerlingen (with €78.7 billion in yearly revenues), Infineon in Neubiberg (€11 billion), AMS in Premstäten (€5 billion), X-Fab in Erfurt (€658 million) and Intel in Magdeburg. There are also foundries in the Netherlands (NXP in Eindhoven, with a yearly revenue of €11.1 billion and the Chinese-owned Nexperia, in Maastricht, with €1.4 billion), in France (Melexis in Ypres, with a yearly revenue of €508 million) and in Ireland (Intel in Leixlip). Furthermore, ST Microelectronics has its headquarters in Geneva, with subsidiaries in France (Tours, Grenoble and Rousset) and Italy (Milan and Catania).

Despite these significant players, some of which have a geopolitical character –such as ASML, as explained above–, the share of the EU in chip manufacturing has steadily declined over the past few decades. Indeed, according to the consulting firm Kearney it has dropped from 25% in 2000 to 8% in 2022.[11] This is why, as explained later in this paper, the EU has set a strategic ambition to more than double its share of semiconductor manufacturing to 20% by 2030.

10 European Strategy and Policy Analysis System (2022). Global Semiconductor Trends and the Future of EU Chip Capabilities. Global-Semiconductor-Trends-and-the-Future-of-EU-Chip-Capabilities-2022.pdf (espas.eu)

11 Kearny (2022). Europe's urgent need to invest in a leading-edge semiconductor ecosystem. Europe's urgent need to invest in a leading-edge semiconductor ecosystem - Kearney

# 3 Support measures from the EU and its Member States for the semiconductor ecosystem

## *3.1. The emergence of a European priority*

The aim of reinforcing Europe's competitiveness in semiconductor technologies and applications was not originally on the agenda of the current European Commission in September 2019. Neither the political guidelines presented by Ursula von der Leyen[12] nor her mission letters addressed to the Vice President Vestager and Commissioner Bréton contain a single mention of the words chip, semiconductor or microelectronics. Furthermore, there is even no trace of them in the State of the Union speech delivered by the President of the European Commission in September 2020,[13] except a vague reference to developing a European next-generation microprocessor, connected more with the issue of the decade old European High-Performance Computing Project than with a coherent and fully-fledged European Chip Strategy. The aftermath of the COVID-19 pandemic confinements changed political priorities around the world regarding the approach to the semiconductor ecosystem. A succession of events during the confinements and the first months of the so-called 'new normality' caused a shock in the semiconductor supply-chain and several industrial sectors (automobile, electronic consumers...) began to experience a scarcity of the chips for their final products. The scarcity was aggravated by various natural catastrophes (the worst drought in half a century affecting Taiwan[14] and severe storms in Texas)[15] and other accidents (a fire in a manufacturing plant)[16] that disrupted operations in chip-manufacturing plants. By the end of the first semester of 2021 the major economies, and the EU among them, started to be fully conscious of the need to depend on resilient and trustworthy semiconductor supply-chains for the sake of strategic autonomy.

In December 2020 the EU's Member States made their first move to reinforce the semiconductor ecosystem and to expand the Union's share of the global supply chain by signing the 'Joint declaration on processors and semiconductor technologies'.[17] The main commitment raised from the Declaration was setting up an Important Project of Common European Interest (IPCEI) on semiconductors. Taking advantage of the funds provided by the Recovery and Resilience Facility (RRF), Member States engaged in co-investment efforts following a public-private partnership model and opened negotiations on the project. The

12 Von Leyen (2019). 'A Union that strives for more. My agenda for Europe. Political guidelines for the next European Commission 2019-2024' https://commission.europa.eu/system/files/2020-03/political-guidelines-next-commission_en.pdf

13 Von Leyen (2020). 'State of the Union Address by President von der Leyen at the European Parliament Plenary' https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_20_1655

14 Financial Times (Marzo 2021). 'Taiwan's chip industry under threat as drought turns critical', https://www.ft.com/content/7bb86092-4cad-45c5-ba8b-e0985f80c107

15 Reuters (Febrero 2021). 'NXP shuts two Austin plants as Texas reels from winter storm', https://www.reuters.com/article/us-nxp-semicondtrs-texas-weather-idUKKBN2AH1UC

16 Reuters (Marzo 2021). 'Global auto recovery to take more hits from Japan chip plant fire, severe US weather: IHS', https://www.reuters.com/article/us-autos-chips-idUSKBN2BN27E

17 European Commission (2020). Joint declaration on processors and semiconductor technologies, https://digital-strategy.ec.europa.eu/en/library/joint-declaration-processors-and-semiconductor-technologies

actors of the EU electronics value chain, including academia, research and technology organisations, gathered in the Industrial Alliance on Processors and Semiconductor Technologies, and actively supported this approach.

The European Commission had approved a previous IPCEI on microelectronics in 2018. The first IPCEI is expected to be under development until 2024 and is the effort of 32 companies/RTOs from four EU Member States (France, Germany, Italy and Austria), as well as the UK. According to official figures, this first IPCEI is financed by up to €1.75 billion in public funds and aims to unlock an additional €6 billion in private investment. The new IPCEI foreseen in the Joint Declaration is envisaged to be more ambitious and will involve more than 98 companies in 19 Member States with a total budget exceeding €20 billion. However, its level of ambition goes hand in hand with its complexity and obtaining state-aid approval for the project has proved to be an arduous road: the European Commission and the Member States started the informal negotiation of the new IPCEI in the first quarter of 2021, the pre-notification was sent to the European Commission in December 2021 and it was not finally approved until June 2023.

### *3.2. The European bet on being a leading actor in the reconfiguration of the global supply-chain*

During the second half of 2021 each of the main economic blocs became fully conscious of the need to achieve their own strategic autonomy in the field of semiconductors. Although all the governments of major countries had been working for decades on the implementation of their Digital Agendas, chips and semiconductors were not central in almost any of these strategies. However, the supply-chain shock proved the value of chips as the 'DNA' of technology and its role in transforming every aspect of the economy and society, from agriculture and transport to healthcare, leisure, telecommunications and the Internet. The bipartisan proposal for a Chips Act for the US, presented to the Senate in May 2021,[18] was the final straw that changed semiconductor sector policies worldwide.

The US Chips Act proposed in May 2021 and approved in August 2022 with few conceptual differences by the House of Representatives and the Senate except for the inclusion of more social requisites and stronger guardrails to ensure national security, was conceived as an instrument to incentivise the investment in semiconductor manufacturing through generous grants. The proposal was a complete strategy to promote semiconductor research, development, manufacturing and workforce development on US soil, to ensure a self-contained and resilient supply chain within the US borders. Although in its final version the programme was merged with other proposals in the Chips and Science Act, the budget foreseen for grants to strengthen the semiconductor ecosystem remained at around US$50 billion throughout.

18 Reuters (Mayo 2021). 'Senate Democrat proposes $52 billion for US chips production, R&D', https://www.reuters.com/technology/senate-democrat-proposes-52-billion-us-chips-production-rd-2021-05-18/

Because of the US proposal, a stream of subsidies appeared worldwide and, as early as the beginning of the last quarter of 2021, the EU understood that it needed a stronger instrument than an IPCEI to revitalise the European ecosystem.

On 15 September 2021 the President of the European Commission took advantage of the State of the Union address[19] to announce a forthcoming Chips Act for Europe. Although very little additional information was made public by the Commission at that moment on the shape and contents of the Chips Act, the general objectives of the regulation were mentioned by Ursula von der Leyen in her address: linking together capacities on research, design and testing, the coordination of EU and national investment along the value chain, the creation of a state-of-the-art European chip ecosystem (including production) and ensuring the security of semiconductor supplies. More details were revealed by Commissioner Bréton on the same day in a blog post,[20] that mentioned three dimensions for the EU Chips Act: a European Semiconductor Research Strategy; a collective plan to enhance European production capacity; and a framework for international cooperation and partnership. No budget allocation was officially announced, although Bréton suggested some days later in an interview at the Atlantic Council[21] that the EU along with its Member States would be providing roughly the same figures as in the US.

In February 2022 the European Commission presented its European Chips Act proposal. It took little more than a year for the legislative powers to reach a political agreement and it is foreseen that it will enter into force in the last semester of 2023. In order to achieve the general objectives described above, the regulation is composed of three pillars which we will describe below: The Chips for Europe Initiative, a framework to ensure security of supply, and a monitoring crisis and response mechanism.

The Chips Initiative for Europe aims to reinforce its technological leadership by facilitating the transfer of knowledge from lab to fab. The initiative will be implemented through the EU Chips Joint Undertaking (Chips JU) and will be supported by €6.2 billion in EU public funds to boost design capabilities, create advanced pilot lines, accelerate the innovative development of quantum chips and establish a network of competence centres. The Act also establishes a 'Chip Fund' to facilitate access to debt and equity financing for start-up companies.

The second pillar introduces a fast track for the approval of state aid for certain types of projects to help accelerate the creation of a strong European semiconductor ecosystem. For this purpose, it introduced the concept of 'first-of-a-kind' (FOAK) installations that contribute to securing the supply for the internal market, which can benefit from a prioritisation of approval for public intervention. These facilities can include advanced semiconductor manufacturing facilities and chip manufacturing equipment production facilities. Although

19 Ursula von der Leyen (2021), 'State of the Union Address by President von der Leyen at the European Parliament Plenary', https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_21_4701.

20 Breton (2021). 'How a European Chips Act will put Europe back in the tech race' https://commissioners.ec.europa.eu/news/how-european-chips-act-will-put-europe-back-tech-race-2021-09-15_en

21 Atlantic Council (2021). 'A conversation with European Commissioner for the Internal Market Thierry Breton', https://www.atlanticcouncil.org/event/a-conversation-with-thierry-breton/

innovative design centres are not considered to be FOAK they can be subsidised as part of a manufacturing facility. The range of facilities has been broadened as regards the original European Commission proposal, which only included those of the first type. It is also significant that jointly with the Chips Act certain modifications on the General Block Exemption Regulation were introduced to increase the limits of grants on semiconductors up to 80% of the investment for projects of medium-sized companies, or of 90% in the case of those of a smaller size.

It is important to highlight that no budget is allocated at the EU level for this pillar, and the success of its implementation depends on the Member States' public investments to support private investments. This difference with the US Chips Act has been criticised and there is some scepticism about the capacity of the Member States to mobilise the €42 billion in investments expected by the European Commission. However, as we shall see later, it is a feasible goal.

The third pillar proposed by the European Commission has been enriched with a strategic mapping tool tabled by the European Parliament. This amendment has also helped to improve and provide more precise monitoring and crisis response mechanisms for the regional supply chain. The monitoring mechanism is essential to alert for any future signs of potential crises in the supply chain that might trigger enhanced joint responses to shortages, allowing the deployment of measures such as information gathering, prioritisation of orders from critical sectors or common purchasing approaches. The monitoring of the supply chain is a global concern that is stated but only sketched in many international agreements, and the early definition of a European model for this purpose could provide inspiration worldwide and as a result create a 'Brussels Effect' in this area.

Finally, the regulation also includes the establishment of a governance structure underpinned by the creation of a network of National Competent Authorities and a European Semiconductor Board. The Parliament and the Council have enriched this pillar with contributions that define more specifically the framework and role of the EU and Member States within international cooperation with strategic partners. However, a stronger wording of the Chips Act could have been better in order to ensure a greater coordination in the future. The bilateral negotiations between the US and the Netherlands on the semiconductor manufacturing equipment trade restrictions over China, without any role played by the EU, has shown the limits of European coordination on the matter.

## *3.3. The role of Member States in the development of the European semiconductor ecosystem*

The approach taken by the EU Chips Act makes the role of Member States critical for the success of Europe's semiconductor policy. There is neither a big central budget allocated by the EU (except for €3 million for the Chip Research Joint Undertaking) nor control over all the projects by the European Commission (except the necessary approval within the state-aid framework). Therefore, national semiconductor strategies and pledges of grants and public investments by Member States need to be outlined to gain a full overview of Europe's efforts to revitalise the ecosystem, particularly in the four largest Member States (Germany, France, Italy and Spain).

Germany is said to be the main European hub of the semiconductor industry, mainly concentrated in three regions (Saxony, Baden-Württemberg and Bavaria). A number of R&D institutes across Germany within the Fraunhofer Group for Microelectronics and the Leibniz Association are also playing a decisive role in consolidating the country as a major international semiconductor and electronics research location. Although there is no comprehensive semiconductor strategy, there have been numerous investment announcements supported by the government. As part of the IPCEI (with grants of 80% expected and €1.5 billion earmarked in the National Recovery Plan),[22] Bosch has announced new acquisitions worth €3 billion and a joint venture between Wolfspeed and ZF for a new production line in Saarland valued at €3 billion. Infineon has started a €5 billion (with a €1 billion grant) expansion of its production line in Dresden. The biggest investment announced so far in Germany is the Intel factory in Magdeburg, which has been under negotiation for more than a year. The US company will spend more than €30 billion with subsidies worth nearly €10 billion. Finally, TSMC, Bosch, Infineon and NXP have established a European Semiconductor Manufacturing Company to produce 28/22 nm and 16/12 nm chips with a total investment of €10 billion (government grants have not been disclosed).

As part of the strategic 'France 2030'[23] plan that aims to revive the country's industrial economy and to create future technological champions, in July 2022 France launched 'Electronique 2030'. The plan is expected to make public investments of up to €5 billion with the aim of mobilising €10 billion in research and manufacturing capacity. By April 2023 the European Commission has already approved the provision of grants through this budget to the new STMicroelectronics/Global Foundry plant in Crolles. France is also committed to the new IPCEI in its National Recovery Plan,[24] without specifying a budget.

22 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Germany', https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=SWD%3A2021%3A163%3AREV1&qid=1626959016062

23 France (2022). 'France 2030 : un plan d'investissement pour la France', https://www.economie.gouv.fr/france-2030

24 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for France', https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52021SC0173

The Italian government claims the country is the second-largest European semiconductor ecosystem by number of enterprises in the microelectronics industry (1,872). Some studies[25] estimate an even bigger ecosystem, with well over 2,000 companies. In March 2022 a decree in Italy committed more than €4.6 billion in public investments in the semiconductor sector up to 2030, with no details on the projects to be funded or the source of the funds. The Italian National Recovery Plan[26] foresees €340 million in supporting the development of the strategic value chain of microelectronics by investing in Silicon Carbide substrates, an investment that already passed the state-aid exam in October 2022.

Spain has so far been a secondary player in the European semiconductor ecosystem. The Spanish National Recovery Plan[27] included a €500 million budget earmarked for the new IPCEI in its 2021 version. However, the country has recently approved a sectoral strategic plan (PERTE Chip)[28] that dramatically enlarges the public support for the microelectronic ecosystem with a €12 billion budget, to be funded by RRF once the addenda to the National Recovery Plan is approved by the EU. In May 2023 a cooperation agreement was announced between Intel and the Barcelona Supercomputing Centre that will establish an R&D lab valued at €400 million. The biggest project so far was made public in July 2023 by Broadcom, which will invest US$1 billion in the construction of 'large-scale back-end semiconductors facilities unique in Europe', according to the Ministry's statement. In July 2023 a letter of intent was announced between the Spanish government and IMEC to set up its second largest R&D centre in Europe. IMEC, based in Leuven (Belgium), is considered the 'Switzerland of microchips', as it is the world's leading research centre in the field of semiconductors and a supplier of a strategic asset for the global value chain: the printing presses that enable semiconductors to be designed.

Besides the big four European economies, other countries in the bloc have also announced some kind of support to semiconductor and microelectronics companies. Up to 19 Member States will take part in the new IPCEI and part of these commitments are in the National Recovery Plans of the various countries, as in the case of Romania[29] (€500 million) and Austria (€125 million).[30] Other countries' National Recovery Plans earmarked different investments

25 Bellumore (2022). 'Semiconductor Industry in Italy: mapping and future developments', Riccardo Bellumore, https://www.politesi.polimi.it/bitstream/10589/195171/1/Riccardo%20Bellumore%20Thesis.pdf

26 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Italy', https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021SC0165

27 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Spain', https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0147&qid=1624628827022

28 España (2022), PERTE de microelectrónica y semiconductores, https://planderecuperacion.gob.es/como-acceder-a-los-fondos/pertes/perte-de-microelectronica-y-semiconductores

29 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Romania', https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0276&qid=1666943354251

30 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Austria', https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0160&qid=1624626088799

in order to strengthen their local semiconductor ecosystems. For instance, Belgium[31] has included the budget for an Impulse programme value chain for microelectronics (worth €20 million).

Summing up, it looks highly likely that Europe may be able to mobilise more than the announced €42 billion investment in the semiconductor sector, although an important part of the commitment is yet to be confirmed. Still, concerns about geographical disparities and a 'two-speed scenario' across Member States have been raised, as explained later in this paper.

31 European Commission (2021). 'COMMISSION STAFF WORKING DOCUMENT Analysis of the recovery and resilience plan of Germany Accompanying the document Proposal for a COUNCIL IMPLEMENTING DECISION on the approval of the assessment of the recovery and resilience plan for Belgium'

# 4 The EU's semiconductor system in the global scenario: partnerships and strategic autonomy

## *4.1. The reinforcement of the EU's role in international cooperation towards a resilient and trustful global supply chain*

Despite the EU's drive towards strategic autonomy on semiconductors, the complexity of the supply chain means that it is impossible to achieve full self-reliance in this area, making the case for international cooperation with strategic partners. As mentioned above, the EU Chips Act has a more specific definition of the framework and role of the EU and Member States in the trade and diplomacy arena. Nevertheless, before the entry into force of the new instruments included in the Act, the EU has established a network of alliances with other economic blocs for the purpose of reducing the chances of future supply chain shocks.

To begin with, semiconductors have been on the agenda of the EU-US Trade and Technology Council (TTC) since its inception as a renewed platform for transatlantic dialogue with the US. Building up secure supply chains, especially regarding semiconductors, was included as one of the areas of cooperation agreed upon in the conclusions of the Council's inaugural meeting at Pittsburgh in September 2021. The two partners decided to work together to identify gaps in the semiconductor value chain and strengthen their domestic semiconductor ecosystems. The main outcome of this alliance was achieved at the December 2022 meeting, where an agreement on a joint early warning mechanism to address and mitigate semiconductor supply chain disruptions was signed, as well as a commitment to reciprocal transparency on semiconductor subsidies, in order to avoid a subsidy race. The development of these two items was completed at the May 2023 meeting, according to the statement released later.[32]

Transatlantic cooperation on semiconductors at the private level has been significant. A two-way ecosystem has been created over the past few years, from joint research and technology transfer to supply arrangements.[33] European firms participate in US manufacturing research projects (Sematech, Albany's College of Nanoscale Science & Engineering and the US national labs extreme ultraviolet, or EUV, consortiums), and US firms participate in European research organisations, such as IMEC in Belgium, Fraunhofer in Germany and CNET-Leti in France. European firms have chip production facilities in the US (Infineon, X-Fab and BAE Systems) and US firms make chips in Europe (Intel, GlobalFoundries, ON Semiconductor, IXYS and Analog Devices).

32 EU-US TTC (2023). Joint Statement EU-US Trade and Technology Council of 31 May 2023 in Lulea, Sweden. https://ec.europa.eu/commission/presscorner/detail/en/statement_23_2992

33 Sujai Shivakumar, Charles Wessner, Thomas Howell (2022). Opportunities and Pitfalls for US-EU Collaboration on Semiconductor Value Chain Resilience. CSIS. https://www.csis.org/analysis/opportunities-and-pitfalls-us-eu-collaboration-semiconductor-value-chain-resilience

However, there are certain vulnerabilities in the EU-US tie to work together on a resilient, secure, competitive semiconductor ecosystem. While mapping vulnerabilities is a positive, forward-looking step, the TTC working group identified some critical semiconductor shortages, 'in particular legacy logic chips, analogue chips, and optoelectronic chips, as well as the substrates and raw materials [for chips] used in critical industries and economic sectors including automotive, healthcare, industrial automation, communications, and energy'.

Beyond mapping, there is still no indigenous manufacturing capacity for the most advanced semiconductor assets, namely 7, 5 and 3 nanometre design rules, either in the US or the EU. While Intel is investing in 7 nanometres, so far the development of these and smaller nodes is only located in South Korea and Taiwan, although China has apparently achieved a 7 nanometre design capacity.[34]

Besides cooperation with the US, cooperation on semiconductors has been on the agenda of all the recent high-level bilateral meetings between the EU and other economic areas. In May 2022 the final Joint Statement of the EU-Japan Summit[35] included an agreement to launch the EU-Japan Digital Partnership to work on the resilience of global supply chains in the semiconductor industry, which has been consolidated in a Memorandum of Understanding between the two economic areas in July 2023.

In May 2023, after the EU-India Trade and Technology Council,[36] the two parties agreed to coordinate their semiconductor policies through a dedicated Memorandum of Understanding to be signed in October. That same month, the Joint Statement following the Summit between the EU and the Republic of Korea[37] included the agreement to develop a common mechanism for the security and resilience of the semiconductor supply chain and to cooperate in research and development in the field of leading-edge semiconductors. India has presented itself as the alternative for the location of multinationals such as Apple and Samsung, to diversify its supply chains away from China.[38] India has also been investing in its homegrown technology sector[39] to build up its own economic and security statecraft thanks to both government support and public-private schemes in frontier-technology development.

34 South China Morning Post, September 2023, While under US sanctions, where did Huawei get the advanced chips for its latest Mate 60 Pro smartphone? , https://www.scmp.com/tech/big-tech/article/3233166/while-under-us-sanctions-where-did-huawei-get-advanced-chips-its-latest-mate-60-pro-smartphone

35 EU-Japan (2022). Joint Statement EU-Japan Summit 2022 https://www.consilium.europa.eu/en/press/press-releases/2022/05/12/joint-statement-eu-japan-summit-2022/

36 EU-India TTC (2023). EU-India Trade and Technology Council (TTC) Joint Statement https://digital-strategy.ec.europa.eu/en/library/eu-india-ttc-joint-statement

37 EU-Korea (2023). Joint statement European Union - Republic of Korea Summit 2023, https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_23_2863

38 Patrizia Cogo, Raquel Jorge Ricart (2023). The EU-India Trade and Technology Council: opportunities and challenges ahead. Elcano Royal Institute. https://www.realinstitutoelcano.org/en/commentaries/the-eu-india-trade-and-technology-council-opportunities-and-challenges-ahead/

39 Nisha Holla (2022). The Role of the State in Facilitating an India-First Technological Imperative. Observer Research Foundation. https://www.orfonline.org/research/the-role-of-the-state-in-facilitating-an-india-first-technological-imperative/

Given the general trend towards reducing dependence on China in critical sectors, India has conducted several technology crackdowns on the country since at least 2020. It has either banned Chinese apps and services or subjected Chinese manufacturers to investigation from India's Enforcement Directorate, which has seized bank accounts and accused many companies of tax evasion. Section 69 of the Indian Information Technology Act enables[40] the Indian central government to block access –by invoking emergency powers– to any domain or app that is deemed to be a threat to national security.

However, India's attitude towards China should be revised by the EU, especially when it comes down to the recently propagated approach of 'de-risking' instead of 'decoupling'. The EU's position on China is not as tough as India's.

Nevertheless, bilateral cooperation is insufficient to build up a trustworthy and resilient supply chain, particularly if de-risking from countries of concern needs to be added to the formula. Multilateral forums are another scenario where the EU has sought agreements in this area, especially to reduce dependencies from malicious actors and reduce technology transfers to them. This was one of the topics of discussion at the G7 meeting of May 2023,[41] at which Members agreed on cooperation in export controls on critical and emerging technologies such as semiconductors in order to address their misuse.

The year 2023 has seen a revamp in the EU's relationship with Latin America and the Caribbean. Technology has been at the top of the agenda, with the EU-LAC Digital Alliance[42] and the Global Gateway Investment Agenda. However, semiconductors have seen only a limited mention. The closest project to semiconductors is the EU-LAC Digital Accelerator, which aims to connect large corporations to start-ups and innovative SMEs, supporting these joint ventures up to an investment-ready stage, providing specific benefits for each. Its first initiative, 'Smart Production', includes a workstream on electronics, although it remains unclear to what extent and how semiconductors will be covered.

Instead, references to critical raw materials (CRM) have been made across many initiatives, such as in the revamped EU-CELAC Summit[43] in July 2023, whose political declaration acknowledges the importance of CRMs and technology transfers in this regard. Despite this regional view, implementation relies on bilateral agreements with each country, which can vary widely. While Chile and the EU concluded the modernised EU-Chile Advanced Framework Agreement in December 2022 to promote tariff-free EU exports and greater access to raw materials, such as lithium, other discussions may take longer –such as the long-lasting negotiation over an EU-MERCOSUR trade agreement, considering that Brazil

40 Asha Hemrajani (2022). The Indian Government Ban on Chinese Apps and the Singapore Connection. *RSIS Publications*. Available at https://www.rsis.edu.sg/rsis-publication/cens/the-indian-government-ban-on-chinese-apps-and-the-singapore-connection/#.Y-YwgHbMK5c

41 G7 (2023), G7 Hiroshima Leaders' Communiqué, https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/20/g7-hiroshima-leaders-communique/

42 European Commission (2023). EU-LAC Digital Alliance. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1598

43 European Commission (2023). EU-CELAC 2023 Summit Political Declaration. https://ec.europa.eu/commission/presscorner/detail/en/statement_23_3924

is the major supplier[44] of niobium (of which 92% of the element is to be found in the country)–. Niobium-based semiconductors[45] are increasingly becoming an important asset offering great advantages in the development of photocatalysts for hydrogen generation.

In the case of the African continent, the EU has been long developing fully-fledged initiatives with the AU and bilateral ties with specific countries on technology, digitalisation and innovation: the EU-AU Digital Economy Task Force, the Digital for Development (D4D) Hub and the Africa-Europe Innovation Partnership (AEIP), among others. However, none has included a specific focus on semiconductors or similar elements in the value chain, except to some extent the ENRICH project from January 2021 to December 2023, or has boosted the local innovation landscape with entrepreneurs and innovators. While it does not explicitly address semiconductors, it promotes green technologies, which may be a closer area.

As the main hub for international cooperation, the OECD has also launched plans to create diverse, resilient, secure and more transparent semiconductor supply chains through the Committee on Industry, Innovation and Entrepreneurship (CIIE) and the Committee on Digital Economy Policy (CDEP). The main goal is to build an exchange network of officials involved in semiconductor industry policymaking, where participants share information on the current state of the ecosystem and recent public and private initiatives in their respective countries. The results of this effort can include a repository of information on active and planned semiconductor production facilities in participating countries, a catalogue of public support initiatives and an overview of regulatory best practices. This effort has already captured some funding from the US government.[46]

## *4.2. Consequences of the semiconductor ecosystem in the EU's strategic autonomy goals*

In practical terms, semiconductors are playing a major role in the scope of possibilities for the EU to act independently, to reduce vulnerabilities from dependencies on third countries and to be a key player in the global arena. Looking back to the recent past, a noticeable effect was Brexit, and the withdrawal of the British company ARM as one of the leading EU companies in the global semiconductor landscape. ARM, which has long been considered the biggest rival to Intel, was the most important EU company for microprocessor chips, especially graphic processing units (GPUs). If compared to the human body, microprocessor chips would be the brain, in charge of analysis and calculations. Its main rivals are Intel, but also IBM, Qualcomm and Nvidia. Also, ARM is one of the top five Intellectual Property core licensing companies, whose market share was 40% worldwide in 2020. Another British company, Imagination Technologies, was part of this group of five leading companies, jointly with three US firms. Its leadership in the category of microprocessor chips and in the

44 European Commission (2020). Study on the EU's list of Critical Raw Materials (2020) Final Report. https://ec.europa.eu/docsroom/documents/42883/attachments/1/translations/en/renditions/native

45 Chao Zhou, et al. (2020). Recent advances in niobium-based semiconductors for solar hydrogen production, *Coordination Chemistry Reviews*, Volume 419, https://doi.org/10.1016/j.ccr.2020.213399

46 US Government Factsheet, June 30th, 2023, International Engagement Project Under the CHIPS Act/International Technology Security and Innovation Fund https://usoecd.usmission.gov/international-engagement-project-under-the-chips-act-international-technology-security-and-innovation-fund/

value chain stage of intellectual property was seen as an industrial policy loss in the EU. To give an example, the founder of ARM, Hermann Hauser, acknowledged that 'Brexit is the biggest loss of sovereignty since 1066'.[47]

In 2023 the EU has two leading semiconductor firms: IMEC and ASML. Both companies provide critical reflections on the scope and level of coordination, coherence and cohesion across EU Member States in the implementation of joint measures to support the EU's strategic autonomy goals. In July 2023 a letter of intent was announced between the Spanish government and IMEC to set up its second R&D centre in Europe. The establishment of new R&D centres of a European company across other Member States is an opportune sign of the effort to support a technological-industrial base, of measures to create, attract and retain talent, and policies to strengthen technology transfer and cutting-edge research and development with a collaborative outlook.

On the other hand, the Dutch government announced in March 2023 export restrictions regarding 'very specific technologies in the semiconductor production cycle'. Specifically, the sale of deep ultraviolet lithography systems that print fine details on microchips are part of the export restriction. In 2023 ASML is the only known company worldwide to manufacture these systems. ASML said in a statement[48] that only its 'most advanced' immersion lithography tools are affected by the export controls. This decision means that the Netherlands decided to restrict the sale of directly impacted ASML capacity to sell products to China without a specific export licence. This initiative was part of the pressure exerted by the US on the Netherlands to converge with it and Japan to a similar export restriction regime on semiconductors to China.

While it is important to note that export restrictions are not equivalent to sanctions, there are some similarities in the way EU Member States have varying degrees of ease to restrict certain exports. Sanctions are agreed at the EU level by all Member States, but their interpretation and implementation depend on the national level and might differ. This issue has opened up a discussion on the necessity of thinking about potential flaws, overlaps and missing points in coherence across Member States on how to govern semiconductors.

Due to this lack of coherence in the semiconductor ecosystem across Member States, and for other reasons, the EU announced its new Economic Security Strategy[49] in June 2023, which aims to boost a greater level of communication, coordination and exchanges between Member States, in identifying, assessing and managing risks in four areas, all of them related to semiconductors: resilience of supply chains, including energy security; physical and cyber security of critical infrastructure; technology security and technology leakage; and weaponisation of economic dependencies or economic coercion.

47 The Guardian (2022). Interview, by Jasper Jolly. https://www.theguardian.com/business/2022/jul/23/hermann-hauser-founder-of-arm-brexit-is-the-biggest-loss-of-sovereignty-since-1066

48 ASML (2023). Statement regarding additional export controls. https://www.asml.com/en/news/press-releases/2023/statement-regarding-additional-export-controls

49 European Commission (2023). An EU approach to enhance economic security. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3358

However, this effort to foster a greater coordination across EU Member States is nothing new. A clear case is the Anti-Coercion Instrument (ACI)[50] proposal by the European Commission in 2021, released after China's blockage of many Lithuanian companies' supply chains after the potential acknowledgment of a new Taiwanese Embassy, instead of a Taipei Trade Office, in Vilnius. The ACI is first and foremost designed to act as a deterrent against any potential economic coercion. The latter include the imposition of tariffs, restrictions on the trade in services and restrictions on access to foreign direct investment or public procurement. Still, recent cases show that there is a greater need for further economic security integration across Member States, also in semiconductors.

Finally, an additional challenge to the EU's strategic autonomy does not derive from third partners or from Member-State coordination. It also derives from the within each country and the role of sub-regional actors in the semiconductor ecosystem. During the launch of the EU Chips Act proposal in February 2022, Vice-President and Commissioner Margrethe Vestager acknowledged that 'Spain is a European global champion when it comes to the design, development and manufacturing of electronic components for cars' passive keyless entry, with more than 60% of the global market share. But with all this strength we are still lagging behind when it comes to cutting-edge'.

Given the reality in countries such as Spain of a geographical diversity with regionalised industrial clusters, it is strategic to make visible the role of the regions as industrial and governance entrepreneurs. This is the case of the Valencia Silicon Cluster, an initiative that emerged to respond to the challenges derived from the Spanish PERTE initiative for microelectronics, integrated photonics and semiconductors. With 50% of all national human resources in microelectronics and 60% of those in integrated photonics, more than half of all specialised employees in the sector in Spain work in Valencia. This regional concentration of talent and technological capacity calls for greater state-regional involvement in the promotion of a European industrial policy that responds to the needs of the region.

In cases where certain countries do not have a strong semiconductor ecosystem, their capacity to attract foreign investment or to create an ecosystem of talent remains paramount.

50 European Commission (2023). Political agreement on new Anti-Coercion Instrument to better defend EU interests on global stage. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3046

# 5 Policy recommendations for the EU

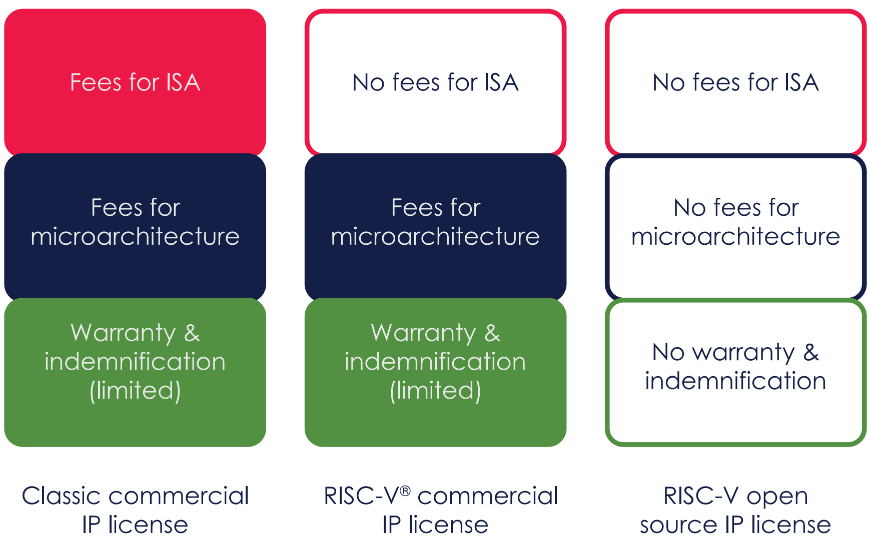
In light of the analysis above, there is a set of policy recommendations for the EU that could be followed in order to reinforce the EU's role in the supply chain of semiconductors, ensure the correct functioning of the Union's main industries (eg, the automotive industry) and increase European strategic autonomy in the technological field.

Policy recommendations for the EU could be structured around five different categories: (1) design; (2) manufacturing; (3) machinery; (4) talent; and (5) coordination efforts at the EU level.

## *5.1. Design: licences and tools*

There are three main types of licences in the semiconductor ecosystem: royalty-free; open-source licences; and upfront licence fees. As for open-source licences, the best-known instruction set architecture (ISA) is RISC-V that, unlike most other ISA designs, is provided with no tariff or charge. This means that the open-source RISC-V has no warranty or identification, no fees for microarchitecture and no fees for ISA. However, there are certain RISC-V models that are commercially driven because no fees are applied for ISA, but the other two conditions (warranty and identification, and fees for microarchitecture) do apply. The second category is the fully commercial licence, which requires all three conditions (including fees for ISA).

**Figure 2. Types of licence, by type and accessibility (commercial, open source)**




Source: Semiengineering (2022), 'Open source vs commercial RISC-V licensing models', https://semiengineering.com/open-source-vs-commercial-risc-v-licensing-models/.

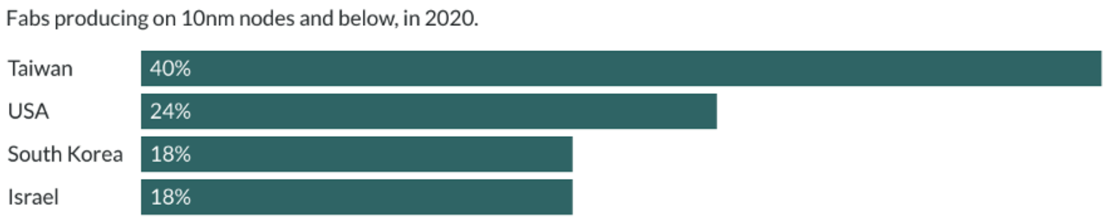
While commercial IP licences have a significant share of the semiconductor ecosystem, with companies such as Britain's ARM, the chip arms-race between countries in recent years has led some companies and countries to turn to RISC-V for its global, open nature, to create homegrown processors and accelerators amid sanctions, shortages and other barriers that obstruct the free trade in semiconductors.

The EU should promote both a positive and a negative agenda. Technically, RISC-V is far from the high level of competitive advantage of ARM or x86, but evidence shows that many countries are investing in RISC-V to gain an advantage in their endogenous production of chips and to offer this model as an alternative to developing countries, which would opt for an open and royalty-free based chip purchase. On the positive side, the EU should promote the development of RISC-V models. On the negative side, it should avoid playing the role of fellow-traveller with countries of concern. Some Russian companies, such as Elbrus and Yadro, are developing RISC-V cores as an alternative. The Chinese Academy of Sciences, which is on the US Entity List of trade-restricted organisations, has developed 64-bit RISC-V cores.[51] Therefore, the EU should focus on proceeding with a comprehensive assessment of the actual impact of sanctions on Russia, especially in semiconductors.

## *5.2. Manufacturing*

At present, the EU is not home to any leading-edge production facility, with only Intel's plant in Leixlip (Ireland) and STMicroelectronics in Crolles (France) producing the 14nm node.[52] Moreover, as shown in Figure 5 and explained above, the concentration of edge technology chips is especially notable in Taiwan and South Korea. Only the US and Israel seem to be in a position to compete with these Asian countries in this type of cutting-edge chips (especially in chips between 5 and 10 nm, with the role of Asian countries in manufacturing chips below 5 nm being even higher). Therefore, the starting position of the EU in terms of cutting-edge chips manufacturing is not favourable and enormous amounts of public and private financial resources would be needed to create a competitive environment.

**Figure 3. Global semiconductor manufacturing capacity location**



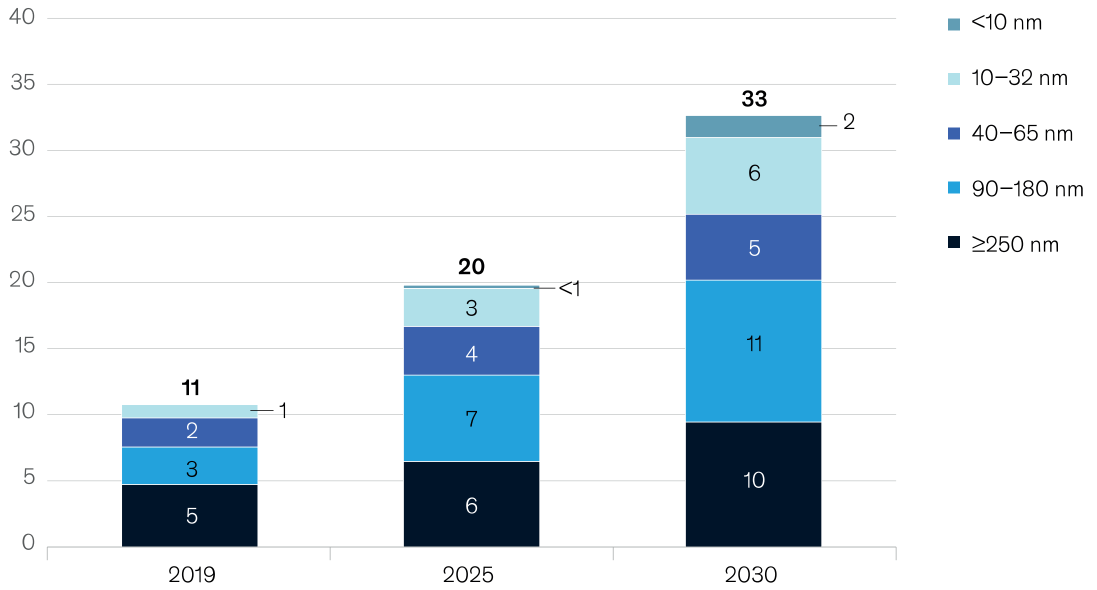

Source: Kearny and Bertelsmann Stiftung, 2020.

51 Agam Shah (2022). RISC-V keeps its head down amid global chip war. The Register. https://www.theregister.com/2022/02/17/riscv_chip_wars/

52 Mschmitz. (2023, June 16). The Curious Case of Taiwan: Will the EU get its Chips Together? Global & European Dynamics. https://globaleurope.eu/europes-future/the-curious-case-of-taiwan-will-the-eu-get-its-chips-together/

Even if the EU's starting position for cutting edge chips is not positive, the main question is whether the EU actually needs to make substantial efforts to change this. And the answer is very much linked to the types of chips used in different devices and the relevance the production of those devices plays for the EU economy as a whole. In particular, a distinction needs to be made between advanced electronic devices such as phones, Wi-Fi routers and computers and the automation industry, which plays a key role for the EU economy. Indeed, personal electronic devices need more advanced chips, whereas vehicles are mostly based on so-called legacy chips.[53] It must also be noted that advanced chips deteriorate more rapidly than legacy chips, in light of the very speedy developments in personal electronic devices. As shown in Figure 6, most automotive wafer demand in the future will continue involving semiconductors of more than 90 nm.[54]

**Figure 4. Annual demand for 12-inch wafer equivalents, automotive semiconductors, by nanometre (nm)**




Source: McKinsey, 2020.

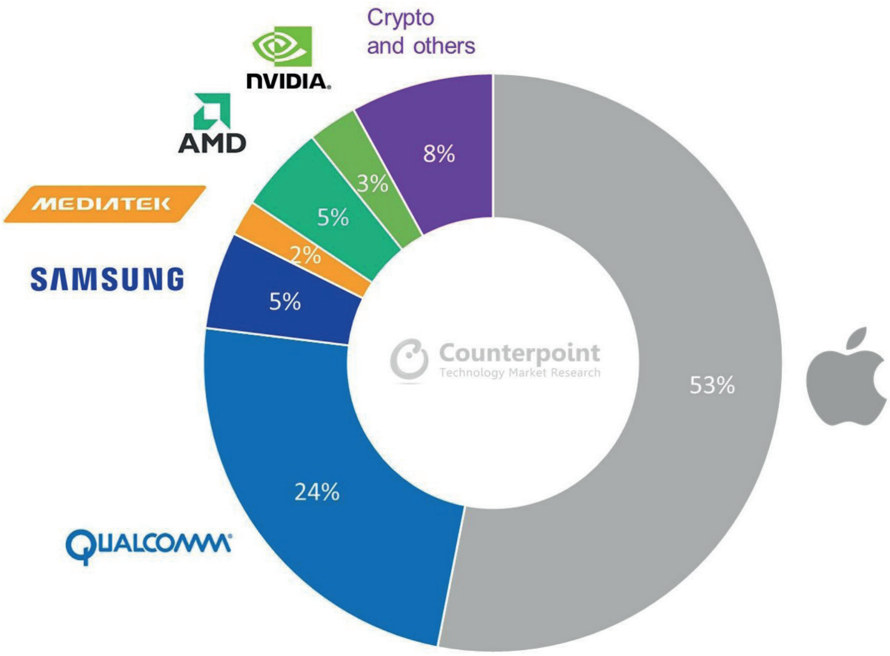
Moreover, Figure 7 shows that in 2021 Apple, Qualcomm, Samsung, AMD and Nvidia demanded 90% of 5 nm chips.[55] None of these is an EU company.

53 Legacy chips used to be cutting edge a number of years ago, but with the launch of more innovative chips, they have progressively turned into so called legacy chips.

54 McKinsey & Company. Will the supply–demand mismatch persist for automotive semiconductors? (2022, October 14). https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/will-the-supply-demand-mismatch-persist-for-automotive-semiconductors

55 Counterpoint Research. Foundry Industry's robust revenue growth to continue in 2021. (2021, January 14). https://www.counterpointresearch.com/foundry-industry-revenue-growth-continue-2021/

**Figure 5. 5-nanometre wafer shipment breakdown by customer in 2021**




Source: Counterpoint Research, 2021.

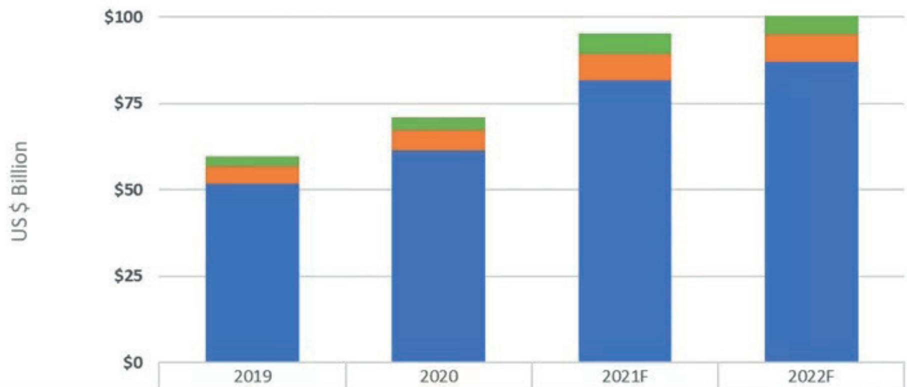
Therefore, even if the Digital Compass presented by the European Commission back in 2021 indicates that the EU should strive to host manufacturing capacity below the 5nm node, on top of increasing its share in global chip production to 20% by 2030, in light of the structure and needs of EU industry and the large amount of dependencies the Union needs to tackle in several fields, it would be advisable for the EU to focus on prioritising and putting a greater effort on legacy chips, at least initially. Once the EU has made progress in reaching the 20% global share production target and has better ensured the value chain of its main industries, as in the automotive sector, plans could be adopted to take part in the manufacturing of more advanced chips.

## *5.3. Manufacturing equipment*

The importance of semiconductor manufacturing equipment in the global supply chain reached the public on 7 October 2022, when the US imposed export controls on these items to China. The trade restrictions on the more advanced of these kinds of equipment limited the ability to produce technology-edged chips in China. The importance of this segment of the semiconductor value chain is reinforced by its global revenues, at more than US$107.6 billion in 2022.[56]

56 SEMI (December 2022). Global total semiconductor equipment sales forecast to reach record high in 2022 https://www.semi.org/en/news-media-press/semi-press-releases/global-total-semiconductor-equipment-sales-2022

**Figure 6. 2022 year-end total equipment forecast by segment (US$ bn)**




| | 2019 | 2020 | 2021F | 2022F |
|---|---|---|---|---|
| Assembly & Packaging Equipment | 2.87 | 3.85 | 6.01 | 6.39 |
| Test Equipment | 5.02 | 6.01 | 7.58 | 8.03 |
| Wafer Fab Equipment | 51.74 | 61.20 | 81.70 | 86.89 |

Source: SEMI (2022), 'Global total semiconductor equipment sales forecast to reach record high in 2022', December.

It should be highlighted that there is not only one type of semiconductor manufacturing equipment in a foundry. The production of chips requires the participation of several types of them for different purposes and treatments on the wafers: the application of chemicals, lithography of the circuits, etching and cutting, metrology and optical measurement of quality, and so on. The market is functionally fragmented and for each purpose there is a highly dominant player. One of these players is a European company, ASML, which is the main and most technologically advanced player in lithography machines. ASML is a company that is critical to the manufacturing process of the most advanced chips and without its machines all foundries will be obliged to produce the same components as 10 years ago.

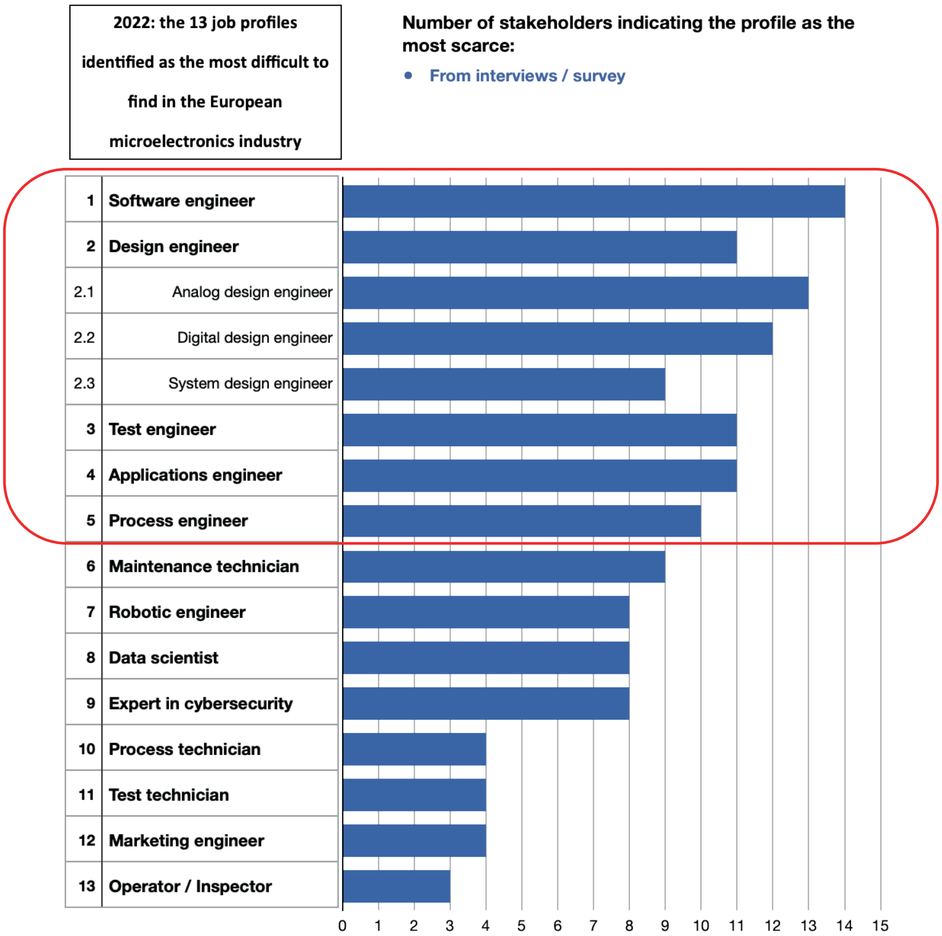
All the different types of manufacturing equipment are what Jack Sullivan, National Security Advisor at the White House, calls a 'small yard, high fence', meaning that it is better to focus on a few, but highly strategic sectors. Many years of research and development are needed to produce the more advanced ones and each generation of product is built on top of the previous. However, it is still possible for Europe to create or reinforce companies in this segment, particularly in the metrology and quality assurance area based on the strengths of optical companies, eg, Zeiss. Support of this kind of companies with grants and public investment is also very open with the final version of the EU Chips Act, that has included manufacturing equipment in the list of products allowed to take advantage of the fast-track in state-aid approvals.

## *5.4. Talent*

According to the EU-funded METIS project, which aims to support accreditation and certification to build a skilled workforce in the microelectronics sector, the European industry directly accounts for 200,000 and indirectly for 1 million highly-skilled jobs. The demand for new skills keeps growing, but there is a major skills shortage.

According to its 2022 report,[57] the most critical job profiles (those that are the most sought after by the industry and most difficult to fill) are software and design engineers –system design engineers, digital design engineers and analogue design engineers–. However, the demand for and shortage of software engineers, data scientists, cybersecurity experts and application engineers has risen sharply over the past two years.

**Figure 7. The 13 job profiles identified as the most difficult to find in the European microelectronics industry, 2022**




Source: METIS4Skills (2022), 'METIS Skills Strategy Report', https://www.metis4skills.eu/deliverables/.

57 METIS4Skills (2022), 'METIS Skills Strategy Report', https://www.metis4skills.eu/deliverables/.

Based on this scenario, the EU and Member States should foster more fundamental knowledge in semiconductors to allow job-to-job mobility within the industry and across sectors that might leverage the potential of semiconductors. Also, design for production standard tools should be heavily promoted, alongside manufacturing. Another proposal, raised by the METIS project, is to foster more engineering profiles of generalists that have fundamental knowledge instead of knowing in-depth details. As proposed by some national associations, such as Spain's AESEMI,[58] there is a need for more curricula dedicated to semiconductors.

Additionally, there should be incentives for hiring employees. Likewise, mechanisms must be established to improve the training of specialised personnel and mobility between companies and universities/research centres, such as the participation of industry specialists in university curricula teaching, the promotion of industrial doctorates to encourage greater public-private cooperation, support for temporary staff and visiting fellowships, and support for upskilling and reskilling programmes to adapt existing workforces to new employment opportunities within companies.

## *5.5. Coordination efforts at the EU level*

As described in section 2, there seems to be a race between EU Member States to capture the private investments of leading companies. For this purpose, Member States are putting up huge amounts of EU funds, some of which stem from EU facilities such as the Recovery and Resilience Mechanism. This situation risks creating an uneven playing field among Member States as, obviously, those with higher fiscal space will be able to offer more public funds and thus attract more private investment. But not only does this situation risk damaging highly-indebted EU Member States, it is mainly inefficient and dangerous for the entire bloc and for all of its countries individually. In light of the current situation in the semiconductor industry as described in this paper, it is not sensible for any EU Member State to aspire to have on its own territory the entire semiconductor value chain. This will simply not happen and would create a risk that the EU would not to be able to concentrate the complete value chain through different Member States. In turn, the European Commission should make a deep analysis of the chip value chain in the EU and come up with a proposal to divide the different parts of the chain among Member States, based on their initial competitive advantages. Common EU funding should be provided for this purpose.

58 AESEMI (2023). Propuestas de impulso a la Industria de los Semiconductores. https://aesemi.org/wp-content/uploads/2023/07/AESEMI_Propuestas-de-Impulso-a-la-Industria-de-los-Semiconductores.pdf

# 6 Conclusions

On the basis of the analysis of global and EU value chains, the different initiatives in major jurisdictions, cooperation arrangements and geopolitical tensions, this paper presents a set of policy proposals.

Regarding design, the EU should promote both a positive and a negative agenda. Technically, RISC-V is far from the high level of competitive advantage of ARM or x86, but evidence shows that many countries are investing in RISC-V to gain an advantage in their endogenous production of chips and to offer this model as an alternative to developing countries that would opt for an open and royalty-free based chips purchase. On the positive side, the EU should promote the development of RISC-V models. On the negative side, some Russian companies, such as Elbrus and Yadro, are developing RISC-V cores as an alternative. Therefore, the EU should focus on proceeding with a comprehensive assessment of the actual impact of sanctions on Russia, especially regarding semiconductors.

When it comes to manufacturing, the starting position of the EU in terms of cutting-edge chips manufacturing is not favourable and enormous amounts of public and private financial resources would be needed to create a competitive environment. Still, the most important European industries need legacy chips (>90 nm) and not cutting-edge chips. Thus, even if the Digital Compass presented by the European Commission back in 2021 indicated that the EU should strive to host manufacturing capacity below the 5nm node, in addition to increasing its share in global chip production to 20% by 2030, in light of the structure and needs of EU industry and the large number of dependencies, the Union needs to tackle several problems. It would be most advisable for the EU to prioritise and place a greater effort in legacy chips, at least initially.

As for manufacturing equipment, many years of research and development are needed to produce the most advanced equipment and each generation of product is built on top of the previous one. However, it is still possible for the EU to create or reinforce companies in this segment, particularly in the metrology and quality assurance area based on the strengths of optical companies, such as Zeiss. This is possible since support for this kind of companies with grants and public investment is also well open given the final version of the EU Chips Act.

EU plans for chips will not succeed unless there is sufficient and adequate talent in the EU. To this end, the EU and Member States should foster more fundamental knowledge in semiconductors to allow job-to-job mobility within the industry and across sectors that can leverage on the potential of semiconductors. Also, design for production standard tools should be promoted, alongside manufacturing. Engineering profiles of generalists should be fostered, with fundamental knowledge instead of in-depth detail, while at the same time more curricula dedicated to semiconductors should be introduced. Additionally, there should exist incentives for hiring employees. Likewise, mechanisms must be established to improve the training of specialised personnel and mobility between companies and universities/research centres, such as the participation of industry specialists in university curricula teaching, the promotion of industrial doctorates to encourage greater public-private cooperation, the support of temporary staffs and visiting fellowships and the support of upskilling and reskilling programmes to adapt existing workforces to new employment opportunities within a company.

Finally, there seems to be a race between EU Member States to capture private investment of leading companies. For this purpose, they are putting on the table huge amounts of EU funds. This situation risks creating an uneven playing field situation among Member States and is very inefficient and dangerous for the bloc as a whole and for its members individually. In turn, the European Commission should carry out a deep analysis of the chip value chain in the EU and come up with a proposal to divide the different parts of the chain among Member States, based on their initial competitive advantages. Common EU funding should be provided for this purpose.

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